PHYSICS IN DEVELOPING COUNTRIES:

Past, Present and Future

Editors
Dr. Hameed A. Khan
Prof. Dr. M.M. Qurashi
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April 2006

Commission on Science and Technology for
Sustainable Development in the South

8

COMSATS' Series of Publications on Science and Technology

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Published: April 2006

Printed by: *M/s A.R. Printers*

This book is published under the series title *COMSATS' Series of Publications on Science and Technology*, and is number 8th of the series.

Copies of the book may be ordered from :
COMSATS Headquarters
4th floor, Shahrah-e-Jamhuriat
Sector G-5/2, Islamabad, Pakistan
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Physics in Developing Countries: Past, Present and Future

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PREFACE

It is a hard reality that the countries of the Third World lag far behind the developed world, primarily due to the absence of well-equipped scientific institutions, universities and facilities. The level of training and research in physics varies remarkably across the world, with the most advanced nations producing far more PhDs in Physics than the developing countries. Realizing this deficiency, it is imperative for the developing countries to have a good-quality system for science-education in place, if they want to grow economically. It is also true that, in the past, individuals made significant discoveries, but now teamwork is essential to achieve that. Presently, useful contributions come mostly from groups of highly educated and skilled individuals who are working on big machines and in centers with huge infrastructure and sophisticated equipment. Today, no single developing country in isolation can accumulate enough experience or infrastructure to cater for its scientific, technological and consequent economic needs. South-South cooperation and, where needed, South-North cooperation are imperative in this regard.

In order to (a) highlight the importance of Physics in development, (b) bring forward the experiences of developed and developing countries in which physicists have contributed towards the growth of the economy, and (c) devise strategic recommendations for promoting Physics and related disciplines for sustainable development, COMSATS organized an International Seminar on Physics in Developing Countries: Past, Present and Future, on July 27-28, 2005, at Islamabad. This seminar was organized in collaboration with the Islamic Educational, Scientific and Cultural Organization (ISESCO). Other objectives of holding this Seminar included enhancing awareness of the potentials of Physics for improving the lives of the people, particularly those of the developing world, and emphasizing the role of international co-operation in Physics and requisite modalities of instituting and promoting South-South and South-North cooperation.

It was a welcome coincidence that the world's physics community was celebrating the International Year of Physics-2005 when this seminar was organized in Islamabad. The objectives of the seminar were closely related to those prescribed by the IYP-2005. As a matter of fact, the present seminar constituted a part of the IYP-2005 celebrations from Pakistan's scientists and turned out to be a useful component of the celebrations of the International Year. A comprehensive compilation in this context has been included in the present proceedings, which describes the genesis of the IYP-2005, the UN support it received, some salient contributions from the physicists of Pakistan, conclusions, and recommendations. In a way, this analytical review of the IYP-2005 supports and complements several other papers presented in the International Seminar on "Physics in Developing Countries: Past, Present and Future". It is recommended that the reader may like to synchronize the output of this review with those emerging from several other papers included in the current proceedings.

There were a total of 20 speakers in the Seminar who made presentations in 6 Technical Sessions, of which 7 were foreign experts representing the countries of Egypt, Sudan, Sri Lanka, and Tajikistan. Other participants included eminent physicists, heads of S&T institutions, scholars and students from various academic and research institutions. The proceedings of the Seminar include the contents of the presentations made by the speakers and the recommendations that emerged during the various sessions of the seminar.

I would like to express my deep sense of appreciation for Dr. Ishfaq Ahmad, N.I., H.I., S.I., Special Advisor to the Prime Minister of Pakistan, for his guidance, advice and support for this seminar. My gratitude is also due to Dr. Faiq Billal, Director, Islamic, Educational, Scientific and cultural organization (ISESCO), for his ardent cooperation and help in organizing this conference. My earnest praise also for Dr. M.M. Qurashi, Mr. Irfan Hayee, Ms. Zainab Hussain Siddiqui, Ms. Noshin Masud and Mr. Imran Chaudhry from COMSATS whose devotion made publication of the proceedings of this seminar possible.

(Dr. Hameed Ahmed Khan, H.I., S.I.)
Executive Director

FOREWORD

From the pure beauty of general relativity to modern high technology, Physics is a fascinating and worthy subject, leading to both new applications and in-depth observations about the universe. The influence of physics in the enhancement of old technologies and the development of new ones is enormous. Both the methods and the subject-matter of physics are vital to technological development, leading to increased productivity in the economy.

The year 2005 was declared the International Year of Physics (IYP) by the General Assembly of the United Nations Organization. IYP 2005 was a worldwide celebration for physics and its importance. The year 2005 also marked the 100th anniversary of Albert Einstein's three important papers describing ideas that have since influenced all of modern physics. The IYP-2005 provided an opportunity to celebrate Einstein's great ideas, and their influence on our lives in the 21st century.

The celebrations were arranged all over the world. The scientific community of Pakistan, particularly the physicists, took special interest in celebrating the IYP-2005. Academia, researchers, scholars, young science-students and media participated in several activities arranged for this purpose.

COMSATS has played an active role in the celebrations related to the IYP-2005, it arranged and co-sponsored several seminars, symposia, meetings, etc. The present seminar, "Physics in Developing Countries: Past, Present and Future" was a part of these activities.

It is appropriate that the outcome of such an important seminar should be widely disseminated for the benefit of large section of our society. The proceedings of the event will adequately serve this purpose. The seminar, comprising 18 papers on diverse aspects of the title, presented by renowned experts in the respective fields, gives a thought-provoking opportunity to the physicists and policy-makers for devising necessary strategies for a better future of Physics. The areas covered in the proceedings represent, physics education, research in physics, development and technology and, quite appropriately, some historic perspectives. The message emerging from the seminar is clear: that quality of physics teaching and research can be appreciably enhanced by encouragement from the governments, policy-makers and other informed sections of the society. At the world level, the prospects of a better physics would brighten with enhanced international cooperation and through free exchange of knowledge.

I would like to take this opportunity to praise the efforts of Dr. Hameed Ahmed Khan H.I., S.I., and his team who organized this event to enlighten the researchers, businesses and the public about the importance of investment in physics, which can ultimately lead to economic development and an enhanced quality of life.

(**Dr. Ishfaq Ahmad, N.I., H.I., S.I.)**
Special Advisor to the
Prime Minister of Pakistan

THE INTERNATIONAL YEAR OF PHYSICS – 2005 INCLUDING CONTRIBUTIONS BY THE PHYSICS COMMUNITY OF PAKISTAN

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ABSTRACT

The worldwide celebrations of the International Year of Physics-2005 have brought tremendous intellectual and scientific benefits to the physics community. The year 2005 was well chosen for this occasion, as it was linked to Einstein's three revolutionary and imaginative scientific papers published in 1905-remembered as Annus Mirabilis (Miraculous Year) by the men of science. These three publications by Einstein gave an entirely new perception to the thinking processes of physicists in the twentieth century and provided the world with inventions that surround our everyday lives with abundance and with inescapable necessities.

The physics community of Pakistan has participated in the celebrations with zeal and joy. The Commission on Science and Technology on Sustainable Development in the South (COMSATS) has taken a leading role in making the occasion a success, in collaboration with the public and private-sector research and teaching institutions. The objectives and purposes of the IYP-2005 did not remain confined to celebrations alone, but went much beyond that. For Pakistan, like many developing countries, it meant taking stock of the stature of physics, its quality, its benefits to the society and creating new opportunities to improve the education and basic research in various disciplines of physics. The most important aspects were the revival of interest in physics by the younger generation of Pakistan enhanced enrolment of female students in physics classes, creation of more conducive environment for careers in physics and public awareness of the potentials of physics in promoting socio-economic development in the country. Like the three revolutionary papers of Einstein a hundred years ago, three of his very appropriate quotes fitting the importance of IYP-2005 and relevant to Pakistan are (i) imagination is more important than knowledge, (ii) science is a wonderful thing if one does not have to earn one's living at it, and (iii) most teachers waste their time by asking questions which are intended to discover what a pupil does not know, whereas the true art of questioning has for its purpose to discover what the pupil knows or is capable of knowing.

These quotes very subtly refer to the three areas where the physics culture of our society needs readjustment, i.e., quality of physics, careers in physics and teaching of physics. It is evident that Einstein's above-stated quotes will provide our physicists with ample food for thought to address our physic's problems.

This article provides a brief description of the relevant activities linked to the IYP-2005, both at international and national level. A description has also been given of the efforts made by Pakistan's physics community to make this important world event a true success. The Article does not give, by any means, a full discourse on all the events that have taken place in Pakistan, simply because that full data was not available in a timely manner. This will hopefully be compensated in a future edition of this book. Conclusions and recommendations have also been included, which were arrived at as a result of close watch on the events marking the celebrations of IYP-2005. It is expected that these conclusions and recommendations will receive due consideration from Pakistan's physics community and the policy makers.

BACKGROUND AND INTRODUCTION

Physics has played a crucial role both in understanding the fundamental laws of nature that govern the universe and in transforming humanity to the present-day "modern living" by harnessing the potential of these laws. Man has been able to conquer the space, the oceans and the lands, mainly with the power of Physics. On the one hand, secrets of the cosmos are being continuously unfolded by this great science and, on the other hand, man is discovering new universes within the profundities of the atom. A lot of this progress has been made in the span of the past few centuries. Physics is now unfolding new vistas of knowledge and bringing additional might within the control of man, with a breathtaking pace and with mind-boggling diversity. If the present pace of advancement in Physics continues, our present-day civilization might appear primitive to our posterity.

But there is a more serious concern also: the coming younger generations of students are seemingly losing interest in basic sciences, including Physics. Diminishing attractiveness in scientific careers, lack of encouragement and support by the governments, prevalence of non-conducive educational and research environment and greater availability of alternative non-scientific opportunities (linked to better social security and job satisfaction) are some of the main reasons for the depletion in the class- room density of Physics students. It is imperative that our society creates and maintains a critical mass of good physicists, in order to ensure a better future for Physics and consequently a better future for humanity.

Creation of public awareness of the importance of Physics for the progress of mankind is also another serious necessity. People read and learn very little about Physics in their everyday life. There is an appreciable shortage of popular literature on Physics. Hardly is there any interesting and comprehensible media-coverage on what is happening about Physics around the world. One may occasionally see some interesting information on physics, meant for the lay-man, on the internet but how many people have access to this facility? The general ignorance about science and especially of Physics is much more prevalent in the underdeveloped world than in the industrialized nations. So, the knowledge-gap in Physics is rapidly increasing between the developing and the developed societies. Social benefits available from the potentialities of Physics are severely constrained in the developing countries, mainly due to the chronic lack of awareness about this great scientific discipline. Few, if any, would have ever appreciated the extensive and costly fundamental research in Physics that had gone into the commercial production of such commonplace items as transistors, automobiles, electricity, mobile phones, x-ray machines, computers and many more that are now available to give the contemporary world an entirely new perspective of life.

And then there is the cardinal question of moral responsibility of the scientists, physicists inclusive, in the pursuit of their scientific research. Implications of the outcomes of Physics research are by far the most impact producing on the society today than many other disciplines of science. Several world organizations are actively engaged in promoting the concept of Physics for peace and the well-being of humanity. A vast majority of the Physics community is striving to induct the higher norms of ethics into the scientific research and development programmes being carried out around the world. Social acceptance of Physics as a 'benign science' for mankinds' humanitarian service and for the safety of earth's environment is now a common desire of the Physicists working in the laboratories and the educationists in the universities. This is an important aspect for the future progress of Physics and its ensuing `benefits to humanity.

GENESIS OF THE WORLD YEAR OF PHYSICS - 2005

The foregoing ideas and several others have remained in the minds of the conscientious physicists throughout the world for many years. It was, therefore, logical and appropriate for the Physics community to look for an international occasion to highlight and promote the importance of research in Physics, to arouse public awareness, to debate the ethics of the practices of Physics and to discuss the impact of Physics on the social well-being of mankind. Such an occasion was envisioned at the World Congress of Physical Societies in Berlin in December 2000, where more than 40 physical societies from all around the world approved the proposal to declare 2005 as the World Year of Physics because, at the same time, the world scientific community could also commemorate the 100 years of the publication of a series of legendary papers by the most illustrious physicist of modern times, Albert Einstein, who provided in these publications, the basis for three fundamental fields in Physics: the theory of relativity, quantum theory and the theory of Brownian motion. The publications ultimately produced immense impact on the future progress of physics, both basic and applied.

Following the Berlin Conference, the Council of the European Physical Societies agreed in March 2001 to mobilize support in Europe for this initiative. In October 2002, the International Union of Pure and Applied Physics (IUPAP) unanimously adopted a resolution declaring 2005 as the World Year of Physics. The resolution not only provided approval for celebrating "World Year of Physics – 2005", but also laid the foundation of the justifications and the core points which earmarked the need for such an occasion. These core points were (a) importance of Physics for understanding the nature of the physical world, (b) Physics being the basis of much of today's technology, (c) necessity of Physics education for the developing world to improve their scientific infrastructure, and (d) celebration of 100th anniversary of a series of great scientific advances by Albert Einstein.

Subsequent to the declaration of the IUPAP to celebrate 2005 as the World Year of Physics, a number of international organizations expressed their support for the occasion. This was joined by people all over the world. To coordinate the implementation, representatives of 4 continents and 22 countries met in Graz, Austria, for a three-day conference from 6-9 July 2003 to discuss strategies and ideas for better implementation. Several national and regional meetings took place intermittently for the success of the proposed event.

SUPPORT AT THE UN PLATFORM

The idea of celebrating 2005 as the World Year of Physics also attracted enthusiasm and support of the UNO. The 32nd session of the General Conference of UNESCO adopted, in November 2003, a resolution supporting the initiative. The importance attached by UNESCO to the proposal of the World Year can be realized by the text of the resolution encompassing a large array of the characteristics of Physics, its benefits to mankind and the popular support the proposal had gained all over the world. The resolution adopted states:

i. Recognizing that Physics provides a significant basis for the development of understanding of nature;
ii. Stressing that education in Physics provides women and men with the tools to build the scientific infrastructure essential for development;
iii. Considering that research in Physics and its applications have been and continue to be a major driving force to scientific and technological development, and remain a vital factor in addressing the challenges of the 21st century;
iv. Being aware that the Year 2005 marks the 100th anniversary of a series of great scientific advances by Albert Einstein;
v. Welcomes the resolution of the International Union of Pure and Applied Physics (IUPAP), at the initiative of the European Physical Society, to declare the year 2005 the World Year of Physics and carry out, within its framework, activities to promote Physics at all levels, worldwide;
vi. Decides to support the initiative of the World Year of Physics 2005;
vii. Invites the Director General to request the United Nations General Assembly to declare 2005 the International Year of Physics.

Following the passage of the UNESCO resolution, the UN General Assembly took up the matter for formally declaring 2005 as International Year of Physics. It may be noted that the UNESCO resolution in its 7th item of the text had changed the title of the event from the World Year of Physics to International Year of Physics. Implicitly the idea was that if the UN General Assembly would agree to pass the resolution with the new title, the status of the event would have been upgraded. Indeed the General Assembly, in June 2004, adopted the resolution as contained in document A/58/L.62 and declared the year 2005 entitled as the "International Year of Physics" in place of the World Year of Physics. The General Assembly also invited the UNESCO to organize activities celebrating the Year, collaborating with physics societies and groups throughout the world, including those in the developing countries. The aims of celebration were announced by the representative of the Kingdom of Lesotho while introducing the text of the resolution, as

i. the aim of the International Year went beyond the mere celebration of one of the greatest minds in physics in the 20th century. The Year would provide an opportunity for the largest possible audiences to acknowledge the progress and importance of this great field of science.
ii. the Year should also be an occasion to begin prospective debates on the great need for scientific research in the 21st century. The debates would also have to relate to social issues which accompanied the practice of science, in general, and of Physics in particular.
iii. The ethical responsibilities for physicists were enormous.
Iv. The Year would allow all practitioners, especially women, to more actively participate in Physics' advancement

The same sentiments were expressed in the final statement to the General Assembly, which was cosponsored by Brazil, France, the Kingdom of Lesotho, Portugal, the U.K., the Principality of Monaco, with the later addition of St. Kits end Nevis and Croatia. The adoption of the above stated resolution by the UNGA provided two sets of definite ideas regarding the event. First, it laid down the scope and purposes of the Year and, second, it elevated the status of the event to the International Year. It is also important to note that the UNGA did not introduce any amendments to the text proposed by the UNESCO, which clearly indicates the importance and reverence the world body attaches to the prospective progress of Physics in the 21st century. Another noteworthy aspect of UN enthusiasm in endorsing the celebrations of the International Year of Physics – 2005 was that it recognized the potential of Physics to have a significant impact on the everyday life of all human beings, particularly pertaining to the socio-economic uplift of the standards of living in the developing countries.

As contained in the adopted UN General Assembly resolution, the UNESCO launched the International Year of Physics-2005 in its Paris Headquarters in the middle of January 2005. The event was then celebrated widely throughout the year, all over the world. It may be realized that the International Year of Physics-2005, although launched by the UNESCO after declaration by the IUAPP, was not to be placed under the confines of one organizational agency, but was to be regarded as a worldwide endeavour. It, eventually, acquired the desired international character and was welcomed by a broad- based world scientific community as one of its main items on the calendar of the year 2005. As reported (www.wyp2005.org/activities.html and updated Oct. 2005), events were to be found on this occasion in 37 small and big countries of Europe, Canada and USA in North America, 16 Latin American and South American nations, 9 African countries, 17 Asian countries, 4 Middle, Orient nations and also in Australia and New Zealand. The same source also lists around 22 worldwide projects, encompassing a whole range of the diversity of activities related to Physics in connection with the celebrations. Such an overwhelming response was expected by the organizers, in order to achieve the objectives of the International Year of Physics-2005. The IYP-2005, indeed brought significant benefits to physicists, scientific organizations, universities and research groups in most parts of the world. It helped in increasing the profiles of those organizations which participated in the celebrations, built relationships amongst the physicists, created new avenues of funding and support, improved the communication-skills of the scientific staff and, most importantly, provided inspiration to the next generation of scientists.

Contributions from Pakistan's Scientific Community

The scientific community of Pakistan, especially the physicists, attached profound importance to the "International Year of Physics – 2005" and participated in the world-event with full interest and enthusiasm. A particular reason for this interest was the realization by the physicists of Pakistan that the problems facing the declining stature of Physics, and their likely solutions, were more or less the same as experienced by the world scientific community at large. Public awareness of the importance of Physics, sensitizing the governments and policy-makers to the role which Physics can play in socio-economic development and attracting the younger generation to enrol more enthusiastically in Physics courses, are some of the common objectives of the world science- community as well as of the Pakistan's scientists. It is important to realize that the aforestated problems are prevalent in many advanced countries also, where the knowledge-management competencies, technical and financial resources are not lacking. It is, therefore, a unique opportunity for all the nations of the world, rich and poor, to obtain benefits of the experiences of each other and try to solve the challenging problems identified for the progress of Physics during the course of the celebrations held so widely all over the world during 2005.

In Pakistan, much interest was shown in this world event by individual scientists, learned scientific societies, universities, colleges and schools, S&T organizations, teachers, students and the media. Simplicity, soberness and quality were the main features of the activities. Large attendance in the events by a wide cross-section of society, notwithstanding the financial constraints prevailing in these organizations, shows the seriousness that the nation attaches to the development of physics in the country. In these activities, particular attention was paid to the focused approach on the objectives set out, right in the beginning of the celebrations, by the international organizing committee and by the sentiments expressed by the world community at the UN platform. Another interesting feature of the celebrations was that a sizeable proportion of young women studying physics participated in the celebration activities.

MAIN EVENTS

In order to plan and implement activities of the International Year of Physics in Pakistan in an effective and meaningful way, a systematic approach was adopted. Prof. Dr. Khalid Rashid of the Quaid-i-Azam University, Islamabad, acted as the Coordinator (www.djz.edu.my/sciencecamp/eng). Right at the start of the worldwide celebrations, the Executive Director of the Commission on Science and Technology for Sustainable Development in the South (COMSATS), Dr. Hameed A. Khan, participated in the launching conference for the IYP-2005 held in UNESCO Head Quarters, Paris, from 13-15 January 2005. About 12 main events, comprising seminars, symposia, Physics Olympiad, etc., were planned during the year (www.wyp 2005.org/globe/asia/pakistan.htmail, updated December 2005). Several prominent physicists and educationists volunteered their valuable help and inputs to make the event a resounding success. All along the progress of the programme, the precious guidance, advice and participation of Dr. Ishfaq Ahmad, Special Advisor to the Prime Minister of Pakistan and a renowned Physicist himself, remained available wherever possible, to the organizers of the celebrations. Among the many scientific organizations, academia, learned societies, etc., particular efforts were made by the Quaid-i-Azam University, Islamabad; Panjab University, Lahore; Government College University, Lahore; Commission on Science and Technology for Sustainable Development in the South (COMSATS), Islamabad; Ghulam Ishaq Khan Institute of Engineering Science and Technology, Topi; Agha Khan University, Karachi; National Engineering and Scientific Commission, Islamabad; Pakistan Atomic Energy Commission, Islamabad and Pakistan Science Foundation. COMSATS offered premises, secretariat and logistical services at its Head Quarters to manage many seminars, symposia and meetings related to the IYP-2005 activities throughout the year. It is noteworthy that several prominent physicists working in various renowned universities abroad also visited Pakistan and participated in the seminars, symposia and discussions arranged to celebrate the occasion.

A short summary of some of the related events is given in the following pages:

a. International Seminar on "Physics in Our Lives"

COMSATS organized this two-day international seminar (Feb. 23-24, 2005) at Islamabad, in collaboration with the Pakistan Atomic Energy Commission and the National Centre for Physics, Quaid-i-Azam University, Islamabad. The purpose of the seminar was to highlight the ongoing efforts of physicists and their future plans for improving the quality of life of the people by application of the science of physics. It also aimed at (i) providing a forum for interchange of ideas between academia, researchers and the industrial sector, with reference to the role of physics in improvement of the society, (ii) facilitating the public awareness of physics, its economic necessity, its cultural contributions and its educational importance, (iii) providing a medium through which participants could get to know their improved career prospects, (iv) strengthening the linkages between researchers of different institutions and industries and fostering future multi-institutional collaboration in the field of basic and applied physics and, finally, (v) generating sound recommendations for addressing problems concerning the role of physics in society through assessment of research-capacity and identification of high-impact areas leading to refocusing of efforts and of new funding.

The seminar was attended by 29 speakers, including 4 foreign experts representing the countries of Switzerland, Syria, Egypt and Sudan. Other participants included eminent physicists, heads of S&T organizations, scholars and students from various academic and research institutions. COMSATS compiled and published 21 presentations of the seminar in the form of a book, entitled "Physics in Our Lives" in July 2005. The book was distributed among the participants, universities, industry, developmental organizations and R&D institutions as a part of COMSATS policy of prompt dissemination of new knowledge, as widely as possible.

b. 30th International Nathiagali Summer College on Physics and Contemporary Needs – Special Session on the IYP-2005

This prestigious internationally renowned Summer College dedicated a full session to the celebrations related to International Year of Physics on 27th June 2005. The International Summer College is annually organized by the Pakistan Atomic Energy Commission, to keep abreast of the latest developments in various branches of Physics and its applications to the contemporary needs. The special session on IYP-2005 was chaired by Dr. Ishfaq Ahmad, Special Advisor to the Prime Minister of Pakistan, who also gave the introductory and concluding remarks.

During the special session, the first lecture was given by Prof. Sreenivasan, Director of Abdus Salam International Centre for Physics (AS-ICTP), Trieste, Italy. Besides paying rich tributes to the Pakistan Nobel Laureate in Physics, Prof. Sreenivasan presented physics-related activities of ICTP, that were of benefit to the scientists of the developing countries. He also pointed out the need of producing good physicists from the developing world who could effectively take part in the ICTP activities.

The next lecture was delivered by Prof. Dr. Ahmad Ali of DESY, Germany which was focused on Einstein's works in the realm of Physics. He also talked about the life of this great scientist.

Prof. Dr. Riazuddin, Director General, National Centre for Physics, Quaid-i-Azam University, Islamabad spoke on the detailed achievements of Physics in the 20th century and the likely future course of its developments in the 21st century. The title of Prof. Riazuddin's talk was "The Century of Creativity".

The last lecture of the session was from Prof. Zubairy from the University of Texas A&M, USA. His lecture was entitled "From Einstein to Bell". He talked, inter alia, about Quantum Mechanics, the EPR paradox and the current status of our understanding related to the foundation of Quantum Mechanics.

The importance of the International Summer College on the subject of Physics can be envisaged by the fact that high level government dignitaries usually participate either in its opening or closing ceremonies. The year too, more so due to the IYP-2005 celebrations, the inaugural session was chaired by the President of Pakistan. He particularly referred to the importance of science and technology for the development of any country. He also pointed out that development of science and technology was necessary to bring economic prosperity in a nation, and alleviates poverty, which is generally the root cause of any social and other problems.

The special session of the Nathiagali Summer College, devoted to the International Year of Physics-2005, proved very useful and effective in achieving the objectives foreseen by the coordinators of the celebrations in Pakistan. The wide range of interest of the audience, comprising high government officials, policy makers, researchers, R&D organizations, industry, educationists and commercial enterprisers, participants in the deliberations on this particular occasion, provided an excellent opportunity to revive the importance of physics in achieving socio-economic betterment in Pakistan,.

c. Conference on Nano-Science and Technology in Pakistan

The Conference on nano-science and technology in Pakistan was organized by COMSATS, in collaboration with the National Commission on Nano-Science and Technology of Pakistan (NCNST) from 13-14 June 2005. Owing to the revolutionary potential of this rapidly emerging science and related technology in the world and its special significance to Pakistan in its socio-economic development, it needed an appropriate occasion to highlight its importance to the researchers, industry, businessmen and policy makers. The IYP-2005 provided this opportunity in a logical and befitting manner. One of the key objectives of the Conference was to find out ways and means to create an extensive data- base of the scientists and institutions involved in the field of nano-science and technology, so that national policy can be focused to strengthen the knowledge available in this promising field and to develop programmes of basic and applied research. The idea was also to attract a maximum number of young physicists to take reading courses in nano-science and technology and develop interest in making a career out of this new field.

With the above background and objectives in mind and with the realization of the widely diverse applications of nano-science and technology, the speakers were invited from academia, industry, business and S&T organizations to deliberate on the relevant issues, such as:

i. Nano-science and technology and their applications;
ii. Identification of areas, interventions and policies by the government to accelerate the development of nano-science and technology;
iii. National projects and initiatives in the field of nano-science and technology by

various national organizations;

iv. Future business, its commercial scope and impact on the economy of Pakistan;
v. Role of various beneficiaries of nano-science and technology, such as manufacturing industry, scientific organizations, as well as academic and research organizations for the promotion of nano-technology;
vi. Means and modes for public-private partnerships and fund-Generation;
vii. Areas of international cooperation and synergies, as well as governments' role as facilitator, etc.

In addition to the objectives of preparing data base, the Conference was designed to trigger debate on the various other aspects of the subject and to prompt some useful suggestions, recommendations and policy guidelines from the participants.

The subject of the Conference attracted enormous interest and response. About 34 papers on a variety of related topics were presented by scientists, engineers, metallurgists, medical professionals, researchers of R&D laboratories, etc. The audience overwhelmingly participated in the lectures, discussions and question & answer sessions. Several useful guidelines and suggestions emerged, as a result of these activities, and provided the basis for the vision, teaching, research direction and mode of interaction of researchers with industry, academia and to the National Commission on Nano-Science and Technology. The Conference also produced useful ideas for the guidance of policy-makers, both in government and private sectors.

This important event, related to new science and industry and also having close links with the basic and applied physics, was again an appropriate effort by Pakistan's scientific community to make good use of the opportunity provided by the IYP-2005. It is highly desirable that the existing base of nano-science and technology in Pakistan be expanded considerably, in order to make Pakistan an efficient competitor of the advanced countries of the world.

d. International Seminar on Physics in Developing Countries: Past, Present and Future

This international event was organized jointly by COMSATS and the Islamic Educational Scientific and Cultural Organization (ISESCO) in Islamabad from 27-28 July, 2005. The objectives of this seminar were linked to those of the celebrations of the IYP-2005. A particular aspect was the relevance of physics to the sustainable economic development in the developing countries. The main issues to be addressed during the seminar were:

i. The evolution of physics as the basis of all sciences, stressing the key development stages throughout history, as well as the present scenario.
ii. The methodology for enhancing awareness of the potentials of physics for improving the lives of the people, particularly those of the developing world.
iii. The need for greater interaction between physics and other sciences in the solution

of environmental and industrial problems, in view of the interdisciplinary nature of economic growth.

iv. The development of necessary infrastructure and institutions to support physics, as well as the means of carrying out satisfactory experimental physics in relatively simpler laboratories, through suitably thought-out programmes.

v. The importance of international cooperation in physics and requisite modalities of instituting and promoting South-South and South-North cooperation

vi. The framework for slopping the brain drain of scientific talent, and assessing the suitability of sandwich fellowships.

vii. Ways to enhance capacities of the current cadre of physicists in developing countries.

viii. Methodology to promote and support initiatives that show how physics can help the economy.

Participants from foreign and Pakistani universities, S&T institutions, etc., delivered informative lectures, which were highly appreciated by the audience comprising academia, industry, researchers, media, students at graduate and postgraduate levels and technical people working in various R&D organizations. It was realized that awareness of physics, planning, implementation and ethics are key-components for drawing effective benefits from the potentials offered by physics. Underdeveloped societies are not, so far, well equipped with the necessary management tools to acquire the true benefits from the potentials of physics.

Some of the most important and interesting lectures (18 papers) covered a wide spectrum of issues facing the developing countries where the strengthening of physics can play a useful role, a point which was high on the agenda of the IYP-2005 celebrations. Speakers from Sri Lanka, Saudi Arabia, Egypt, Sudan, Tajikistan and Pakistan covered topics, such as the experience of physics in the societies, physics-based industrial linkages, environmental and economic applications, renewable-energy technologies, laser applications, sustainable development, education in physics, low-energy particle-accelerators, space physics, etc. One of the most interesting presentations which was directly aimed at encouraging young students to take up physics as their career, was given by the Rector of GIKI, Topi. The efforts by Pakistani physicists to promote this objective under the STEM Project (Science, Technology, Engineering and Mathematics) with the assistance of Higher Education Commission of Pakistan and utilizing Physics Olympiad mechanism, received particular attention and appreciation of the audience. COMSATS is disseminating the knowledge emerging out of this successful seminar, through the publication and its distribution based on the seminar's proceedings.

e. Conference on Role of Physics in Biology and Medicine

An important Conference in connection with the IYP-2005 was organized by Agha Khan University, Karachi in September 2005. The main objective of the Conference was to highlight the important applications of physics in medicals sciences and how this crucial inter-relationship has helped the humanity in the diagnosis and treatment of various ailments.

In his keynote address conveyed to the Conference, Dr. Ishfaq Ahmad, Special Advisor to the Prime Minister of Pakistan and a noted physicist, intimated that physical sciences form the bedrock on which other scientific disciplines are built. This relationship has recently been well recognized in the establishment of the field of biophysics. He said that there was a long and rich history of applying physical principles and the development of many types of technology for both diagnosis of disease and injury and for a variety of therapeutic purposes. He also mentioned the importance of scientific work done by Einstein a century ago in the realm of physics which has helped the mankind in understanding the hitherto several unexplained natural phenomenon.

Some interesting and important links between physics and techniques applied in medicine were indicated by the President of Agha Khan University, Mr. S.K. Lakha in his inaugural address. He said that the Conference brings together fellow academics as well as anyone interested in science and its role in the society to celebrate the IYP-2005. He was of the view that if, as a result of the Conference, some of the related quarters develop an interest in the role of physics in biology and health sciences, and try to develop ideas about interdisciplinary approaches, it would then be a success of the Conference.

According to the Conference programme in the pre-Conference workshops, around 12 specialists and experts read papers on a range of topics covering applications of physics in medical sciences, radiology and nuclear medicine, anesthesiology, cardiology, lasers, MRI, ultrasound, x-rays techniques etc.

The knowledge value addition to the Conference proceedings was ensured by the panel discussions and question-answer sessions. The Conference, thus, proved to be a befitting tribute to Einstein and served as an excellent occasion to provide scientific and intellectual inputs to the celebrations of the IYP-2005.

f. Popular Lecture on "Einstein - the Genius of the Century"

A specific gathering of scientists, researchers, university and college teachers, physicists from various R&D institutions and school and college students was arranged by the Pakistan Science Foundation in Islamabad on the World Year of Physics-2005 on 29th December 2005. The lecture was delivered by Prof. Dr. Khalid Rashid of the Quaid-e-Azam University, Islamabad, who is also a Member of the International Steering Committee set up for the World-Year of Physics-2005. Pakistan Science Foundation hosted this event in its premises. The Chairman, Pakistan Science Foundation, Dr. N.M. Butt informed the audience that this lecture was specifically designed to address the young students from schools and colleges. He also said that several activities related to the IYP-2005 were being arranged by the Quaid-i-

Azam University and the Government College University, Lahore.

A very encouraging and innovative aspect of the lecture was that, in addition to the main speaker, boys and girls from various local schools and colleges gave short speeches on the life and achievements of Einstein. These speeches were of high quality and contained some very interesting material regarding Einstein and the IYP-2005 celebrations. It was evident from the participation of younger generation of physics-loving students and from the question-answer session that a great potential does indeed exist in the student community to take serious interest in physics and to make this science as their career, both in teaching and in research. In this respect, the efforts of Pakistan Science Foundation and the organizers of the lecture certainly achieved the objective of arousing popular interest in physics and converge the students' potentialities towards adopting physics as their career.

Another outstanding achievement of the event was that the free exchange of ideas and experience among the participants during the question-answer session pointed to the recommendation that it was necessary to enhance the capacity of the scientific institutions in the country. As a part of the celebrations of the IYP-2005, the Pakistan Science Foundation prepared a small brochure containing the brief life- history of Einstein, his most important scientific works, awards and degrees, his quotes and some indication of his non-scientific work. This idea was well received by the scientists and appreciated as a quick source of information on Einstein and the twentieth century physics.

BENEFITS AND IMPACT ON THE SCIENTIFIC COMMUNITY OF PAKISTAN

The idea of celebrating the International Year of Physics – 2005 was widely welcomed by the scientists of Pakistan, in general, and the physics community in particular. The large number of activities undertaken in Pakistan, to make the objectives of the IYP-2005 a success, clearly speak of the interest and importance attached to this event by the physicists of Pakistan. The large participation by a wide spectrum of the scientists, educationists, students, industrial entrepreneurs, researchers, learned societies, media, etc., has generated awareness and revived interest in physics and its potentials to make mankinds' life more comfortable and humane.

As indicated in earlier sections of this text, the idea of IYP-2005 was that it should not remain confined to mere celebrations, but should go much beyond that. It should enable the people to take a good look at the status of physics as it exists today, and take practical steps to improve its health in order to render it much more serviceable to humanity than it is capable of doing it in the present age. It should also sensitize policy- makers and government functionaries to understand the contributions that physics can make to the socio-economic uplift of the society and to involve more physicists in the processes of policy and decision-making. Many other related aspects were recognized by the organizers of the event, as have been mentioned in the earlier part of this write-up.

The main benefits and impact that the celebration of IYP-2005 have brought to the scientific community of Pakistan are briefly mentioned below:

i. It has provided an opportunity to acquire renewed awareness of the current status of physics in Pakistan and to set out a better understanding of the future trend of its progress, in relation to its international evolution.
ii. It has been realized that physics is not entirely a disabled science in Pakistan, but has the potential to evolve to world- standards if appropriate vision is in place and implementable policy-decisions are taken at the higher level.
iii. A close watch by Pakistan's scientific community at the world events that have taken place in connection with the IYP-2005, has helped in enriching scientists' knowledge of the latest trends in physics and its spin-offs so as to make physics a beneficial science for the interests of Pakistan.
iv. The teaching of physics and mathematics at secondary, higher secondary and undergraduate levels in Pakistan needs prudent changes. Activity-based teaching that engages students in the learning process and not the old "chalk and talk" methods are to be employed if the quality of physics has to be raised in Pakistan.
v. The scarcity of able physicists and mathematicians is not only the problem of the underdeveloped countries, but is now increasingly being seen in the advanced countries also. It would be beneficial for the world scientific community, as a whole, to engage in joint collaborative efforts of improving teaching, experimenting and researching, so that an international high standard of learning and practicing physics is achieved. International hubs of centres of excellence, with liberal intake policies from the developing countries, would be desirable to create a critical mass of physicists and mathematicians both at national as well as the world level.
vi. Government and private organizations responsible for teaching and research in physics are currently not providing adequate incentives to the students to take up physics careers. Basic physics and research is under tremendous stress, as a large majority of good physicists abandon basic research and move on to work for industrial enterprises. This is causing continuous brain-drain at the intra and inter-country levels. Reversing such trends would create useful impacts on the welfare of the scientific community, as well as on society as a whole.
vii. In the developing countries, there is an acute shortage of women-physicists, both in teaching and in research. More enrolment of female students in the educational institutions, with career incentives, is needed at the policy level. Gender disparity in physics leads to negative impact on the science-based economy of any society.
viii. The physics curricula should include topics such as ethics of practicing science and code of conduct for the scientists and researches. Appropriate attention should also be given to the practice of safety-standards while undertaking the laboratory work by the scientists and researchers. The good safety culture in laboratories of the universities leads to safety against industrial accidents and limits the production of hazardous industrial wastes. Such practices will create a positive impact on the environment, which is becoming an increasing concern of the modern industrial age.

ix. A major impact of the celebrations of IYP-2005 on Pakistan's physics community has been that more scientific contacts have been established amongst the physicists within the country and abroad. As a result, more avenues of communications have opened up for the exchange of ideas and experience on innovative techniques, which have surfaced as a consequence of IYP-2005 events throughout the world.

x. One of the outstanding benefits of the IYP-2005 has been that the world has been enlightened afresh about the role that physics can play in the sustainable socio-economic development of the emerging economies. Pakistan can fine tune its scientific approach to address its priority economic needs by appropriately focusing upon the potentials of physics, in the light of new experiences, information and strategies available as a result of the scientific activities carried out in connection with the IYP-2005.

CONCLUSIONS

The worldwide celebrations of the IYP-2005 have provided enough inputs to the physics community to take up the follow-up actions needed to fulfil the objectives of the IYP-2005. A relevant and befitting event concerning this aspect was the World Conference on Physics and Sustainable Development held in Durban, South Africa from 31 October – 2 November, 2005. It was jointly organized by UNESCO, the Abdus Salam International Centre for Theoretical Physics (ICTP), the International Union of Pure and Applied Physics (IUPAP) and the South African Institute of Physics (SAIP). Around 350 people from around the world participated in this Conference, including representatives of physics organizations and the private sector.

The Conference was a unique opportunity for the international physics community to join efforts and come up with a plan for tackling some of the large problems facing the world. The contributions made by physics in the past to the welfare of society are numerous. These contributions are ongoing, but the larger benefits are going to the developed rather than the developing nations. This Conference gave the physicists of the world a chance to begin to focus on how they could collectively work to bring more benefits of physics to the less developed world.

The most important feature of the Conference having direct relevance to the goals and objectives of the IYP-2005 was the emergence of a Resolution which provided a basis for commitment of the world physics community on specific issues identified during the Conference deliberations and an action plan proposed in the form of well defined projects to achieve the goals agreed in the Conference. The main themes which could have a direct impact on the society at large and which also structured the main body of the Conference resolution and drew the attention of the participants were (a) Physics Education (b) Physics and Economic Development (c) Energy and Environment and (d) Physics and Health.

The Conference not only addressed the issues formulating the major objectives of the

IYP-2005 but also renewed interest in the work done in earlier conferences (UNESCO-ICSU World Conference on Science, June 1999 and the UN World Summit on Sustainable Development, Johannesburg 2002). It also identified areas where physics can play an important role in socio-economic development in the world. It is expected that the action plan of the Conference will be collectively implemented by the various organizations of physicists, including national physical societies, etc.

The outcomes of the IYP-2005 and the World Conference on Physics and Sustainable Development provide ample substance to the physicists of Pakistan to strengthen the foundations of physics in the country, to take proactive approach to establish scientific collaboration with the world's renowned physicists and the physics laboratories and to strengthen ties between physics and the society. The IYP-2005 has shown that the enviable progress made in the field of physics in the advanced nation during the last century was only possible due to sustained support of the governments and the industry. Pakistan cannot be an exception to this universal rule. The IYP-2005 seeks to send this thought provoking signal to the Pakistan's society at this right moment which needs to be acknowledged with seriousness and care.

The formal closing event of IYP-2005 was held in the European Centre of Nuclear Research (CERN) on 1st December 2005. The function was in the form of a continuous webcast from 12.00 to 24.00 hrs. The title of the event was "Beyond Einstein". Further information or details of the programme are available on the website public.web.cern.ch

RECOMMENDATIONS

Lessons learnt as a result of the IYP-2005 celebrations lead to some recommendations, which may prove useful for the progress of physics in Pakistan. A few are given below:

i. The various IYP-2005 related scientific events held in the world have generated useful knowledge and experience. Information relevant to Pakistan may be extracted from the body of this knowledge and experience by a panel of eminent physicists of Pakistan and appropriately utilized in the teaching of physics and in basic research. This activity could be undertaken with the participation of Pakistan Science Foundation and Pakistan Physical Society, either jointly or separately.
ii. Coordinated Research Projects (CRP's) may be established between the physics organizations of Pakistan and the relevant world renowned counterparts on the themes identified in the World Conference on Physics and Sustainable Development held in Durban, South Africa (31 Oct. – 2 Nov. 2005). The HEC of Pakistan can play an important role in this regard.
iii. Physics organizations and the Government of Pakistan may be urged to launch campaigns to popularize physics among the masses. Print and electronic media, mobile exhibitions, specific scholarships at school, college and university level to read physics and mathematics, physics essay competitions at grass root level and

establishing a world-class physics museum in Pakistan will help create awareness and interest in physics at general public level.

iv. Nobel Laureates in Physics may be invited to Pakistan as State Guests for short periods of time (one week) to deliver popular lectures to secondary school, college and university students all over Pakistan. Wider networking of such lectures could be organized through tele-conferences and through popular TV channels. Radio talks in the local languages originating from these lectures could also be broadcast all over the country, through well designed programmes.

v. There is a strong need to raise the quality of physics teaching and research in the country. The IYP-2005 has come up with new and innovative ideas to achieve quality education and research. Experiences of Physics Education Research (PER) groups of the USA and of UNESCO, through the efforts of the Asian Physics Education Network (ASPEN) for active learning methods, rather than the passive learning methods in physics may be given due attention. Relevant projects in Pakistan at test-level could be fruitful.

vi. A Standing Advisory Committee of renowned physicists, educationists and researchers may be established on all Pakistan basis to keep a continuous watch on the status of physics in the country and publish reports, at regular intervals, on the assessment and evaluation of the progress being achieved to improve the quality of physics teaching and basic research, both in the private and public sector organizations. The proposed Advisory Committee should have an independent status and may send its findings and recommendations to the Government of Pakistan through Pakistan Science Foundation and through Pakistan Academy of Sciences.

vii. A special fund may be created to undertake projects on new techniques of teaching-physics and to create bastions of original, creative and imaginative basic research in selected universities and other research organizations. These projects should not be assessed on the number of publications, but merely on the quality of knowledge created by the researchers. Emphasis should be on knowledge-creation and not on information-generation. This aspect could be one of many others, to change the culture of physics research in the country.

By no means should one assume that the above-stated recommendations are the only ones to improve the status of physics in Pakistan. Several other ideas may prove to be more useful and appropriate. These ideas will have a possibility to be tried and tested by various competent fora of physics in Pakistan and may also have positive complementary impacts to achieve the much desired purpose of taking physics to a much higher status than it enjoys today in the country. The IYP-2005 has, indeed, provided the opportunity to all of us to come up with such new ideas and to devise ways and means to implement them for the assured results. No doubt, the physics community of Pakistan has the resolve and competence to follow up the outcomes of the IYP-2005 and to transmit its benefits to the society in Pakistan's best national interests.

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50+5 YEARS OF PHYSICS IN PAKISTAN, A PERSONAL PERSPECTIVE

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ABSTRACT

Fifty five years of Physics in Pakistan have been analyzed from a personal perspective. Successes and failures, together with their causes, are also discussed. The current trends in development of Physics are also mentioned.

EARLY PERIOD 1947-1959

Before independence, the institute of Chemistry at the Punjab University was well established under the leadership of Dr. Shanti Saroop Bhatnaggar. At the time of partition of India, many good chemists remained in the newly formed Pakistan, but Physics was left almost at zero when most of the top physicists left for India. At the Punjab University, only Dr. Abdul Majid Mian was left. Later, in the early 50's Drs. R. M. Chaudhri and M. Ishaq migrated to Lahore from India. Dr. R. M. Chaudhary joined the Government College Lahore and, dedicatedly, established experimental physics facility there. A little later, Dr. Mujtaba Karim established a Physics Department at Karachi University, A. B. Pal joined Punjab University, and in 1956 Dr. M. Aslam Khan established an Atomic Spectroscopy Laboratory at Karachi University.

Dr. M. M. Qurashi (who attained his Ph.D in 1949 from the Govt. College Lahore) joined PCSIR, while Dr. M. Sultan and M. Afaf after joining Government College, Lahore left, for jobs, elsewhere Dr. Tahir Hussain who joined GC, was mainly engaged in teaching.

Except for Dr. Mian, all the others were experimentalists. Prof. Abdus Salam came back for a short period (1951-53) and joined Government College Lahore as Professor of Mathematics and simultaneously became chairman of Math department at the Punjab University. The first slide represents the flavour of publications for the early period (1950-1959) as appeared in the Physical Review (nothing seems to appear before that, at least in the Physical Review).

All the data I am going to present is from the American Physical Society (APS) journals (mostly Physics Review and Physical Review Letter) for the following reasons.

- This is the only source available to me.
- APS journals have one of the highest refereeing standards.

- They have high Impact Factor as they are widely read.

One may say that this is biased, may be so. But the conclusions which I will draw at the end, will be quite general. I divide the 50+5 years by decades, except the first decade 1960-1969 which I subdivided into two: 1960-1966 and 1967-1969 for the reason that the Physics researched shifted from Lahore to Islamabad after 1966.

1960-1966

Some positive developments took place: Dr. I. H. Usmani became chairman of Pakistan Atomic Energy Commission (PAEC) and together with Prof. A. Salam as a part time member of PAEC (later he became Chief Scientific Advisor to the President of Pakistan), revitalized the commission with the following results:

Results of Physical Review Search

[Back to Search form]

Expand/Refine Search:

AND | Abstract/Title: | MATCHES |

Refine Search

Showing results 1 through 5 (of 5 total) for pakistan

- 1. **Energy Levels in Fluorine-19 Nucleus**
  A. Hossain and A. N. Kamal
  Phys. Rev. **108**, 390-392 (1957) [View Page Images or PDF (420 kB) [Order Document]]

- 2. **Emission of Electromagnetic Radiation by the Impact of Positive Ions of Hydrogen on Metal Surfaces**
  R. M. Chaudhri, M. Y. Khan, and A. L. Taseer
  Phys. Rev. **104**, 1492-1493 (1956) [View Page Images or PDF (444 kB) [Order Document]]

- 3. **Nuclear Energy Levels of Be^8 from $Li^7(d, n)Be^8$**
  M. A. Ihsan
  Phys. Rev. **98**, 689-690 (1955) [View Page Images or PDF (353 kB) [Order Document]]

- 4. **Renormalization**
  P. T. Matthews and A. Salam
  Phys. Rev. **94**, 185-191 (1954) [View Page Images or PDF (1198 kB) [Order Document]]

- 5. **Fredholm Theory of Scattering in a Given Time-Dependent Field**
  A. Salam and P. T. Matthews
  Phys. Rev. **90**, 690-695 (1953) [View Page Images or PDF (949 kB) [Order Document]]

- A massive training program was started by PAEC
- The status of Scientists was raised.
- Atomic Energy Centre was established by PAEC at Lahore.

- This was joined by many Physicists who returned after their Ph. D. Anwar Hussain, Abdul Ghani, Ishfaq Ahmed, M. A. Shaukat established the emulsion group in Particle Physics, but this was not sustained.
- Naeem Ahmed Khan and Sabtain Bokhari were interested in low-energy nuclear physics and Saeed Durrani joined for short period, but then left PAEC.
- Theoretical Physicists working at Lahore Centre were:
  Riazuddin, F. B. Malik, Raza Tahir kheli and Fayyazuddin.
- Professor M. J. Moravscik visited the Lahore centre during 1962-1963 under International Atomic Energy Agency (IAEA) and describing his stay was a morale booster for the group.

1967-1969

The scene shifted from Lahore to Islamabad. The institute of Physics was established at the University of Islamabad. The pioneers were Riazuddin, Fayyazuddin, Faheem Hussain, A. Q. Sarkar, Haroon-ur-Rashid, M. A. Rashid, Arif-uz-Zaman, Saifuddin, Gulam Murtaza, S.K. Razmi, Kamaluddin Ahmed. They formed the Theoretical Physics group. Others physicists were Masud Hussan, and M. Ijaz. The latter established teaching Laboratories and introduced the Fortran Programming for the first time in the University. For the first time in the history of Pakistan, a regular postgraduate program in Physics was started. Later, the Institute of Physics diversified to Condensed Matter Physics, with A. H. Nayyer, M. Zafar Iqbal and Hamdani as pioneers. Below I give the Publication Analysis.

Perhaps a better indicator of research is number of publication per author or ever better per scientist. These are given below;

The following comments on the above graph are in order:

- Peak is in the period 1967-1969, followed by a slightly lower peak in the decade 1970-1979.
- Sharp fall after 1979: Some pioneers left, very few new young persons joined.
- Slight rise between 1980-1989 and 1990-1999 as Pervez Hoodbhoy and Suhail Zubairy joined. Again, one sees a slight decline as Pervez Hoodbhoy's interests became wider and Zubairy left.

REASONS FOR SUCCESS

1. Patronage at Highest Level
President M. Ayub Khan became personally interested in the development of the University of Islamabad;

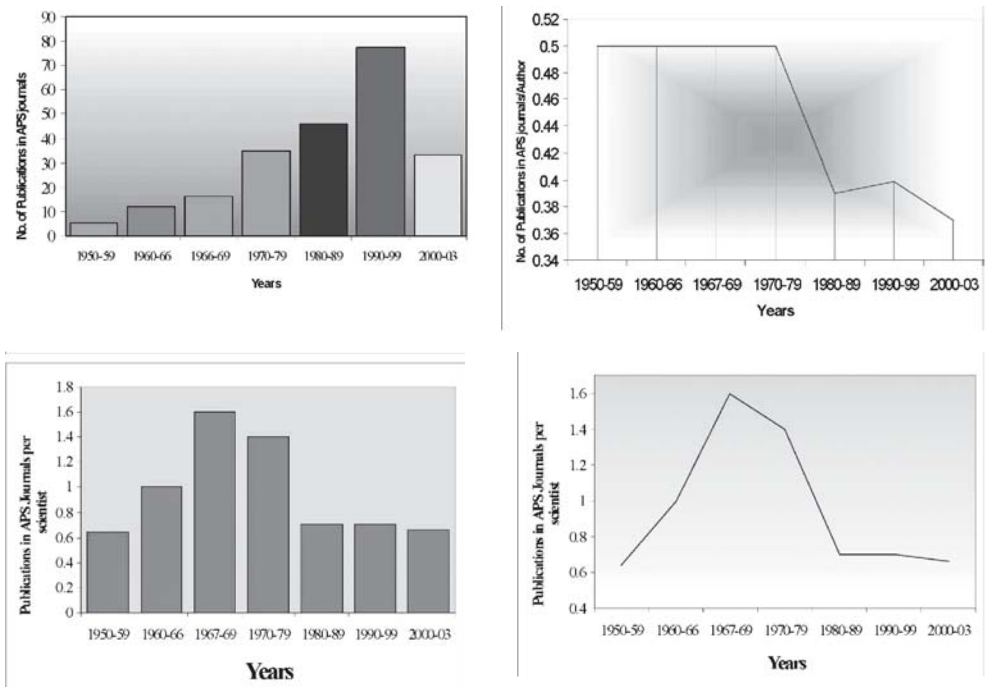

Figure - 1: Number of Publications

2. Appointment of a Competent Vice-Chancellor

Dr. M. Raziuddin Siddiqui, an eminent educationist who himself went through the process of Higher Education, educated at Cambridge and Leipzig where he rubbed shoulders with the topmost physicists and mathematicians of that era, was appointed the first Vice-Chancellor.

3. A New Concept of Structuring the University

This was done in the form of institutes, rather than departments. Each institute was headed by a Director who was also the Dean of the faculty, enjoying considerable autonomy, particularly in the academic appointments;

4. Critical Size

Young faculty were attracted by offering them positions at a level higher than what they would normally get in any other university and assuring them that they would not be isolated. Thus, young people in their late twenties or early thirties were appointed at associate-professor level. Efforts were also made to collect a critical number of trained scientists at place. Once a critical number is reached, a chain-reaction starts and the group becomes self-sustaining. Otherwise, it is simply withers and dies away.

5. Mobility and International Contacts
To ensure greater mobility of faculty and to provide them with international contacts, the following steps were taken:

I. Liberal sabbatical leave rules, which would enable the members of a faculty to get a sabbatical leave after every three years of service.
II. International support and its effective utilization in the following forms:
   a) The Ford Foundation grant (which the V. C. could somehow succeed to obtain) used for short-term international contacts. This enabled us to invite distinguished visitors from abroad for visits, lasting one to three months, where research was going on in the fields at the Institute. Also, under this grant, funds were available for the members of the Institute to attend International Conferences.
   b) The support of the International Centre for Theoretical Physics at Trieste, Italy, for visits of the faculty to that centre during the summer vacation. The UNDP grant, which was mainly used for the development of experimental facilities and for long term visitors relevant to the fields to be developed.

6. Idealism of the Youth
It was the idealism of the youth that not only enabled many of us, (who could have stayed abroad), to return, but also infused a great enthusiasm to succeed in the pioneering role of establishing a new institution from scratch;

7. Quality assurance
To maintain quality, the concept of contractual service was introduced for the first time in Pakistan, in the sense that the work of a faculty member would be evaluated after 3 years before giving him tenure. The results were spectacular; within 4 years, the Institute of Physics was on the international map. For the first time in the history of Pakistan, a postgraduate-program leading to Ph.D. degree in Physics was started on a regular basis. The Ph. D's produced were of international standard.

SUBSEQUENT TRENDS

Development of science and technology requires more than material infrastructure. It is the development of manpower at different levels that fosters it. In Pakistan, adequate attention has not been given to this aspect of development of science. Professor Moravcsik who visited Pakistan several times, wrote in his letter to the president of Pakistan, after his last visit in 1987:

> *"In surveying Pakistani scientific manpower, one is struck by its being overwhelmed by older people. In 1962, when I first come in contact with Pakistani science, there was a large group of bright young men in the sciences, many still in the progress of being educated at an advanced level, but most already showing talent and achievement. Many of them*

> *contributed to science significantly in the following years. Members of that generation today are in their mid-forties or mid-fifties, some still productive, but the group, on the whole, is declining in its contribution to research, perhaps because of administrative preoccupations, or perhaps just out of general tiredness."*

This is well illustrated in the next two slides.

(The above chart indicates the Physics as measured by Journal Cumulative Impact Factor)

STATUS AND FUTURE TRENDS

Below I give a summary and trends in question and answer form Questions were asked by Edwin Cartlidge, News Editor, Physics World in the Connection with an article on November 30, 1999 he was writing for "Millennium" (Dec.) issue of Physics World on Physics in the developing world:

Q.1: The major areas of research in Pakistan?
They are Condensed Matter Physics (Semi-Conductors, High Temperature Super-Conductivity, Magnetic Materials and Simulation); Lasers and Atomic Spectroscopy; Quantum Optics; Plasma Physics; Nuclear and Reactor Physics; High Energy Physics (Mainly Theoretical).

Q.2: Major Research Facility that presently exist [A list of Largest facilities such as neutron or synchrotron sources]
10 MW swimming pool Reactor at PINSTECH: Used mainly for neutron diffraction studies, reactor physics, radiography, isotope production and neutron activation analysis. In addition as is international norms, the National Centre for Physics pursues a small number of activities in the experimental high energy physics through a cooperation agreement (already signed) with CERN in Geneva. This work is centered around CERN's CMS (Compact Muon Solenoid) detector at Large Hadron Collider (LHC).

Q.3: Has there recently been any physics research carried out in Pakistan/by Pakistanis that have made major breakthroughs?
Really major breakthroughs are rare even in developed world. I can mention two highly cited works: One is known as Kawarahayashi-Suzuki-Riazuddin-Fayyazuddin (KSRF) relation in the literature on particle physics. Kawarahayshi and M. Suzuki, Phys. Rev. Letters 16, 255 (1966) and independently by Riazuddin and Fayyazuddin, Phys. Rev 147, 1071 (1966): (No. of Citations 579). The other paper is on squeezed states in Quantum Optics by P. Meeystre and M. S. Zubairy, Phys. Letters 89A, 390 (1982). This paper has 210 Citations.

One may also mention influential books co-authored or authored by Pakistanis i):

Theory of Weak Interactions in Particle Physics, R.E. Marshak, Riazuddin and C. P. Ryan, Wiley-Inter science (1969), which is regarded as a classic and has more than 582 Citations. ii): A Modern Introduction to Particle Physics, Fayyazuddin and Riazuddin. World Scientific, (1983) (2nd Edition October 2000). This is adopted as a text book in prestigious universities, like Universities of California, Santa Barbara and Irvine. Got very good reviews in Physics Today, Jan. 1994, and in Contemporary Physics, 2002, Vol. 43, 12. iii): Quantum Optics, M. O. Scully and M. S. Zubairy, Cambridge University Press (1997). Got very good review in American Journal of Physics 67, 7th July, 1999 and Physics Today, Oct. 1998.

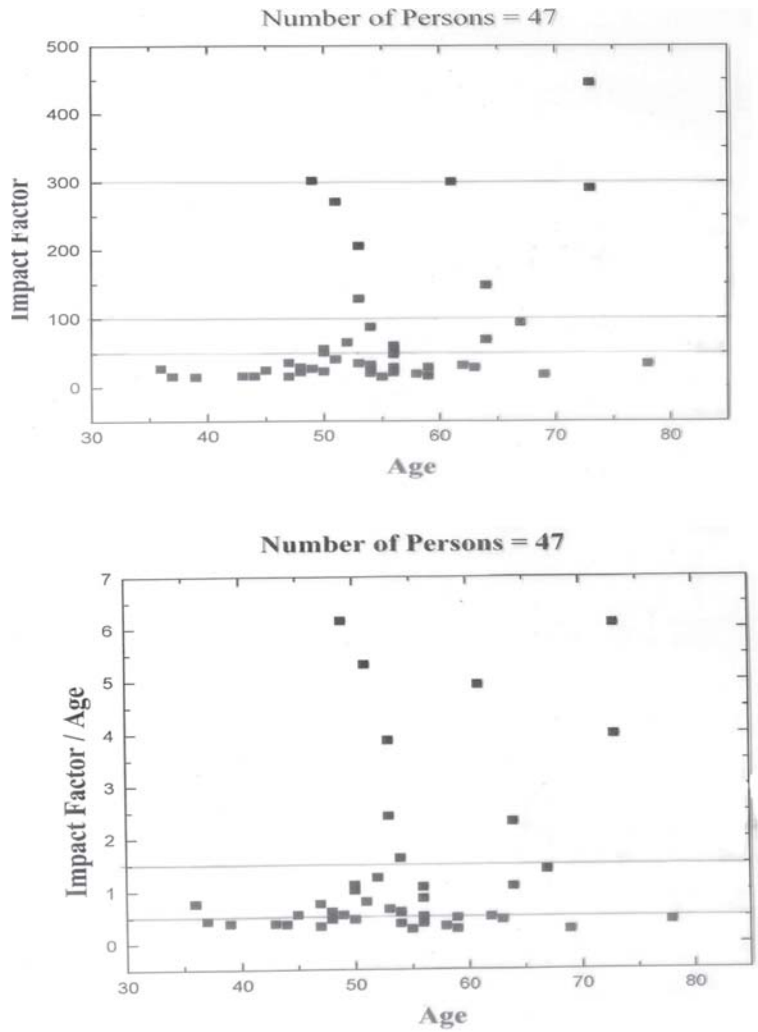

Figure - 3: Moreoverthe physics is concentrated in fewcentersas the next fewslides illustrate (Source PCST book 2000)

Institutions	Scientists	Cumulative Impact Factor
Pakistan Atomic Energy Commission	19	971.996
National Centre for Physics	02	736.693
Quaid-i-Azam University ? Department of Physics ? Department of Electronics	14 04	715.479 297.308
Commission on Science and Technology in South	01	300.244
University of the Punjab ? Centre of Excellence in Solid State Physics ? Centre of Excellence in High Energy Physics ? Department of Space Science	05 03 04	80.967 48.036 2.759

Institutions	Scientists	Cumulative Impact Factor
GC University ? Department of Physics ? Salam Chair in Physics	01 01	32.144 147.900
University of Karachi ? Department of Physics ? Department of Applied Physics	10 05	91.147 6.011
Bahauddin Zakriya U niversity ? Department of Physics	07	50.622
National Institute of Silicon Technology	21	36.155
University of Peshawar ? Department of Physics	04	28.080
University of Balochistan ? Department of Physics	02	27.421

Institutions	Scientists	Cumulative Impact Factor
Gomal University ? Department of Physics	13	23.861
NED University of Engineering and Technology ? Department of Physics	01	15.123
University of Sindh ? Department of Physics	04	11.457
Institute of Optronics	03	9.199
Allama Iqbal Open University ? Department of Physics	04	8.894
National University of Science and Technology ? Department of Physics	01	2.095
Shah Abdul Latif University ? Department of Physics	01	2.064
Islamia University (Department of Physics)	01	0.627

Q.4: The areas of Physics on which Pakistan will concentrate in future.

Computational Physics, Lasers and Laser Spectroscopy, High Energy Physics (in Collaboration with CERN, Geneva). I may now add Nanophysics. Applied work around 5MeV Tandem Van-de-graff accelerator being established at NCP. Synchrotron Radiations particularly building a soft X-ray beam line for SEASME, a synchrotron radiation source being developed in Jordan, of which Pakistan is a founding member. This source will also be used by Pakistani scientists for research in Physics, Chemistry, material sciences and structural biology.

Q.5: What should be the Principal aim of science in the developing world?

The principal aim of science in the developing world is to achieve excellence in certain areas of science. Obviously we cannot compete with the fundamental science of the developed World, but we can take part in it through collaborative arrangements with big centers of Physics in the West, like CERN in Geneva, Abdus Salam ICTP at Trieste. The science-technology chain is becoming shorter and shorter, with the result that a scientific discovery becomes utilized faster in technology than it used to be. Thus it is essential that the developing world should at least be aware of what is happening at the Frontiers of Science. This they can do only if at least some percentage of scientists take part in it, through research, so as to further our scientific insights and to build new technological applications on them and above all to produce new generations of researchers.

One should also not forget that the training which a physicist gets is superb, particularly to analyze a problem so as to take care of all the important factors in that problem and attach to each its due weight. This training is useful when a physicist is called upon to work, either in an industrial or technological enterprise or some other projects of national importance. Anyway, economic development and the role of scientists in this development is a somewhat complex problem.

Q. 6: Should the developed world do more to support science in the developing world?

Yes, the developed world should do more to support science in the developing world. As Prof. Salam has said “Scientific Knowledge is a shared heritage of all Mankind; East and West, South and North has all equally participated in its creation in the past, and, we hope, they will in future. This joint endeavor in science is one of unifying forces among the diverse people in this globe”. I may mention that CERN in Geneva is setting a good example in this respect, as I pointed our earlier. To conclude; we have seen that Physics in Pakistan is concentrated at a few places and suffers from the problem of aging. Nevertheless one may mention the following

Achievements:

¾ One Nobel Laureate, Abdus Salam

¾ Some physicists who have made some international impact, exemplified by their citations

¾ Produced good students who have done well abroad and in the country

¾ At least one famous paper with Citations more than 500

¾ One famous book: A classic with Citations more than 582; two other books, which have very good reviews internationally.

¾Played major role in National Security.

Main deficiencies

¾ Sustainability not achieved

¾ Age factor: lack of continuous addition of bright young people

¾ Compromise on quality

¾ Still Physicists are in small number

Let me end by quoting Robert J. Oppenheimer, "We have all of us, to preserve our competence in our profession, to preserve what we know intimately, to preserve our mastery. This is, in fact, our only anchor in honesty". At least physicists of my generation followed to some extent what Oppenheimer said.

PHYSICS PROGRAMS: AN OVERVIEW OF EMERGING TRENDS

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ABSTRACT

Although Physics is one of the most fundamental of all the sciences, yet it is considered as a dry and difficult subject by many of our young prospective students. Rousing interest and motivation can refute this myth. The soft image of physics can be built up if we could make people realize that its study imparts skills and habits that may be helpful in solving multifaseous problems related to science, industry, management and technology. This role can be successfully met through offering physics-programs / courses in a variety of ways. This is what is being adopted by top-class institutions all over the world.

INTRODUCTION

Physics is the science that describes how the physical world works. It is perhaps the most fundamental of all the sciences. It is an exciting and wide-ranging discipline, which occupies the central position amongst the natural sciences, engineering and technology. Physics is at the basis of nature and is involved in everything around us. The work of physicists has a massive impact on the quality of life, through the design, evaluation and manufacture of a multitude of essential goods and processes, industrial and household materials, medical technologies, laser processing, sensors, and advanced materials with specific properties for modern technology. Rapid advances in high-technology areas, such as laser-systems engineering, telecommunications, optoelectronics or medical applications, demonstrate the unique importance of Physics for our lives and the imagination of Physicists.

It is expected that, in this century, the quality of life will continue to improve through the innovative work of Physicists. Accordingly, there will be strong demand for skilled Physicists of all specialties, to be involved in developing better communication systems, improved materials, alternate energy-sources, and in ensuring a cleaner environment.

Physics is important, not only as a subject in its own right, but also as an essential element in all other natural sciences, engineering and technology. Physics is at the heart of almost every facet of modern life and, as such, physics education is a preparation for a lifetime because its study instructs a person in the art of critical and incisive thinking, how to pose questions and how to solve problems. In addition to that, there is also a great deal of enjoyment and satisfaction to be derived from an understanding of the most recent developments in Physics.

CAREERS IN PHYSICS

Young persons trained in physics acquire a set of skills that makes them valued employees in many settings. They have always been in great demand, and that demand increases further as technology comes to play an increasing role in society. Physics is so central in the cluster of scientific subjects that physicists are readily employed to shoulder a variety of responsibilities. Many physicists work in research laboratories, in industry, in universities, and in national laboratories. Some join teaching-careers in high schools, colleges, and universities, helping to inspire and shape the next generation of scientists and to nurture an appreciation of science and its importance to society. Others can be found in hospitals, the military, oil fields, power plants, in the astronaut corps, in museums, in patent-law firms, and in management positions in business and government.

A large number of physics graduates continue in basic research. This type of work extends our understanding of the fundamental laws that govern the origin, evolution and ultimate fate of the physical universe. In case of applied physics research, efforts are made to use the fruits of basic research to accomplish specific human objectives, such as the development of better communications, new medical diagnostic tools and other technologies for the service of mankind, or new energy sources. Physicist can also work in the area of computer-modeling and simulation where they may be utilizing their energies in developing complicated computer-algorithms, to visualize how systems behave in various situations.

A reasonable number of physics graduates are joining financial institutions, like banks and insurance companies, while some are working as managers in industrial units, or managing their own companies.

NEED TO SHOW FLEXIBILITY IN OFFERING COURSE/PROGRAM

There are a number of options available to physics graduates as far as jobs and careers are concerned. This wide range is possible due to the fact that the physics role is a central one in the study of other areas of human endeavor, such as science and engineering.

- A flexible first degree in physics would enhance and ensure maximum job-opportunities to its graduates, because the study of Physics develops theoretical and practical abilities that combine sound mathematical and experimental expertise with the ability to grasp new concepts, to analyze, correlate and solve problems, to work in a team with others and to think critically and creatively. Equiped with such a variety of skills, physics graduates shall be able to apply their expertise to a wide range of familiar and unfamiliar challenges in every career. Furthermore, a flexible physics-program that allows one to take course from other subject(s) would augment their skills to enable them work more confidently in areas which are not directly related with physics.

- It is now common for people to have several very different careers during their life.
- Physics can be taken as a major component of several combined degrees. These degrees enable students to match Science or Advanced Science with another field of study, opening up an even broader spectrum of career-opportunities.
- Physics is becoming increasingly interdisciplinary, as physicists work with mathematicians, engineers, chemists and biologists, in order to understand and solve a wide range of problems confronting society.
- Last but not the least, the Physics Courses must have the largest range of options and variety to attract the largest group of students.

EMERGING TRENDS IN OFFERING PHYSICS PROGRAMS

Many universities are offering physics as a single program. However, there are examples where either a concentration (emphasis) is offered in a particular field of physics or any other subject, or a combined degree program is available for taking physics with any other subject. In such combined degree programs, both the subjects are taught to such an extent that higer education can be obtained in either of the two because both subjects are covered quiet extensively. To make this point more clear, some of the course-offerings suggested in various universities of America, Australia and United Kindom are presented here.

HARVARD UNIVERSITY, USA

- Physics
- Chemistry Physics,
- Physics-Mathematics,
- Physics-Astronomy,

and

- Physics-History of Science
- Physics with Biophysics
- Physics and Teaching

Physics with Certificate

- Physics with Teacher Certification in Physics
- Physics with Teacher Certification in both Physics and Chemistry

PRINCETON UNIVERSITY, USA

- Physics
- Physics with Biophysics Certificate
- Physics with Premedical Requirement

CALIFORNIA STATE UNIVERSITY, FULLERTON

- Physics,
- Medical Physics
- Physics and Astronomy
- Engineering Physics
- Physics with Computer Science
- Physics with Business Studies

Combined Degrees

- Commerce/Science,
- Science/Law,
- Science/Arts,
- Science/Education,
- Science/Engineering

COLUMBIA UNIVERSITY, USA

- Astrophysics
- Biophysics
- Chemical physics
- Geophysics

UNIVERSITY OF NEW SOUTHWALES, AUSTRALIA

- Physics
- Physics with Astronomy
- Physics with computer Science
- Medical Physics
- Engineering Physics

Combined Degrees

- Science / Law
- Science / Commerce
- Science / Arts
- Science / Education
- Science / Engineering

QUEEN MARY UNIVERSITY, LONDON, UK

BSc (3 years Program)

- Physics

- Astrophysics
- Astronomy
- Theoretical Physics
- E-Science
- IT-Science
- Natural Science
- Physical Science
- Physics and Electronics
- Physics and Computer Science
- Physics with Computing
- Physics and Materials Science
- Physics and the Environment
- Physics and Economics
- Physics with Business Studies
- Physics with Finance
- Mathematics and Physics

MSc (4 years Program)
- Physics
- Astrophysics
- Astronomy
- Theoretical Physics
- Physics and Electronics

UNIVERSITY OF YORK, UK

- Physics
- Theoretical Physics
- Physics with Computer Simulation
- Physics with Astrophysics
- Physics with Business Management
- Physics with Philosophy
- Physics with Education

UNIVERSITY OF SUSSEX, UK

- Physics
- Astrophysics
- Physics with Mathematics
- Theoretical Physics
- Physics With Management Studies
- Physics with American Studies
- Physics with Education Studies
- Physics with French, German, or Spanish

UNIVERSITY OF WALES, ABERYSTWYTH, UK

- Physics
- Physics With Atmospheric Physics
- Physics With Planetary And Space Physics
- Physics / Computer Science
- Space Science And Robotics
- Physics With Business and Management
- Physics With Education
- Physics With French
- Physics With German
- Physics With Spanish

BIRMINGHAM UNIVERSITY, UK

- Physics *with* Medical Physics
- Physics *with* Business Management

BATH UNIVERSITY, UK

- Physics
- Applied Physics
- Physics with Computing
- Mathematics and Physics

BLOOMSBURG UNIVERSITY,GERMANY

- BS Physics
- BS Health Physics
- BS Electrical and Electronics Engineering Technology
- BA Physics
- BS. Ed. Physics- Secondary Education

UNIVERSITY OF INNSBRUCK, GERMANY

- Applied Physics
- Medical Physics
- Astrophysics
- Meteorology and Geophysics

OAKLAND UNIVERSITY, GERMANY

- BS Physics
- BA Physics
- BS Medical Physics
- BS Physics: Secondary Teacher Education Program (STEP)
- The Master of Science in Physics

UNIVERSITY OF SCIENCE AND TECHNOLOGY OF CHINA, CHINA

Undergraduate Programs

- Chemical Physics
- Modren Physics
- Astronomy and Applied Physics
- Physics with Mathematics
- Condensed Matter Physics
- Optical Information Science and Technology
- Microelectronics and Solid State Electronics

Graduate Programs

- Condensed Matter Physics
- Optics
- Physical Electronics
- Microelectronics and Solid State Electronics

PEKING UNIVERSITY, CHINA

- Physics (BS)
- Geophysics
- Atmospheric Science
- Space Physics
- Astronomy
- Nuclear Physics and Nuclear Technique

Harbin Institute of Technology, China

- Material Physics and Chemistry
- Applied physics

THE HONG KONG UNIVERSITY OF SCIENCE AND TECHNOLOGY, CHINA

Department of Physics and Materials Science

- BSc(Hons) in Applied Physics
- BEng(Hons) in Materials Engineering
- MSc in Materials Engineering
- Nanotechnology

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DEVELOPMENT OF SOLID-STATE PHYSICS IN PAKISTAN

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ABSTRACT

The development of research in Physics started in 1948 with the immigration of Prof. Rafi. M. Chaudhri to Pakistan. He was a well known Atomic/Nuclear Physicist and a student of Rutherford at the Cavendish Laboratory of the University of Cambridge, U.K. He did his Ph.D under Rutherford's supervision in 1932. At the time of creation of Pakistan, Prof. Chaudhri was Head of Physics Department at the University of Aligarh in British India and opted to migrate to Pakistan. He was appointed as Professor and Head of Physics Department at the Government College Lahore, Lahore. It was Professor Chaudhri who started the tradition of research in Atomic and Nuclear Physics in Pakistan. Although his main emphasis of research was not in solid-state physics, but he indirectly conducted some research on the "radiation effects of on solids" using the high-energy protons from the 1.2 Mev Cockcroft-Walton nuclear accelerator, installed at the High Tension Research Laboratory, Government College, Lahore, in 1954. Since there was no solid-state physics researcher at the time in Pakistan, only some teaching on related topics of thermodynamic behavior of solids, in particular the area of Debye Theory of Solids, was taught as a basic course of M. Sc. Degree Physics. This program, of course, forms the basis of lattice dynamic research of solids.

The research in solid-state physics was infact initiated in Pakistan when the Ph.D. qualified scientists of the Pakistan Atomic Energy Commission returned to Pakistan, in mid 60's. The field of neutron diffraction and scattering from solids, the radiation-damage studies in solids using methods of electron microscopy, electrical resistivety in solids, etc, were initiated at PINSTECH, and later in the 70's when the Physics Department at Q. A. University (then Islamabad University) became operative, the research in solid-state physics in the area of semiconductors, thermal properties of Solids and Magnetic Properties of Solids etc. was initiated there. So far over the years, several international research papers have been regularly published by Pakistani solid state physicists and several conferences, local and International, have been organized in Pakistan.

Further, in early 70's, a specific Center for research in solid-state physics was initiated with the funding of the Federal Government at the campus of the Punjab University, Lahore. Some of this research is described in this paper. Some other steps such as holding conferences on the subject, establishment of related research-centers, and inviting foreign solid state physicists to Pakistan etc. are also mentioned. All of these steps amounted to

the development of solid-state physics research in Pakistan, as we see today. The historical journey through these steps are briefly described in this paper and future trends would be suggested.

INTRODUCTION

After the birth of Pakistan in 1947, there was a serious shortage of Physics-teachers in Pakistan due to the emigration of Hindu professors to India. Only a few Muslim professors of Physics, having Ph.D degrees, were available and they could be literally counted on fingers.

Therefore, not only the teaching of Physics at the university-level was in precarious condition at the time, the Research in Physics was infact non-existant. The solid physics, as such was not even known.

In 1948, Professor R. M. Chaudhri migrated from Aligarh University, India to the Government College Lahore. He was a known researcher in Atomic and Nuclear Physics and not only teaching in Physics got a good start there but he also initiated the research in Atomic Physics mostly based on discharge through gases, a prominent field of research at the time. He also established the Nuclear Physics research mainly on the fabrication and study of Nuclear detectors and in 1954, established the 1.2 Mev Cockcroft-Walton Nuclear Accelerator at the High Tension Laboratory of Government College. This accelerator, one of the latest in the region, was used for study of Nuclear Reactions and impact of Nuclear radiation (protons in fact) and positive ions on solids. These studies concentrated on a new phenomenon at the time where the electromagnetic radiation was emitted as a result of impact of high energy protons and positive ions on solid surfaces like Aluminium and here we heard for the first time the research studies involving solids, though it could not be regarded as 'Solid State Research' in the real meaning of the term today. A series of papers were published in this area in prestigious journal, Nature.

On the teaching side in the mid 50s, Debye Theory of solids were taught in the subject of thermodynamics, which could be regarded as a subject of Solid-State Physics as well. Professor Tahir Hussain taught us this subject in 1955 during our M.Sc. This subject in the later years of late 50's and 60's developed into the well known branch of Solid-State Physics with the title "Lattice Dynamics", dealing with the study of vibration of atoms in solids, particularly crystalline solids, which contributed to the knowledge of crystallography, a subject of great practical applications. Mainly investigations were made using experimental methods of X-Ray and neutron-diffraction in 50's and 60's and later were supported by Mossbauer gamma-ray diffraction in late 60's and 70's.

The subject of study of crystalline-solids using diffraction methods became the central part of my research career starting from early 60's till later years and this was how the subject of solid-state physics using Nuclear Methods in fact became essential part of my life.

RESEARCH IN SOLID-STATE PHYSICS AT PINSTECH: THE INITIATION IN PAKISTAN

While we are discussing the development of solid state physics in Pakistan, I think it is pertinent to mention some of the names, particularly belonging to different areas of solid-state physics and that of course does not mean that a number of others who may not be referred, have not contributed to the solid-state physics of Pakistan.

After my Ph.D in 1965 in Mossbauer gamma-rays diffraction from crystals, in view of the Swimming Pool Reactor installation in Islamabad at PINSTECH by the Pakistan Atomic Energy Commission (PAEC), I was, immediately after Ph.D completion at the Birmingham University in UK, sent by PAEC for one year post-doc training in Germany at the famous Nuclear Research Centre at Karlsruhe. The area of Neutron Diffraction and Scattering from solid. This training was useful for initiating research-programmes at the 5MW (at the time, now 10 MW) Swimming Pool Research Reactor at the Pakistan Institute of Nuclear Science and Technology (PINSTECH), soon after my arrival in October 1966.

The Neutron-Diffraction Group, established by Dr. N. M. Butt in 1967 is viable and well known and has published a number of research papers over the years in international journals in the field of solid state physics using the technique of Neutron-Scattering and Diffraction. Later on, well known physicists like Dr. Mansoor Beg, Dr. Q. H. Khan and Dr. Javed Bashir led the group effectively in these years. Important publications, using the triple-axis Neutron-Spectrometer, installed at the PINSTECH reactor, in the area of phonons in crystals and Debye-Waller Factors of Crystalline Materials, were introduced in famous journals abroad.

With the return of Dr. F. H. Hashmi, Dr. K. A. Shoaib to PINSTECH after their Ph.Ds, the group on radiation damage in solids was established. The main programme was to study the defects in solids caused by neutrons or ions. The planned technique was of use the Electron-Microscopy. The laboratories for which were planned and the Electron Microscopes (Transmission and Scanning) were installed in 80's. The group published a number of papers on the mechanical properties of solids affects by atomic-defects on grain-boundaries. In addition, these laboratories have served other national requirements, such as the study of causes of mechanical failures of parts of aero-planes of Air-Force causing accidents.

PINSTECH, apart from Solid-State Physics, has contributed research in materials science, akin to the subject of Solid State Physics using the Transmission Electron Microscopy. Further, the impurity in solids using scanning electron microscope has been one of the well-used area in the study of solids. These impurities lead to the study of defects in solids, complimentary to such studies using the transmission electron microscopes. The Mossbauer Spectroscopy work initiated by Dr. N. M. Butt, which made extensive progress in investigating magnetic solids, corrosion of iron, ionic distribution in magnetic solids, etc. has been published. PINSTECH continues this research todate. A standard research in the Solid State at PINSTECH was also done in the area of Solid State Nuclear track detection, mainly acquiring information on damage in plastic solids when nuclear particles pass through these materials. In this technique, considerable research leading to proliferation in research papers has made PINSTECH one of the leading laboratories of the world. Dr. Hameed A. Khan who established this area at PINSTECH, is one of the top scientists in the field and has brought out number of publications in a variety of international journals.

PINSTECH gave a boost to Theoretical Solid State Physics particularly in the area of computer simulation applied to study the transport properties of solids, static and dynamic properties of long chain polymers, and catalytic surface reactions etc. This area led by Dr. A. Sadiq and Kh. Yaldram, made good impact on theoretical research on international level, particularly in collaboration with leading laboratories of Germany and France.

In later years, the study of high temperature superconductivity of $Yba_2Cu_3O_2$ and the structure of solids (KBr, KCl, mixed Alkali Halides) using x-ray and neutron diffraction has been an active area of Solid State Physics research. In one of the samples containing several elements like Bi, Pb, Sb, Sr, Ca, Cu and O, a transition temperature 140^oK was also observed (C/O Dr. J. A. A. Khan). This temperature was one of the highest at the time. The neutron diffraction studies of cellulose Polymer and Alkali Halides were extensively studied and notable research on Debye-Waller Factors and texture of materials of international recognition was done. Pakistan (Dr. N. M. Butt) was thus put on the panel of correspondents of the well known international magazine the "Neutron News". Later, work on correlation of micro and macro properties of crystals set new trends and was highly cited across the world.

Recently, research on structure of solids using Synchrotron Radiation source at Elettra, Trieste, Italy was done as a result of acceptance of the project of the PINSTECH Materials Research Group (C/O Dr. M. Javed Akhtar and Dr. J. Bashir). Some work on the development of special laser quality crystals led to the growing of Nd-YAG crystals (C/O Dr. S. Jalal Bokhari) used in the laser technology. These high purity crystals have been grown indigenously and made Pakistan independent of import from abroad. The development of indigenous instrumentation for Solid State Research led to the fabrication of x-ray powder diffractometer of as good precision as available from the imported instruments (C/O Mr. M. Akhtar). It is important that such instruments should be commercialized to substitute import of such an expensive equipment which can be supplied to local laboratories needing powder diffraction of solid materials which is of common need of several laboratories in Pakistan. Over the years (1967 – 2003) out of about 1200 research papers published by PINSTECH in international refereed journals about 200 (~ 17%) form the share of Solid State Physics papers, and claiming of course the major thrust as compared to other specialties in physics papers. In brief, PINSTECH has contributed to the indigenous high quality research in various areas of Solid State Physics.

SOLID STATE PHYSICS AT THE QUAID-I-AZAM UNIVERSITY

The other major contributor to Solid-State Physics are mainly four experimental groups and one theory group at the Physics Department of the Quaid-i-Azam University (QAU). The main areas of experimental Solid-State Physics at Q. A. University are semiconductor physics introduced by Prof. Zafar Iqbal, structure properties of solids (led by Prof. Farid A. Khawaja), thermo physical properties introduced by Prof. Asghari Maqsood and the magnetic properties of solids introduced by Prof. Khurshid Hasanain. The theoretical Solid-State Physics was led by Prof. A. H. Nayyar on magnons – phonon interaction studies of rare-earth magnetic materials and calculation of correlation functions and structure factors of Heisenberg Ferro and anti-Ferro magnets in one and two dimensions. Studies of soliton like excitations in one – dimension Ferro magnets has been popular work by this group. The semiconductor physics centered around Si, and III-V compounds such as GaP, GaAsP, Al Ga As and InP. A number of deep-level systems in n-type Si were studied leading to publications in international journals. The structure properties physics mostly was concentrated on electronic structure, order-disorder phase transitions and stress-strain analysis using mainly x-ray diffraction method. The theoretical work of this group was done on short range order in binary alloys using pseudopotential theory.

The thermo physical research was mainly concentrated on the development and use of the transient hot strip method to study the thermal transport properties of composites. The ceramics at higher temperatures of (300 - 800 °K) were also investigated. Some work was also done on high temperature superconductivity and on the preparation of the high Tc materials. The group contributed to growth of single crystal high Tc materials and investigation of their transition temperatures. Earlier research was concentrated on spin glasses like Nd Fe_2, Pr Py (y < 1), Gd – Al etc. Magnetic properties of maraging steel in relation to deformation and structural phase transitions were also studied. Recent research on Colossal Magnetic Resistance (CMR) using magnetometers and Mossbauer Spectroscopy has been done and current research introduces work on nano-science using Iron particles leading to technological applications of Fe-nano-particles as sensors for diseased cells. Q. A. University Solid State Physics has contributed major share in producing trained manpower in Pakistan in the form of M. Phil. and Ph.D. graduates in the areas briefly mentioned above. It is pertinent to mention that out of the 78 Ph.D. graduates produced by the Physics Department of Q. A. University over the period (1971 – 2005), 15 Ph.D. graduates produced were in Solid State Physics, thus forming about 20% of the Ph.D. (Physics) produced during this period. [Ref: "Physics at Q. A. University", 2005 Physics Dept. Q. A. University, Islamabad].

CENTRE FOR SOLID-STATE PHYSICS, LAHORE

In early 70's, the Federal Government developed a scheme of centres of excellence in various sciences. Under this programme, a centre for Advance Solid State Physics was setup at the New Campus of the Punjab University in Lahore. Late Prof. Muzaffar Ali Shah was appointed as the Founding Director of this centre (the author was offered this position and the Chairman PAEC, rightly then, did not allow my release because of the forthcoming important laboratories on Neutron Diffraction to be established around the 5MW Swimming Pool Research Reactor at PINSTECH. The author however remained in touch with the centre for several years being on the Advisory Board of the Centre). This Centre got a boost under the Japanese Aid-Programme and latest Solid State experimental equipment was provided to the centre. This included the crystal growing, X-ray diffraction, the high temperature furnaces, the electron microscope with Auger – electron studies of surfaces etc.

The centre contributed to the training of M. Phil. Graduates in Solid State Physics as well as research papers in the areas suitable to the experimental equipment. The research publications got boost due to publications of theoretical Solid State Physics on LEED by Dr. Nazma Masud and later by experimental publications on surface physics by Dr. M. Suleman. Publications in the area of electrical properties by Dr. Fateh Mohammad, High Temperature Superconductors by Dr. Saadat Siddqui and variety of papers on X-ray diffraction and magnetic studies were also published by other authors. Theoretical papers were also produced by Dr. Tariq Abdullah. However, unfortunately the Solid State Centre could not maintain the progressive level of research publications in recent years particularly after the death of Dr. Suleman and hence needs a special attention for its support and meritable management by the Government.

SOLID-STATE PHYSICS AT GOVERNMENT COLLEGE, LAHORE

A good amount of research on Solid State Physics mostly concentrating on Solid solutions and metallic alloys dealing with the mechanical properties of yield strength, crack propagation, defects in alloys, fatigue and creep studies were carried out by Prof. M. Zakaria Butt and his students leading to a number of highly cited international publications. In addition, a number of M. Phil. graduates were produced at the Physics department of the Government College.

The transfer of Prof. Zakaria Butt to administrative position has led to the drastic reduction of Solid-State Physics research at the Government College and a great setback to the Solid-State Physics of this area in Pakistan. The management needs to take such decisions with great sense of care as the establishment of research to be seen at the international standards takes years to establish but takes little time to diminish by such decisions. The managers have to see that over the period, viable research groups need to be established so that in case the movement of a scientist is essential, the research level does not get a drastic setback.

OTHER PLACES

Solid State Physics Research publications from other places like Institute of Silicon Technology University of Peshawar where Dr. M. Ali Khattak got trained in Solid State Theory mainly concentrated on its teaching and at University of Karachi has been nominal and sporadic and has therefore not been covered here.

RELATED SCIENCE: MATERIALS PHYSICS

The area of Materials Science is akin to the Solid State Physics in the sense that the experimental equipment is mostly common for the studies of both these areas, whether these are electron microscopes, X-Ray or neutron diffractometers, mossbauer spectrometers or electrical or magnetic property study equipment.

The selection of problems varied in the sense whether the investigations are related to solid state or Materials Science.

Such facilities existed at PINSTECH and in the A.Q. Khan Research laboratories at Kahuta. Some research attempts on Materials Science were made at the UET Lahore and at the PCSIR laboratories. However, though the equipment is mostly similar, the Materials Science needs an extensive work and time to discussion.

OTHER MEASURES OF BOOSTING/SUPPORT TO SOLID-STATE PHYSICS IN PAKISTAN

The Solid-State Physics Development in Pakistan has got progressed due to some of the important other supporting activities which need to mention briefly. These are:

I. International Cooperation

Various research groups whose work has been described above, enhanced because of international research cooperation. This included the visit of foreign scientists to Pakistan as well as the visit of Pakistani scientists to the research centres abroad.

In the area of neutron diffraction, PINSTECH was benefited by the visits of Dr. Blinoski of Poland and Dr. Stig Rolandson, a Swedish scientist for about a year in early 70's. PINSTECH scientists also made visits to Reactor Centre at Karlsruhe (Germany) Oak Ridge National Laboratory (USA), Riso Centre (Denmark) and Royal College Research Reactor at Stockholm (Sweden).

The Radiation Damage Group at PINSTECH benefited from the cooperation of Research centre in Karlsruhe (Germany) whereby the Pakistani scientists visited that centre under scientific cooperation. The group also benefited from the visit of Prof. Shaheen of USA to PINSTECH. The scientists were also benefited by cooperation with France (University of Strassbarg (C/O Prof. M.A. Khan) and university of Mainz (C/O

Prof. K. Binder).

The Q.A University benefited from the visits of Prof. M. Wortis USA (in 70's) and Prof. S. Gustaffson of University of Goteborg, Sweden (in 80's).

II. Aids and Grants

Solid State Physics of Pakistan has also got great advantages through foreign aid and grants.

The Q. A. University and the Solid State Physics centre at Punjab University Lahore received major equipment from Japan through educational Aid programmes.

PINSTECH got Neutron spectrometer from Research Centre of Karlsruhe worth $100,000/- under German donation through Alexander von Humboldt Foundation (C/O Dr. N. M. Butt).

PINSTECH also benefited from various grants and aid from the International Atomic Energy Agency (IAEA) for Neutron Scattering research in the recent years. Recently, PINSTECH Scientists were helped by the Synchrotron Radiation facility Elletra, Trieste, Italy after they competed for a project time and were successful in winning time on this SR faculty for the project proposed in the area of Solid State Structure research (C/O Dr. M. Javed Akhtar and Dr. Javed Bashir).

III. Conferences on Solid-State Physics

Lot of developmental benefits for Solid State Physics accrued from the organization of local as well as international conferences which provided ample chances of mutual discussions by the Solid State Physicists.

On the local level, the conferences were arranged by the Pakistan Physical Society and the Semiconductor Society of Pakistan as well as by the Pakistan Institute of Physics.

In 1974, a major international conference on Solid State Physics was held in Islamabad with the funding (US$ 40,000) of US National Science Foundation (NSF). World renowned scientists like B.N. Brockhouse of Canada, (Nobel Laureate 1994), J.M. Ziman, F.R.S. (UK), G. H. Wannier (USA), W. A. Sibley (USA), K. Ehrlich (Germany), A. B. Lidiard (UK), M. W. Thompson (UK) and W. C. Koehler (Oak Ridge, USA) gave lectures on contemporary topics. Solid State Physicists from all over the country benefited from this 10 days interaction with these renowned Physicists from abroad. A conference on Solid State Physics of that level where such a large number of world-known physicists got together at one time has not been held in Pakistan afterwards.

Since 1976, the Nathiagali Summer Colleges have been arranging the lectures of renowned Solid State Physicists from time to time at their annual summer colleges. In addition to benefits during the summer college, scientific cooperation has been developing thereby greatly benefiting the research in Solid State physics in Pakistan.

Furthermore, Pakistani Physicists have been participating in conferences abroad and making scientific visits abroad under various programmes like DAAD and Humboldt Fellowships (Germany), Commonwealth Scholarships (UK), etc. and thereby bringing new ideas to boost research in Pakistan.

All channels have been benefiting the Solid State Physics Research in Pakistan and this has resulted with quality Physics research in Solid State Physics that we see today.

FUTURE OF SOLID-STATE PHYSICS IN PAKISTAN: NANO-SCIENCE AND NANO-TECHNOLOGY

With ever growing research, the new off shoots, in Science and Technology keep on emerging from traditional areas and giving birth to new names of the emerging Science and Technology. With development of precision tools and equipment used in Solid State Physics, particularly using Electron Microscopes, when the precision has reached to see the atoms and molecules and to handle them in the laboratory, the new area of "Nano-Science and Nano-Technology" has emerged and is influencing all branches of science speedily.

Since the capability to handle and control the atoms and molecules (size of a few nano-meters) is in hand, the enormous application in Biological and Material Sciences, Environmental Sciences, Information Sciences & Technology etc. has emerged. The fact of the matter is that with the evolution of Nano-technology, influence of this technology has engulfed all sciences. Thus today, we see the application of Nano-technology in medicine, Biotechnology, Energy systems, fuel cells, pharmaceuticals, agriculture, various kinds of industry, auto-industry, textile industry, electronics industry etc and in subjects as exotic as control of terrorism and strategic defense in space technology and so on.

NANO-TECHNOLOGY IN PAKISTAN

The vision of researchers in Pakistan has immediately realized the importance of nano-technology and the scientists of Pakistan supported by the Government funding are now paying active attention to take up areas of Nanotechnology with particular need and relevance to Pakistan.

A National Commission of Nano-Science and Technology (NCNST) has already been instituted by the Ministry of Science and Technology (MoST), Government of Pakistan. Before a detailed policy is worked out, the groups which having of course a good track of research relevant to slip over in Nano-science, are being supported by the allocation of Government funds.

These groups in the area of Nano-biotechnology (at NIBGE), quantum devices (optics labs of PAEC), Synthesis & Characterization (at PIEAS), nano magnetism at Q.A. University, Thin films (at CIIT) have already been supported by the Ministry of Science and Technology (MoST) and Higher Education Commission (HEC) funds through the recommendations of the National Commission on Nano-Science and Technology.

Further efforts of NCNST, which has its advisory Members coming from all major scientific organizations and Universities, are in progress to plan national requirements of Nano-science and Technology in Pakistan.

CONCLUSION

This paper is a brief journey through the different stages of development of Solid State Physics in Pakistan. It is of course, does not a full justice to the topic, and considerable material must have been missed, for which I seek apology but, nevertheless this brief recourse gives a fair picture of the developments of the Solid State Physics. It is also a quick peep into window of Nano-Science and Technology and opportunities vastly lying ahead that need to be addressed before it is too late for the very fast growing technology.

ACKNOWLEDGEMENTS

I am grateful to Dr. Zafar Iqbal, Dr. Hasanain and Dr. Aslam Baig for their help in provision of some of the material. I am also grateful to Dr. M. Afzal Sheikh for going through the text of the paper and the suggestions. I am grateful to Director General PINSTECH & PAEC for provision of facility of the office of Scientist Emeritus at PINSTECH (C/O Mr. Abdul Saboor and the other staff).

DEVELOPMENT OF SUCCESSFUL RESEARCH ACTIVITIES IN PHYSICS: A SRI LANKAN EXPERIENCE

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ABSTRACT

Physics plays many vital roles in the developmental activities of a country, whether it is developing or developed. Local expertise in Physics is becoming increasingly essential for the developing countries, to get maximum economical advantages from the knowledge-based technologies and emerging technologies, such as nanotechnology. With the aim of enhancing the local expertise in Physics, a research programme on technologically important materials was initiated, almost from scratch, at the Department of Physics of the University of Peradeniya, Sri Lanka, in 1986. This paper outlines the science and technology situation in Sri Lanka and describes the development of this research activity and its successes. Since the commencement of this research programme, the Peradeniya group has produced 14 Ph.D.s and 5 M.Phil.s., and several M.Sc.s, and has published more than 100 research papers in international refereed journals and presented over 200 papers in national and regional conferences. The Ph.D. and M.Phil. Degrees have been offered on sandwich-basis, with several collaborating universities in Europe. These sandwich programmes have been successful not only in producing Ph.D.s and M.Phil.s of internationally recognized standards, but also in containing the brain-drain of trained Physicists from Sri Lanka to some extent.

1. THE ROLE OF PHYSICS IN DEVELOPMENT ACTIVITIES

Competence in Science and Technology (S&T) is essential for any country, whether it is developed or developing, as the standard of living in a country depends on the degree of expertise that it has in S&T. Development of a country will increasingly depend on its ability to access, comprehend, interpret, select, adapt, use, transmit, diffuse, produce and commercialize scientific and technological knowledge, in ways appropriate to its culture, aspirations and level of development [1]. Therefore, the need for the endogenous competence in S&T is greater in a developing country for the country to be able not only to develop its own S&T base, but also to benefit from technologies imported from the developed world. In order to get maximum benefits and to sustain imported production, methods and technologies must be suitably adopted to fit into the existing social and technological environment of the country. There have been several examples where development projects in undeveloped countries have failed, due to the involvement of foreign experts who are unfamiliar with local situations. Hence, a multi disciplinary knowledge-base, developed through research, is essential in order to build up an infrastructure and endogenous competence in S&T in a country. Such a knowledge-base with emphasis on Physics, as Physics is the basis for most modern technologies, is also important for a country to be able to plan and implement development strategies efficiently [2].

Physics plays many vital roles in the economic development of a country, irrespective of its status of development. It has a major role in many key-sectors, such as transport, eco-friendly energy production, prediction and modeling of natural disasters and metrological events, monitoring environmental changes, healthcare and sanitation, agriculture and food-production, development and production of new devices and equipment, and the emerging field of nanoscience and nanotechnology. As the economy of the world is shifting from resource based to knowledge-based, the knowledge in Physics is becoming increasingly important. Most of the production of consumer-devices is being shifted from developed countries to low cost factories in developing countries, and the emerging field of nanoscience and the associated nanotechnology are not based on traditional raw materials, but based on materials that can be produced even in developing countries. Therefore local expertise in Physics is essential for the developing countries to get maximum economical advantages form the new trends and emerging technologies. Physics also can address a large number of problems that developing countries have to face and help find cheap and easy solutions for many of them, e.g. production of solar energy, monitoring of urban and rural pollution, medical applications, water purification etc.

To enhance the local expertise in Physics in developing countries, not only the educational facilities needs improvement but facilities for basic research are also needed. Advantages of training in Physics research training include the flexibility to tackle a wide range of problems and to be able to move from one discipline to another. It also provides the ability to solve problems from first principles when standard solutions do not apply.

The problems encountered in Physics research and training in developing countries are acute. Some of the common problems are serious lack of funding, which worsens with the economic situation, lack of private-sector demand, political instability, internal conflicts or wars, isolation of scientists, lack of public awareness, lack of policy and institutional framework for research, difficult or no access to scientific publications, lack of information and communication- technology facilities, etc. In spite of all these difficulties, what has been achieved in the development of research activities in some developing countries like Sri Lanka is commendable. This paper concentrates on the development of research activities in Sri Lanka in Physics-related fields, in general, and describes the building of research capacity in Physics at the University of Peradeniya, in particular.

2. STATUS OF SCIENCE AND TECHNOLOGY IN SRI LANKA

According to the criteria commonly used to rank S&T capacity, Sri Lanka is placed among the scientifically lagging countries by a World Bank study, and its performance in S&T is poor compared to that of many countries in South and Southeast Asia [1]. The Table-1, which shows science and technology development indicators for a number of countries in South and Southeast Asia, illustrates this.

The numbers of scientists and technicians employed in R&D work in developed countries as a proportion of the population are considerably greater compared to those in developing countries. For example, in Japan the number of scientists and engineers in R&D per million people is 5,085 and number of technicians per million people is 825. In Sri Lanka the corresponding numbers are only197 and 48. In India these numbers are 120 and 102 respectively. According to the data in the table, the human capital needed for successful science and technology development (scientists, engineers, technicians, as percentage of total population) in Sri Lanka is proportionately large or comparable to that in some countries which are perceived to have more successful S&T systems, such as India, Malaysia and Thailand. However, with respect to the outputs of the S&T system (publications, high technology exports,

Table - 1: Science and Technology Development-Indicators for Selected Countries

Country	Scientists and Engineers in R&D per million people	Technicians in R&D per million people	Scientific and Technical Journal articles	Expenditure on R&D % GDP	High-technology exports		Royalty and License fees		Patent Applications filed	
					$ millions	% of manufactured Exports	Receipts $ million	Payments $ million	Residents	Non-Residents
	1996-2002*	1996-2002*	2001	1996-2002*	2003	2003	2003	2003	2002	2002
Bangladesh	(52)	(33)	177	0.03	1	0	0	4	[32]	[184]
China	633	(200)	20978	1.2	107543	27	107	35748	40346	140910
India	120	102	11076	0.8	2292	5	29	356	220	91704
Indonesia	(182)	---	207	(0.07)	4580	14	---	---	0	90922
Japan	5085	(827)	57420	3.1	105454	24	12271	11003	371495	115411
Korea, Rep.	2979	(318)	11037	2.5	57161	32	1325	3597	76860	126836
Malaysia	294	57	494	0.7	47042	58	20	782	[50714]	[71036]
Pakistan	88	14	282	0.2	120	1	8	36	0	1168
Philippines	(157)	(22)	158	(0.22)	23942	74	2	273	0	81697
Singapore	4352	381	2603	2.2	71421	59	197	3334	511	93748
Sri Lanka	197	48	76	0.2	19	1	---	---	0	88379
Thailand	289	116	727	0.2	18203	30	7	1268	1117	4548
U.S.A.	4526	---	200870	2.7	160212	31	48277	20049	198339	183398

* Data are for the latest year available
Source: World Bank Development Indicators 2005; ( ) 1987-97 data; [ ] 1998 data

royalty & license fees, patent applications etc) Sri Lanka is considerably behind these countries. For example, in 2001 the number of scientific publications from Sri Lanka was a mere 76, which is the lowest among the countries listed in Table-1.

This poor performance is not due to inferior quality of scientists in Sri Lanka, but is due to various difficulties they face in carrying out R&D work. Some of the reasons for poor performance in S&T of Sri Lanka have been identified, at a recent workshop conducted by National Academy of Sciences of Sri Lanka [3], as follows:

- Low overall expenditure on R&D
  Sri Lanka spends only about 0.20 % of its Gross National Income (GNI) on R&D, as against 3% of GNI by developed countries.
- Low investment in S&T by the state sector
- Low private-sector expenditure on S&T
  In developed countries, the private sector accounts for over 60% of total R&D expenditures; but in Sri Lanka, it is only about 1.5% in 2001.
- Poorly developed high-technology production
- Inappropriate policy-environment
- Brain Drain
- Lack of efforts to promote high-technology industries

The possible remedies for overcoming these difficulties are mentioned in Reference-3.

Although Sri Lanka contributes nearly 0.2% of its GNP for R&D, a major part of this modest expenditure goes largely to pay salaries and allowances of staff, with relatively little going to finance the actual implementation of R&D programmes. Majority of the available research-grants go to applied-research areas, such as agriculture, healthcare, life and chemical sciences The real contribution going to Physics research is very small, and can be estimated to be around US$ 100,000 per year, which corresponds to 0.0006% of GNP. The low amount allocated to Physics is because it is considered as one of the fundamental fields, rather than a field useful for the economic development.

3. PHYSICS EDUCATION AND RESEARCH IN SRI LANKA

Proper university system in Sri Lanka was initiated in 1942, with the establishment of University of Ceylon by amalgamating the existed University College and the University Medical College. Physics was taught as a subject in the Faculty of Science, situated in the Colombo campus of the University since then. However, no expertise and facilities were available for majoring in Physics and for postgraduate studies at the beginning. Physics Special (major) degree-programme was made available only from about 1945. Until then, the majoring and postgraduate degrees in Physics were obtained abroad, mainly from the universities in the United Kingdom. With the commencement of the Special Degree programme, 3-5 physicists were trained each year. As the demand for science education grew, a new Faculty of Science with a well equipped Physics Department was established in 1961 at Peradeniya. However, the new Department was able to offer Physics major programme starting form 1968 only. The two campuses in Colombo and Peradeniya were made independent and named as University of Colombo and University of Peradeniya in 1967.

At present, there are 13 universities in Sri Lanka including one Open University. Faculties of Science exist in all these universities, except in the University of Moratuwa, at which only a Physics Unit is available. Physics is taught as a separate subject in 10 of these universities in the Faculties of Science. Generally, Physics is offered as one of the three subjects for the 3-year General Degree course or as a Major subject for the 4-year Special Degree Course. A large number of students, about 100 students per year in each of the 10 universities, offer Physics as one subject for their 3-year General Science Degree course. Around 10 students per year study Physics as a major subject in each of the 8 universities that offer the Special Degree Course. The Science Degree courses offered by Sri Lankan universities are of good standard and comparable to those offered in many developed countries. Large number of our Physics major graduates, and some of the General Degree graduates with Physics as a subject, get admission to US universities after competing with students from other countries and nearly all of them not only complete their degrees successfully but contribute to the R&D of US significantly.

Even though, the undergraduate programmes were maintained up-to-date from the early days, no serious effort was made in developing the postgraduate programmes in Physics. During the late 1940's and early 1950's, there had been some research activities on cosmic rays and elementary particles at the University of Colombo and on ionosphere at the CISIR (now ITI) in Colombo. Later on, in the 1960's, there was an effort to carryout research on geomagnetism in Colombo. However, these activities did not continue due to various difficulties, such as inadequate qualified researchers, isolation and heavy teaching duties. The only research activity that was continued, without interruption, is the solar-cell material research initiated by Prof. K. Tennakone in the late 1970s (first at University of Sri Jayewardenepura, then at University of Ruhuna and later at the Institute of Fundamental Studies). This activity resulted in many international publications and enabled Prof. Tennakone to become a scientist of international repute. He is at present heading the Institute of Fundamental Studies in Sri Lanka, at which a number of frontier-research activities in Physics are being carried out. In 1977/78 a research programme on Atmospheric Physics was initiated in the University of Colombo with financial support from the International Programme in the Physical Sciences (IPPS) of the Uppsala University, Sweden. Later on, another research-programme on Molecular Desroption was also started in Colombo in 1981, with IPPS support. These two programmes are still continuing with successful outputs. In addition, there are several research activities on a smaller scale at universities of Kelaniya, Sri Jayewardenepura, Ruhuna and Jaffna. These activities mainly concern semiconductors, solar cells, geophysics, solar energy, new materials and superconductivity.

The research activity in the University of Peradeniya, on which this paper is based, was initiated in 1986 with financial support from IPPS. The activity at the initial stage was concentrated only on Solid Electrolyte materials, but now includes a variety of technologically important novel materials involving polymer- electrolytes, conducting polymers, ceramics, semiconductors, etc.

4. DEVELOPMENT OF PHYSICS RESEARCH AT THE UNIVERSITY OF PERADENIYA

The Department of Physics at the University of Peradeniya was started as a sub-department affiliated to the Colombo Physics Department, with only a few qualified staff members in 1961. As such, the staff had to concentrate on developing the undergraduate programmes, mainly the three-year General Degree programmes. Students found eligible for Physics major degrees, at the end of the first-year qualifying examination, were sent to Colombo. No significant research activities took place at Peradeniya during the early period.

Because of the growing demand for Physicists, a special degree-programme in Physics was started at Peradeniya in 1968, with the help of two visiting British lecturers sponsored by the British Council. A total of 10 fresh general-degree graduates, including myself, were admitted, to follow an additional two-years to complete the Physics special degree. Of the 10 admitted two gave up the course halfway and eight completed the degree successfully in 1970. The first six, including myself, who have obtained First Class or Second Class Upper Division were absorbed into the Department as Assistant Lecturers and sent abroad for postgraduate training. The newly trained staff returned to the Department, one by one, starting from 1976 and the staff strength of the Department continued to improve from that time onwards. The Department at present consists of 3 Professors, 1 Associate Professor, 10 Senior Lecturers (all with Ph.D. training in various areas of Physics), and 1 Probationary Lecturer plus 6 Temporary Assistant-Lecturers all with Physics major degrees. The Department, now, offers a number of courses in Physics for the General and Special Degree students, conducts an M.Sc. Degree course in Physics of Materials and offers a variety of research projects for M.Phil. and Ph.D. students.

In the early 1980's, (with the staff situation improved) the Department began to introduce short-term research projects as part of the undergraduate programmes and offered an M. Sc. Course in Physics (by Course work) with a 3-month research component. Even though the Department had around six qualified staff with Ph.D., most of them trained in Solid State Physics, it was not possible to start any serious research activity due to lack of facilities and funds. In 1983, I came across a fellowship programme offered by the International Seminars in Physics (now IPPS) of Sweden, which allowed post-doctoral training in Sweden with the possibility of receiving follow up support to continue the research at home. At my request, the IPPS offered a fellowship in 1983/84 for me to undergo research- training on Solid State Ionics, an emerging field at that time, at the Chalmers University of Technology at Gothenburg, Sweden, under the supervision of Prof. Arnlold Lunden. This was the turning point for the Physics research at Peradeniya.

With the idea of continuing the research at Peradeniya, Sulphate-based Solid Electrolytes were identified as the materials for the first stage of research because the materials had good scientific scope and samples for measurements can be easily prepared in Sri Lanka (with readily available chemicals) and the investigations can be carried out with low-cost instruments. A hydraulic press, an Impedance analyzer and a furnace were the instruments needed initially to embark on this research. Satisfied with the progress of the research activity and future plans, the Director of the IPPS visited Peradeniya in 1984 and convinced himself that Peradeniya had the basic requirements, such as sufficient number of academic and technical staff, laboratories, library and machine shop, to embark on collaborative research activities. I returned to Peradeniya late in 1984, and a colleague of mine from Peradeniya (Prof. M.A.K.L. Dissanayake) was immediately sent to Chalmers University under an IPPS fellowship to undergo training and continue the research work at Chalmers University.

In early 1986, following our training, a Solid State Physics research-group was formed at Peradeniya and a research project on Sulphate-based Solid Electrolytes was initiated, with the equipment donated by the IPPS, in collaboration with Chalmers University, Sweden. A research paper, based entirely on the research done at Peradeniya, was presented at the Regional Workshop on Materials for Solid State Batteries held in June 1986 at the National University of Singapore. The first postgraduate student (P.W.S.K. Bandaranayake) recruited to work on the project obtained his Ph.D. degree from the University of Peradeniya in 1991. It took him a little over 5 years to complete his degree, as he had to carry out part of his research work in Sweden on sandwich basis under IPPS fellowship scheme. This was the first-ever Physics Ph.D. awarded by a Sri Lankan University. Dr. Bandaranayke has been absorbed into the permanent cadre of the Physics Department and he is an active young member of the research group at present.

Over the past 20 years the Solid State Physics research group has expanded considerably. Two more major areas, Semiconductors and Ceramics have been included, and the solid-state ionic activities have also been widened to include two major areas: Ionically Conducting Polymers and Electronically Conducting Polymers. Four subgroups have been formed to concentrate on each of the above areas. The entire group as at present consists of 9 senior members with Ph.D.s and 10 M.Phil./Ph. D. students. The group began its experimental work with a high- temperature furnace and an HP 4192A impedance-analyzer donated by the IPPS. But now it has a fairly well-equipped laboratory with several experimental facilities, including X-ray diffractometer, Vacuum coating-unit with sputtering facilities, DSC, Spectrophotometers, etc. While continuing the fundamental research on many new materials, the group also conducts several application-oriented studies, such as polymer rechargeable batteries, artificial muscles with conducting polymers, fabrication of low-cost ceramic bricks, value-addition to raw materials, low cost and polymer-based solar-cells. The research facilities are also used for the student projects at both B.Sc. and M.Sc. levels.

Because of dedicated hard work, the Peradeniya group was able to attract considerable funds from the IPPS. Over the past 22 years, IPPS has contributed well over 10 M SEK(nearly US $ 1.3 M), in the form of training of senior staff, fellowship to students to do part of research abroad, equipment, support to attend conferences etc. [4]. Having monitored the progress closely, the IPPS has promised to continue its support for the group, until the group can sustain its activities on its own both financially and scientifically. Through its untiring efforts the group has also obtained considerable funds from the European Union (1992-1995), ICTP, National Science Foundation, Sri Lanka, Postgraduate Institute of Science (PGIS), Sri Lanka and University of Peradeniya. The group has established links with a number of research institutions and Universities, both local and foreign, for joint research work and sandwich Ph.D. programmes. Some of the Collaborating Institutions are Chalmers University (CTH) and Royal Institute of Technology (KTH), Sweden, Technical University of Denmark (DTU), Denmark, Aberdeen University, Sheffield Hallam University and Warwick University, U.K, INPG, Grenoble, France, Swiss Federal Institute Zurich (ETH), Switzerland, IIT, Bombay, India and University of Oklahoma, U.S.A.

Since the start of the research programme, the group has published more than 300 research papers, out of which nearly 100 are in peer-reviewed international journals. Also, 14 students from the group have received their Ph.D.s, of which 11 obtained their degrees from the University of Peradeniya under sandwich arrangements and the other 3 has received their Ph.D.s from the collaborating Universities abroad. Five students have completed their M.Phil. Degrees and several students have received Master of Science degrees. All these graduates have been successful in securing employment or in continuing their education. Of the 14 Ph.D.s produced by our group, 8 are employed as academic staff in the universities in Sri Lanka, one is a director of an educational institute, one is a senior researcher at the Institute of fundamental Studies, four are abroad (one employed and 3 are postdoctoral fellows). At present, there are about 75 active Physicists with Ph.D.s in Sri Lanka; probably twice as many stay abroad. Of the 75 Ph.D. holders staying in Sri Lanka, 20 have been produced on sandwich- basis, both at Colombo and Peradeniya. These figures indicate the effectiveness of the sandwich programmes in providing postgraduate training of internationally recognized standard and in containing the brain-drain of trained Physicists from Sri Lanka, to some extent. Nearly 90% of the Peradeniya Physics Major graduates, including all the bright ones, go abroad for higher studies but hardly any of them return to serve in Sri Lanka. But nearly 70% of the graduates trained through our sandwiched Ph.D. programmes have remained to serve the country. Similar results have been reported by the University of Colombo, which is also offering sandwich Ph.D. programmes through IPPS support and produced 12 Ph.D.s in Physics over the past 25 years.

Due to the dedication, interest and careful planning of the activities by the group-members, the group's activities have attracted attention of local authorities. The senior members of the group have been given responsible positions in several research and funding organizations. Prof. Dissanayake and I have been elected as members of the National Academy of Sciences of Sri Lanka. Some of the members have been serving as committee-members in the National Science Foundation, which is responsible for the promotion research in the country. Prof. Dissanayake has been appointed as the director of the Postgraduate Institute of Science (PGIS), a national institute for providing postgraduate degree programmes in Science. I have been serving as a member of the University Grants Commission and recently appointed also as a member of the National Research Council whose main function is to promote research in Sri Lanka by providing incentives for the active researchers in the form of awards and substantial research grants. Some of our members have received President's Research Bonus awards and are serving as members of editorial boards of journals. Many members have been serving as officials in some Scientific and Professional associations.

Some activities of the group have received regional and international recognition. Prof. Dissanayake and I have been involved actively in the activities of Asian Society for Solid State Ionics since its inception in 1986 and have organized the 5th Asian Conference on Solid State Ionics (ACSSI-5) successfully in Sri Lanka in1996. Now the group has been again entrusted with the task of organizing 10th Asian Conference on Solid State Ionics (ACSSI-10) in Sri Lanka in 2006. The group is also planning to make Peradeniya as a regional centre for promoting research in technologically important materials in the region, with the support of IPPS in the near future. Plans are underway to train some of Cambodian Physicists as a pilot programme under the proposed centre.

All the above achievements during the period of nearly 20 years have been possible due to several reasons: the closely monitored continued support given by the IPPS, the correct choice of research projects, the proper guidance and support offered by the host Scientists, mainly from Sweden and Denmark, and the good team work by the members of the group. Apart form sustaining high-level research programmes on technologically important novel materials, the group has also catalysed the research-work in other universities in Sri Lanka and in the region. This has been done through training young researchers, organizing seminars, workshops, conferences and by publishing joint research papers.

5. CONCLUDING REMARKS

The Department of Physics at the University of Peradeniya provides a successful example for the development of research activities in Physics in a Developing Country. This programme also has demonstrated the effectiveness of the sandwich Ph.D. programmes, not only in providing a combination of local and foreign postgraduate training to students but also in reducing the brain drain of trained Physicists.

Technologically important new materials is a good area for research in developing countries, as the input required is minimal and (once established) the research can be sustained with local resources. This line of research, while helping to build the knowledge-base of the country, may be useful in developing material and knowledge based industries. The dedication of the researchers, team work and correct choice of projects are essential for the success of the research activities. However, to maintain the standard and to keep the research up-to-date and to give opportunities for the students to work in advanced laboratories, the project must be carried out, whenever possible, in collaboration with well-established institutions.

The authorities in developing countries should provide encouragement and incentives for the researchers to initiate and sustain Physics-related research activities. The donor agencies, following the practice of the IPPS, should play an active role in promoting research-activities in developing countries, rather than merely providing funds. For the success of the research activities, the agencies should interact with the researchers, closely monitor the progress and provide assistance in identifying collaborators from the developed countries with a commitment to support the deserving projects on a long-term basis.

ACKNOWLEDGEMENTS

The financial support provided by the IPPS, Sweden, European Union, National Science Foundation, Sri Lanka, University of Peradeniya, PGIS, Sri Lanka, and the guidance and support provided by all our collaborators for developing the Solid- State Physics research at Peradeniya are greatly acknowledged. Appreciation is also extended to COMSATS for providing financial support towards my participation in the International Seminar on Physics in Developing Countries: Past, Present and Future.

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COMBINING COLONIAL AND AMERICAN EDUCATIONAL SYSTEMS TO IMPROVE THE STANDARD OF PHYSICS IN THIRD-WORLD COUNTRIES

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ABSTRACT

The physics teaching environment of a traditional university in Sri Lanka is analysed, taking into account the link of the educational system in the university to the colonial past of the country. The teaching environment of a newly formed American-based university in Colombo is also analysed and various characteristics of the two systems are compared. The effectiveness of the colonial system and the American system in the transferring of innovative skills and smart thinking in Physics to the students is investigated by applying feedback techniques to two similar samples of students in the two systems.

Three voluntary tasks were given to the two groups at different stages of the course. The outcome reveals that the American model is more effective in developing the innovative thinking and effective knowledge-transfer. Based on the outcome of the analysis, an appropriate method of combining the colonial and American systems to improve the quality of Physics in a third world country is proposed.

INTRODUCTION

Many countries in Asia and Africa were under the rule of either British or French Empires for over 100 years before they were offered liberty in the mid nineteens. Therefore in many such countries the educational systems were formulated according to the colonial concepts that prevailed in the early 20th Century. While the colonial masters have gone through many educational reforms to adopt new teaching and learning methodologies during the last few decades, the countries which were under these regimes have been self-locked in conceptual dungeons built up in the beginning of the last century. Although the description is applicable to other spheres as well, in this paper the contents are confined only to Physics.

Several countries with such colonial past broke away from their self imposed frames during the last quarter of the 20th century by adopting educational systems similar to that in USA. Thailand, Korea and Singapore are examples for such countries. They have reached considerably high levels of performance in physics education by the advent of the 21st century. Therefore, in this paper our objective is to investigate the pros and cons of colonial educational system and to propose a method to transfrom such a system into an American educational system with the least hazardous effects on the student-teacher communities.

To achieve the above discussed tasks, we selected two educational institutions in Colombo, namely the University of Colombo and the American National College (ANC) which is an extended campus of both Patten University and Northwood University in USA. The University of Colombo has a history of almost 100 years (the name has been changed several times). It was established during the time that Sri Lanka was under the British Government; thus the educational system, even at present has many resemblances to the colonial era. In contrast, the ANC was formed in the year 2002. The institution offers the courses in various streams for the first 6 semesters for a student seeking an American Degree. After this period, the students are transferred to an American University, depending on the results obtained. In both institutions, the selected samples comprised freshmen who are taken immediately after their high school career. Hence, the chances of them being completely absorbed into the respective systems are minimal.

THE EDUCATIONAL ENVIRONMENT

At the University of Colombo, the syllabi of subjects at a department is formulated after going through a long reviewing procedure by a panel of experts. Thus, the final syllabi are very good in standard. Once the syllabi are formulated and approved by the faculty board, they are in operation for a period of about 10 - 12 years. The individual lecturers that conduct the courses have very small margin to deviate from the core syllabus. The examinations are held, usually as a single written paper at the end of the semester or academic year. The practical component is conducted as a separate subject unit. Despite some reforms done recently, the physics syllabi still contain a vast collection of information on the concepts of elementary physics. Such vast syllabi reflect the lack of interactive and demonstrative teaching in the system. In particular, due to the long syllabus that has to be covered within a limited period, the teacher concentrates more on achieving time-goals rather than conducting classes in an interactive environment. A large course-content of elementary principles given in the notebook-format, in place of a short syllabus with demonstration kits and interactive modes, has proven to be a poor replacement, as it may direct the students to regard physics as a knowledge to be memorised and recalled at the examination (Zollman, 1990)

Most of the physics lecture-halls of traditional universities are characterised by a large closed table with a height of about 1.2m that separate the last student line and the lecturer's teaching position. Originally, this table has been designed for conducting practical demonstrations; however, now such performances are hardly practised and the table has become a large psychological barrier between the student and the teacher.

Basically, in the colonial frame within which physics is taught, the subject knowledge and scientific imaginations of the student are developed around the personality of the teacher, as has been revealed by the surveys done with a large sample of physics students. This heavenly figure of the teacher is a direct result of the master-servant perception of the colonial era and boosted by the father-centred social system in South Asia. Such conceptual impressions develop negative approaches among the students, both in subject-exploration skills and their scientific personality.

At American National College, the responsibility of formation and alteration of the syllabi is vested on the lecturer who conducts the courses. Thus he has a vast scope to design the course in a way that it suits his teaching skills and student group. The evaluation procedure has been divided into six segments and is conducted throughout the semester. The evaluation consists of two written papers on module quizzes, mid-semester and semester-end written papers, and a group presentation. A continuously evaluated practical component is also integrated into the course. The students are individually approached by the lecturer after each examination and advised regarding their lapses. The lecture rooms are also designed to have more physical approach between the students and the teacher. The students are in a semi-circle around the teacher who conducts lectures at the same floor-level. Thus, psychological barriers between the student and the teacher are minimised. In an American-system based educational environment, Physics is treated not as a collection of information that should be stored in the student's memory and recalled at the examination, but as a way of observing, collecting data, critically thinking, building models and comparing with nature. Thus, teaching physics is a challenging task, rather than a routine work of imparting the information the teacher has gathered. When this fact is understood the course implementation as well as the teaching techniques can be reorganised in such a way that the students are premeditatedly attracted towards the physics streams (Nappi, 1990; Konuma, 1992)

METHODOLOGY AND OUTCOME

The objectives of the following investigation were to understand the efficiency of imparting physics knowledge and skills to the students and to determine the development of innovative thinking of the students with respect to physics. A sample of students that follow a course on general physics, at the beginning year at the university of Colombo, was selected in the year 2001. The regular attendance to the class was around 80. They have passed the General Certificate of Education (Advanced Level) examination with good grading. At ANC, a group of students that follow general physics course has been selected in the year 2003; the regular attendance was about 25 students. They are of somewhat lower educational standard compared to that of the sample at the University of Colombo. The course syllabi at the two places were similar; however, the depth of sections of the syllabus at ANC was less. The teacher in both cases was the same.

Results: The students were given a spot-test (written) on the subject, 3 weeks after the commencement of the course. At ANC the test was treated as a part of their evaluation process (quizzes-1). According to the results at ANC, the marks were fitted into a Gaussian distribution with mode value around 60% of the full marks. At the University of Colombo, about 10% of the students got almost full marks (above 95%), while about 70% of the students got marks less than 40% of the full marks. However, at the year-end examination, the same group obtained marks that could be fitted into a Gaussian distribution with mode value at 62% of the full marks.

In the second test, conducted during the 6^{th} week, the students were asked 10 oral questions from general concepts of physics. The questions were given to the entire class, one after the other, and the students are asked to give answers on a totally voluntary basis. At the University of Colombo, the students responded in only 4 questions (one response for each question) and all four responses were correct. At ANC, 23 responses were obtained for the 10 question, out of which 6 were correct.

In the third case, at the end of the course, the students were asked to prepare a short document explaining a solution to the energy-crisis, considering that fossil-fuel will be completely exhausted within the following year. The students were told that the task is voluntary and a no-response is not going to affect their grading or any other requirement. At the University of Colombo, none of the students responded to this request, while at ANC 19 responses were received. Subsequent personal communication revealed that the students of the University of Colombo were not interested in the task, as they had to spend their time on preparatory work for the year-end examination. The students at ANC had only their semester-end examination during this period, which carries only 30% of their final grading.

DISCUSSION OF RESULTS

The outcomes of the three tests conducted show that the knowledge-transfer, skill-development and the enhancement of innovative thinking is better in the American Educational system, despite a well revised, high-quality syllabi applied in the traditional university system. The major reasons for this drawback in colonial university system may be the teaching environment, student-teacher relationship and the teaching methodologies that give priority to time-constraints, rather than interactive transfer of knowledge.

The development of conceptual understanding is an important component of learning physics. A goal is to have students describe and explain physics in words and put their knowledge into practise in a teacher-guided environment, in place of just solving numerical problems and recalling information. The teacher should also assist the students' general intellectual development, as well as improve their knowledge of physics. In the American system, these goals are generally reached through teacher-guided activities, rather than teacher-centred learning as being practised in the colonial system (Van Heuvelen, 1991). While, some modern educational technologists recommend student-centred learning as a better replacement to teacher-centred learning, this may cause very undesired outcomes in countries having a long- standing colonial system. In many South Asian countries, the youngsters up to maturity are mostly dependent on the family, so that they are brought up in an environment in which they built up their character and personality around a father-figure. Similarly, in the educational environment, the students develop knowledge-base and thinking on the image of the teacher. Hence, destroying this conceptual frame and suddenly adopting a student-centred learning environment may cause very undesired sequences, such as mental strain, frustration and personality retardation among the students. Therefore, a colonial physics-education system should be carefully and gradually transform into a teacher-guided system, taking social and ethical barriers of the country also into account

RECOMMENDATIONS

i. The universities in the third-world countries should model the physics-education system in wuch a way as, to encourage the development of innovative scientific imaginations within the students.
ii. In planning the education, system the social and cultural background should be taken into account. A teacher-guided, student-friendly atmosphere should be developed in the classroom.
iii. The evaluation methodology should be split into several parts

ACKNOWLEDGEMENT

The author would like to thank the head, Department of Physics, University of Colombo, and the Dean, American National College for providing the facilities at their respective institutions to conduct this research.

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PROSPECTS OF THE APPLICATION OF CERTAIN ASPECTS OF THE SOVIET SYSTEM OF EDUCATION IN NATURAL SCIENCES IN THE DEVELOPING COUNTRIES

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ABSTRACT

Dr. Salikhov of Tajik State University (Tajikistan) and Dr. Khan of Kohat University (Pakistan), in their paper "Prospects of Application of Certain Aspects of the Soviet System of Education in Natural Sciences in the Developing Countries" shed some light on some of the salient elements of the Soviet education system that existed during the Soviet days. The driving force behind penning this piece is the fact that advancement made by the mankind, particularly the West, are not reaching a significant chunk of the world, i.e., the developing and the under-developed world. The authors believe the solution to this problem is addressing the education system in the developing world and that the Soviet education-system is worth having a close look at, particularly vis-a-vis education in natural sciences.

The authors believe the USSR had an effective system for research education as well as for to produce scientists of high calibre. To implement that system of education fully elsewhere is obviously not easy, especially in the developing countries. However, some elements of this system can be used to develop physical sciences in several developing countries and thus implement modern technologies for their economic growth and to raise the standard of education and, with that, the standard of living of the population in these countries.

INTRODUCTION

About 100 years ago, Albert Einstein discovered the objective properties of space and time and presented his world-famous theory of relativity. A few years earlier, Max Planck had discovered the quantum nature of thermal radiations that gave birth to Quantum Physics Quantum Mechanics, followed by the Quantum Field Theory. The subsequent developments in physics are almost entirely based on these two events. Compared to all the previous achievements of mankind, the twentieth century was, no doubt, an era of great scientific development; with physics taking the lead, especially in nano- and laser technology. All these strides may be (rightly) called the intellectual property of mankind as a whole. In essence, it has given birth to a new world – a world with strong communications, high standards of living, and high technological advancements.

Unfortunately, not much of the comforts of such advancements have been accessible to a huge population in under-developed and developing countries. Add to it the high population growth-rate in these countries, and the result is the widespread deprivation and disenchantment. This has resulted in a logical tendency of migration from such countries to the developed ones. As such, a strategically important issue crops up that warrants support in education and ensure equitable share in the fruits of modern technologies. Part of this responsibility is to be shared by the physical sciences; physics included.

PROPOSED SOLUTION

One possible solution to this problem could be afforded by a suitable choice of effective system of education in physics. In this respect, the study of the educational system of the Soviet Union might be useful, since physics was developed these at the highest level. In this regard, one may observe that this system was established after the end of the Second World War. Some essential elements of this system are listed below:

1. Education was free of cost at all levels, from school to university
2. Network of schools with 4-, 7- and 10-years of education was established in all the villages, with the same educational standards
3. The children used to spend the first four years in one school, then go to another school for education up to Class 7, and on to another school for education up to Class 10
4. The trainings, as a rule, were conducted in the national languages (more than 100 nationalities!)
5. The Main books were published in all the national languages
6. One uniform system of alphabets – Cyrillic - was used
7. All children were trained both in national and Russian languages
8. In some Republics (Georgia, Armenia, Baltic Republics and West Ukraine), apart from Cyrillic, education was provided in the national language, using their national alphabets
9. Education was made compulsory for all the children from age seven
10. It was considered a crime if a child of that age was not given education, for which the local authorities and the director of schools were to be penalized
11. A sufficient number of state boarding-schools for orphans were built, where they were provided books, clothes, four meals a day, accommodation, and were engaged in study and sports

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12. The teacher was held in high respect by the people and the local authorities
    - In remote villages, he was considered as the carrier of knowledge and culture
13. High salaries were offered to the teachers
    - Salaries paid to the teachers exceeded the salary of the head of region or city (up to 1960), while the salary of a professor was up to two times the salary of

the leader of a republic (up to 1985)

14. Training for teachers was conducted in pedagogical universities and colleges
    - In Tajikistan, the Pedagogical Institutes were opened in Dushanbe (capital of the Republic), Khujand (north of the Republic), Kulob (south of the Republic) and Khorog (east of the Republic)
15. There were two types of trainings in these institutes:
    - Formal (morning and evening programs); and
    - Distance learning
    - The students (teachers of the primary schools) from far off places would complete 2-3 assignments/tests in each subject, each year
    - During the school-holidays (June-August), they were to attend lectures in a college/university for two months and were then allowed to take the examination
16. Multiple national and technical universities were established all over the country
    - For example, the Tajik State National University was established in 1948
17. All the educational labs were equipped with modern equipments
18. University education was of 5-year duration
19. In all universities, courses of physics, chemistry, mathematics and other disciplines were conducted under uniform program and, whenever possible, the medium of instruction was a national language
    - It allowed the students to master the contents of physical and chemical laws, and also mathematical formulas in a better manner
19. Students were required to do research work in order to get the degree
    - Often research was conducted on such a high level that it was published in international journals
20. There were three types of stipends available to students:
    - Ordinary: All the students passing the examination in good category were entitled to this (e.g., $45 per month in 1965);
    - Higher: Students passing 75% of the examinations in excellent category were entitled to this (e.g., $60 per month in 1965);
    - Lenin: Students passing all the examinations in excellent category with some active participation in the community work were entitled to this (e.g.,$110 per month in 1965)
21. Large research centers were created where only physics, chemistry, mathematics and biology were developed
22. Talented young scientists were appointed as directors of these centers. The number of such centers increased with time
    - An example of such centers of science was the Novosibirsk Centre of Science, on the basis of which centers of science were setup in the Western and Eastern Siberia, Ural and also in the Far East
23. National academies of sciences were established in all the allied and autonomous republics
    - The main research directions in these academies were the investigation of natural resources and development of fundamental sciences
    - Eminent scientists in physics, mathematics, chemistry, and biology were

invited from the major scientific centers of the Soviet Union to these academies
    - For example, in 1951 the Tajik Branch of Academy of Sciences was transformed into the Academy of Sciences, Republic of Tajikistan
- Hereinafter, the number of institutes in the Republic of Tajikistan reached up to 22
- With this, the number of scientists at the academic institutes also increased:
    - For example the S. U. Umarov Physico-Technical Institute, which had 30 scientists in 1964, had 300 scientists working in 10 labs in 1985
- In these labs, equipped with modern instruments, experimental researches were conducted on the following themes:
    i) Raman scattering of single crystals;
    ii) Acoustic properties of some single-crystals near temperature of phase transitions;
    iii) Relaxation properties of liquids and electrolytes;
    iv) Growth of new opto-acoustic crystals and study of their structures and properties;
    v) Physical properties of organic and inorganic semiconductors for a wide range of temperature- variations;
    vi) Study of the Features of the destruction of many polymeric materials through Mass-spectrometry;
    vii) Thermo-chemical processes in the lasers radiation field;
    Viii)A series of experimental researches was conducted on the spectral properties of different filaments, including that of cotton;
    ix) In 1978, for the first time in Central Asia (and also Islamic World) the liquid Helium at T=4K was obtained and spectral polarization and electro-physical properties of single crystals and some high- temperature superconductors at liquid Helium temperatures were studied;
    (x) The molecular theory of structural relaxation in simple fluids was presented; and
    xi) The theory of the double-scattering of light near the critical point was constructed
- A research lab (ca. 1000m^2 area) was installed at an altitude of 5,000m amsl in the eastern Pamir, with the cooperation of other republics and Poland, where research was conducted on the investigation of the energy-spectrum of the cosmic rays and physics of high energy
    - As a result, new discoveries were reported about the interaction of cosmic rays with the atmosphere and Earth's magnetic field on this installation
- During existence of this institute, its scientists published more than 20 books and about 2,000 research papers in international journals

24. Multiple specialized physico-mathematical schools were opened all over the country
    - Students for these schools were selected at All-Union Olympiads and regional competitions held in mathematics and physics for schoolchildren
    - Many graduates of such schools became prominent scientists in these areas

and made significant contributions, in particular, to modern physics

- Regular summer physico-mathematical and chemical schools were held for the young generation
- As a rule, these schools were set up in the comfortable places at the hilly stations, and headed by famous scientists from the Academy of Sciences
    - For example, in Tajikistan, the President of the Academy of Sciences, a well known scientist and philosopher, M.S. Asimi, was head of such a school
- The teachers selected for these schools were scientists from the Physical-Technical Institute, Institute of Mathematics and Institute of Chemistry, Tajik Academy of Sciences (TAS)
- During training in these schools, the students from different regions and institutes had the opportunity to meet famous scientists
- A good relationship would thus he established between students and scientists and also among students of different institutes in this academic village
- At the concluding session, olympiads were conducted among senior students (Class 10)
- The winners would get a certificate for admission in various universities of USSR (without an entry test)
- Students of lower classes would get a scholarship to continue their studies in the physics-mathematics school of Novosibirsk city

25. The so called "Small Academies" were organized to select gifted and talented schoolchildren. Young academicians were elected to the academy
26. The system of postgraduate institutes (called Asperantora) was meant for PhD students:
    - Admission to these institutes was based on competition
    - Post-graduate students were completely relieved of their other duties and were occupied in research work
    - The entire needed lab. equipments were made available to them
    - As per this education system, they were taught English and the fundamentals of philosophy
    - They were provided scholarships (more than $100 per month) and free accommodation
    - If a student's level was not up to standard, he would spent two years in any centre of science in the USSR, before coming back to the postgraduate institute
    - If one failed to complete his PhD research in 3 years, he would get dropped and no re-admission was allowed
    - For the successful completion of PhD, the student should have a minimum of 3 publications in international journals and would submit a thesis for defence
27. For producing high caliber scientists, there existed a system of Doctorantora [doctor degree] of 6 months to 2 years duration
    - Only those scientists could go for Doctorantora who had a certain number of publications in international journals
    - They were also required to take leave from teaching and other duties

- They had the opportunity to go to the centers of sciences and complete their research by utilizing all the available facilities, including information bank of libraries
- For the defence of doctoral thesis (second scientific degree), there existed a committee relating to that field of research in these centers
- Only those scholars were recommended for defence who has some new scientific discovery or some sort of invention
- The average time required for the doctoral degree was 10 years
- In exclusive cases (news about a huge discovery, either theoretical or experimental, resulting at PhD level), the doctoral degree could be conferred earlier.
- It may also be known that the second scientific degree existed only in the USSR; not in the western countries

CONCLUSION

Thus, it can be concluded that the USSR had an effective system for education and research as well as to produce scientists of high calibre. To implement that system of education fully elsewhere, is obviously not easy, especially in the developing countries. However, we believe that some elements of this system can be used to develop physical sciences in several developing countries and thus implement modern technologies for their economic growth and to raise the standard of education and, with that, the standard of living of the population in these countries.

PHYSICS EDUCATION IN PAKISTAN: AN ACCOUNT OF THE EARLY DECADES

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SUMMARY

This paper will cover the following aspects of Physics education in Pakistan:

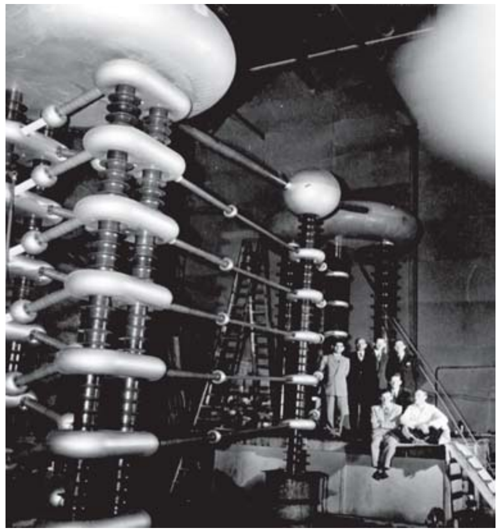
i. The position of Physics education and research at the time of independence (1947)
ii. Development of Physics education and research in 1950s and 1960s
iii. Revolution in teaching of science at different levels of education in developed countries after the launching of Sputnik by the USSR in 1957
iv. Curriculum reforms in science subjects at various levels of education in Pakistan in 1960s

POST INDEPENDENCE SITUATION (1947-1960)

At the time of Independence (1947), there was only one University in West Pakistan – The University of the Punjab. There were few departments like Institute of Chemistry in the University where Post graduate teaching and research work were being done. The Post-graduate teaching in Physics was done at the Government College, Lahore but practically no research work was being done in Physics. Later, the University established its own Physics department in its campus. In early stages, the Department concentrated on theoretical physics and on “Special Paper in Electronics” for M.Sc classes.

Prof. Dr. Rafi M. Chaudhry joined the Government College, Lahore as Professor and Head of the Physics department in 1948. He also asked me to join the College and introduced Research work in Nuclear Physics at the M.Sc. Level. He also succeeded in establishing “High Tension Laboratory” at the college. In 1954, 1.2 million volts Cockcroft – Walton Generator, Accelerator and allied equipment were installed in the Laboratory. Research publications started appearing in Nature and other journals. Later, one PhD was produced in Physics from this College and a number of reputed Physicists from abroad visited the Laboratory. Apart from that, Duke of Edinburgh also visited the Laboratory. Large number of Universities also started establishing in the various provinces and the capital of the country. There are now more than 100 universities in Private and Public Sectors in the country. Research work in Physics was also started by the *Atomic Energy Commission*.

Large number of Physics M.Sc students from Govt. College, Lahore also joined the



Cockcroft – Walton Generator (1.2 million volts) installed at High Tension Laboratory

Commission.

1960s When I took over as the Head of the Physics Department in 1962, I also started examining the contents of the syllabi and books in physics which were being taught at various levels of education. Wave mechanics was not being taught even at the M.Sc. level. Some of the latest theories were casually introduced in the M.Sc syllabi but detailed treatment was not given. The same was the case at lower levels. At B.Sc level even Vectors were not introduced. At intermediate level, stress was given to history of Physics rather than latest theories. Topics like Fluid theory of heat, Washing machine

Prof. M.L. Oliphant, F.R.S. Director Research School of Physical Sciences, Canberra, Australia visited High Tension Laboratory - 1955

etc. were being taught.

PERSONAL EXPERIENCES

I started studying the teaching of Physics at different levels of education being followed by various countries of the world.

After launching of sputnik on 4th October 1957 by the USSR, a revolution started in teaching of science subjects at different levels in USA and many other countries of the world. I got a chance to visit USSR, Turkey, France, U.K and USA in 1960s to study these programmes.

USSR

USSR succeeded in taking initiative in Space Science in view of their science education system. At school level, every student had to study all the science subjects i.e. Biology, Physics, Chemistry and Mathematics in addition to other subjects such as language, and so on. Great stress was given on Biology, Mathematics, Astronomy and technology.

There was a Secondary Polytechnic Institute, a Scientific Research Institute, in Moscow. One of its department was the Academy of Pedagogical Science. This Institute was divided into three sub sections

i. Arts
ii. Mathematics, Physics, Chemistry, Biology
iii. Polytechnic.

Continuous research work was carried on contents of subjects and methods of teaching etc.

There were a number of Experimental Schools in Moscow and at other places in USSR attached to the Institute. The institute was also running Postgraduate classes upto Doctorate level.

Every five year, teachers were brought to the Centre for training where they took part in development of curriculum, writing of text books, methods of teaching and other related activities.

Before appointment, teachers had to undergo nine month's training at Pedagogical Institute.

In USSR, there were Pioneer Palaces and Museums for children where students spent their summer vacation. Facilities were provided for students to play with science kits / models, which developed their creative habits and also exposed them to latest concepts in science. Observatory was also available in addition to photographic, sports and similar other facilities.

Germany and Cuba

In other Socialist Countries such as Former East Germany and Cuba, various trades were also made component of curricula. In former East Germany, subjects like tailoring were introduced in schools. In Cuba, work on agricultural fields was made compulsory.

USA

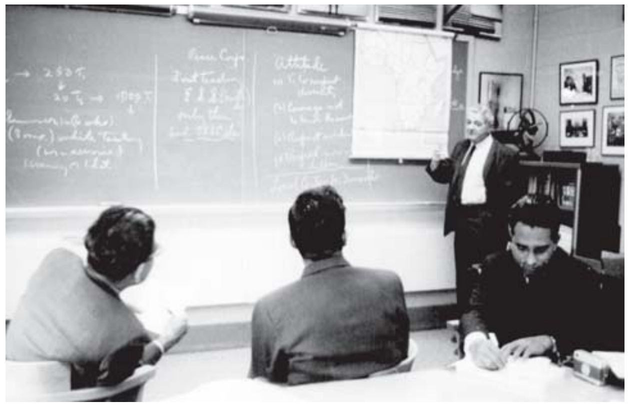
After the launching of Russian Sputnik, large number of projects for the improvement of science education were launched in USA and other countries of the world. In 1958, National Science Foundation, USA provided about 69 million dollars for the improvement of Science Education.

Some of the projects launched by USA were as follows:

i. Elementary Science Study (E.S.S) (Grade I to VII)
ii. Introductory Physical Sciences (I.P.S) (Grade VIII to IX)
iii. Physical Science Study Committee (P.S.S.C)
iv. Chemical Education Material Study (Chem Study)
v. Molecular Bond Approach (M.B.A)
vi. School Mathematics Study Group (S.M.S.G)
vii. Biological Sciences Curriculum Study (B.S.C.S)
   a. Yellow Version (An inquiry to life)
   b. Blue Version (Molecular approach)
   c. Green Version (Ecological approach)
viii. American Association for Advancement of Science Projects (AAAS)
ix. Harvard Physics Project
x. Berkeley Physics Course (after PSSC)
xi. M.I.T. Physics Course

Most of these projects were organized by Universities in USA, Many other programmes on the improvement of science and mathematics teaching were started by various Universities and related Educational Institutions in USA.

a. In the E.S.S programme, Teachers' manuals were written. Contents of the subjects to be taught were also written. Curriculum was not framed as such. It was different for children of different places. Simple teaching kits were designed. Teachers training programme for teaching the course was also launched. Teachers were required to give chance to students to play with the kits and find answers to the problems themselves under their supervision.



Professor Zakarai at M.I.T., Explaining the P.S.S.C. Project

One of the examples was that the student made their own balance with identical pans, thread and a wooden rod. They were also provided with uniformal small balls of equal weights. The student found the weight of a body in their own units of measurement. Teachers then brought the students to the conclusion that if every person uses his own units of measurement there will be difficulty hence the need for standard units.

b. Similar approach was carried out in I.P.S programme. The theory and practical works were integrated in the class room. For example, in teaching of Boyles Law, the teacher introduced three variable pressure, volume and temperature. The students were provided with simple type of Boyles Law apparatus with the help of which students discovered the relationship between pressure and volume while keeping the temperature constant under the supervision of teacher.

c. In P.S.S.C, shift was made from teaching of facts to thinking. Text book, Teachers'

Professor Harvay White Explaining a Model at Berkeley

Manuals, Simple Laboratory Equipment, Laboratory Manuals and Films were prepared. Teachers training programme was launched for teaching the course.

During my visits to the United States on different assignments, I used to visit research laboratories in Nuclear Physics, such as at New York, Chicago, Stanford, Berkley, M.I.T., Harvard which helped me in updating my lectures in Nuclear Physics for the M.Sc classes.

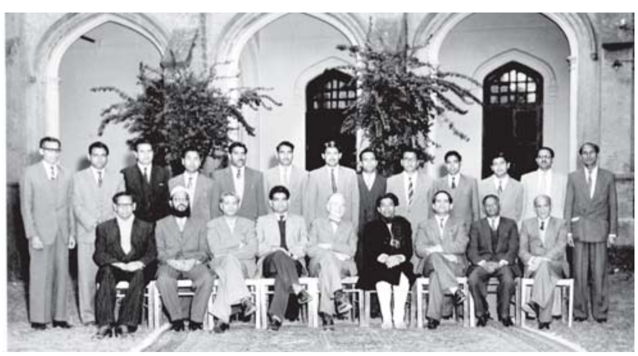
Scientists from U.S.A and other developed countries also visited my Department. Some of the Scientists who visited my Department are:

1. Prof. Emilio Segre, Noble Laureate, USA
2. Prof. Harvey White, USA
3. Prof. Pimental, USA
4. Prof. Marshak, USA
5. Dr. W.D. Allen, UK
6. Prof. P.M. Endt, Holland

United Kingdom

In UK, Nuffield Foundation launched Science Teaching Project. Text Books, Teacher Guides and Laboratory Manuals were written and laboratory equipment was designed in the subjects of Physics, Chemistry and Biology.

Australia In Australia, a new programme 'Science for High School', an integrated approach, was launched. Experts from all the branches of science sat together and prepared one course and brought out the book 'Science for High School' along with teachers guides and laboratory manuals. Separate books in Physics, Chemistry and Biology were also written for Senior Students. This wave of reforms also reached the Asian Countries.



Prof. Emilio Segre, Nobel Laureate, visiting Physics Department, Govt. College, Lahore

The reforms in Science Education in countries like USA, UK (described earlier) were shift from stress on technology to concepts of science in order to produce scientists who could create more knowledge and make new discoveries in their fields in order to compete with other developed countries.

With the discovery of new fields such as Bio-technology/ Genetic Engineering, Development of Computers, Space Science, Energy and Environment problems, the curriculum were again changed to link it to the world of work.

For example, in Physical Sciences, chapters like 'Science and Technology', Energy and the Future were introduced. Use of computers was introduced practically in all the programmes. Computer Test Bank and Teachers Guides etc. were made components of the programme. Computer Sciences became an important component in teaching of science and mathematics.

Denmark

In Denmark, Polytechnic Institutes were made open to workers who were running shops, etc. in the relevant fields to update them in their fields. Similar programme were also run by Sweden and some other countries.

Pakistan

In Pakistan, Curriculum reforms were introduced in Physics, Chemistry, Botany, Zoology and Mathematics during 1960s at all levels of education. Outdated theories

Prof. Emilio Segre, Noble Laureate, with Physics Students (Jone's Physics Society), Government College, Lahore

and history of science were removed and latest concepts were introduced in the curriculum taking help from similar programmes in other counties. New text books were written. Teachers were also trained to teach the new text books.

In physics, chapters on Birth of Modern Physics, Elementary Quantum Mechanics, Theory of Relativity, Vectors etc. were introduced at Intermediate level. At B.Sc level, Waves and Oscillations, Modern Physics and other topics, (taking help from Berkley Physics course) were introduced. At M.Sc level, full paper on Quantum Mechanics was introduced. Other papers especially Atomic and Nuclear Physics were updated.

Introduction of New Syllabi in Australia

A. A new approach to teaching of science and mathematics (1989) were evolved in Australia. Board of Secondary Education, New South Wales, Australia had developed a syllabus 'Mathematics in Practice' for students in years 11 and 12 who are preparing for the Higher School Certificate. The course was designed to be studied by beginning with situation which involve mathematics rather than by beginning with mathematics itself.

The objectives of this syllabus are addressed through eight modules:

- The Consumer
- Transport
- Travel
- Accommodation
- Health
- Design
- Social Issues

Prof. Pimentol and Prof. Harvey White visiting Nuclear Research Laboratory Government College, Lahore.

- The Mathematics for Early Childhood.

The Mathematical skills involved include:

- Collecting and presenting information
- Interpreting and using data
- Interpreting and constructing graphs
- Calculating
- Substituting into formulae
- Estimating
- Analyzing situation and making decisions
- Using geometrical instruments
- Measuring

There are a number of implementation strategies such as:

- Use of Computers
- Use of Hand-held Calculators
- Field work and excursions, etc.

A brief description of one of the modules is given below:

- Consumer
  i- Income
  a) Earning Money: Students should be aware of many ways of obtaining income.

Activities

- Collecting information regarding types of pay and rates of pay in various jobs

Prof. P.M. Endt, University of Utrecht, Holland visiting Nuclear Research Laboratory, Govt. College, Lahore (1967)

including part-time work

- Calculating gross pay from information on hourly rates, salary, overtime, retainers and commissions, pensions, piecework payment and bonus payments.
- Calculating net pay, taking deduction into consideration including taxation.

ii. Making Money

Students should be able to determine a suitable retail price for a simple item, taking into account labour and material costs, to achieve a profit or break even. Students could engage in running a small business, for eg By selling handicrafts at a school fete.

A number of activities are included as in the case of Income
iii. Saving Money Students should become aware of the possibility of saving for future purchases

A number of activities are included:

ii. Expenditure

Following topics are covered in the same way as for Income:

i. Spending money
ii. Borrowing money
iii. Deferred Payment

Prof. Nicholas Kemmer, FRS, Institute of Mathematical Physics, Edinburgh University, visiting Nuclear Research Laboratory, Government College, Lahore

iv. Insurance
v. Energy Consumption

The remaining seven modules are treated in a similar way in the syllabus.

In this syllabus student learns Mathematics by practicing it and he also understands and becomes capable of handling situation which he faces in his daily life.

A similar syllabus has been produced by the NSW Department of Education for Primary Schools Introducing Mathematics K-6 to the Community.

2. Similarly a syllabus for years 11-12 in integrated science, 'Science for Life' has been developed which emphasizes the relationships that exist between science, technology and society by the Board of Secondary Education, NSW Australia. The course content is organized in the form of modules which fall into three broad subject matter areas.

a. People, work and leisure
b. People and the environment
c. People and technology

The modules studied in these broad modules are:

a. People, Work and Leisure

i. Fashion and Science
ii. Horticulture
iii. Human Body
iv. Science fiction
v. Science of toys

Hameed Ahmed Khan during his Post MSc Research Work at Physics Department, Government College, Lahore

vi. Sports Science

b. People and the environment
   i. Disasters
   ii. Managing natural resources
   iii. Marine or river studies

C. People and Technology
   i. Biotechnology
   ii. Communication
   iii. Consumer Science
   iv. Space Science

Each module has been further divided into different Focus Ideas. Each Focus Idea carries with it skills and suggested activities.

Students of Physics in Pakistan

The Physics students produced in early decades in Pakistan have done and are doing excellent work abroad and in the country. Some of them are working in Pakistan Atomic Energy Commission (PAEC), National Engineering and Scientific Commission (NESCOM), Kahuta Research Laboratories (KRL), Commission on Science and Technology for Sustainable Development in the South (COMSATS) and other Research and Teaching institutions. They are keeping themselves abreast with the development of technology and the subject in their fields.
Suggestions for the Promotion of Physics in Pakistan

Foundation Conference of the Federation of the Universities of the Islamic World, Rabat, Morocco, 30th November and 1st December 1987

a. Some universities in Pakistan should have Departments for the development of Science and mathematics syllabi, teaching methods, teachers training, teaching aids etc. for all levels of education. These Departments should have a library containing all materials – syllabi, text books, teachers manuals, laboratory manuals, Films and other teaching aids of all level of education from developed and developing countries. Teachers from different levels of education should also be sent abroad in selected universities for training. Teachers training programme should also be organized by these Departments. If the Universities do not establish such Departments, COMSATS can undertake this project.

b. The Islamic Educational, Scientific and Cultural Organization (ISESCO) should also launch a joint big project like CERN on topic to be decided by the Physicists who are engaged in research work. These countries have trained manpower and resources.

CONCLUSION

If anyone now tries to get the data on the projects from the countries which I have mentioned in this paper, he will find a different world today. Everything is in motion in the Universe. According to scientific rule, any living species that do not adjust to the environment and time, vanish. So is the case with nations. Any nation which does not move with time is left behind and is left at the mercy of developed nations. So please join hands, use all the resources (men and material) and move forward so that the ISESCO countries become developed nations. Talent, trained man power and resources are available in these countries.

CHALLENGES FACING THE ROLE OF PHYSICS IN THE DEVELOPMENT PROCESS

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ABSTRACT

Before speaking about the role of physics in developing countries, it is more convenient to speak about the background which makes physics and other fields of science to be active, and not passive. For instance, there are many parameters, which I find, from my point of view, very necessary to make the developing process effective in the developing countries. These parameters are enumerated, elaborated and discussed in this paper.

Keywords: Physics role, developing countries, developed countries, applications, thin films, sensors, photocatalytic, titanium dioxide.

INTRODUCTION

1. Basic Parameter

Many parameters that may affect the role of physics and science in developing countries, which are:

- History
- Talent Discovery & How to Be Directed to the Right Direction
- Creativity
- Life Planning (Planning for every thing, short and/or long)
- Centers of Excellence
- Media and Public Audients
- Good User – Producer
- Science and Industry
- Local Solutions for Local Problems
- Minimizing the Leakage and Misuse of Resources
- Culture
- Forces against Developing (Locally & Internationally)
- Democracy

In National Research Center NRC, and also in our group-work in Solid State Physics Department, there are many attempts concerning this matter, such as:

- Physics and Applications

- Link between Science and Industry
- Center of Excellence at NRC (ex. Nobel Project)

2. Definitions

I'd like first to mention three important definitions, as given in the dictionary:

- Developed Countries: Advanced in industrial capability, technological sophistication, and economic productivity.
- Developing Countries: Having a relatively low level of industrial capability, technological sophistication, and economic productivity.
- Physics: The science of matter and energy and of interactions between the two, grouped in traditional fields such as acoustics, optics, mechanics, thermodynamics, and electromagnetism, as well as in modern extensions including atomic and nuclear physics, cryogenics, solid-state physics, particle physics, and plasma physics.

3. History

It is very important to learn from history and to learn from our mistakes to avoid the same mistakes in the presented and in the future. Development is accumulated process, and the history is an important parameter in it.

What do the developed (modern) countries base their development? Do they base their development only on things they invented or inherited? I think all mankind, from the beginning of the history till now, shared in the developing process.

What we now call developing countries led the progress and the development almost two hundred years ago and they still share in the process!

Many scientists who are graduated from the developing countries are involved directly or indirectly in almost all the sophisticated research programs in the developed countries.

4. Talent Discovery and How to Be Directed

It is very important for the children and young people to be directed to the suitable fields of study, which meet their qualifications. They have to find themselves in these directions and to have fun, then, they can be creative persons.

Also, all the community has to know the importance of talent, and to realize that each position is very important for the community, and to put the most suitable person in the suitable position.

5. Creativity

It is very important to build our educational system on the technique of solving problems, not just to memorize a lot of information to reproduces it in the exam, and then nothing remains in the head after!

In each course, the students would have to learn small points or issues which have never to be forgotten. So, after their graduation in this manner, they will have the essential basics and background that make them capable enough to analyze any problem and solve it. Also, for one problem, there may be many ways for solution, which makes them creative, and trained to invent new solutions.

6. Life Planning

Planning has to be a tradition for each person. In some countries, the person usually raised upto make plans for any thing and every thing he wants to do: work plan, holiday plan, …. even plans for their lives. Development of this tradition will increase the awareness and the importance of the science and research, and of course of physics.

7. Centers of Excellence

It is impossible to change all the community and society at once, but if we try to create centers of excellence to be good example to the society, this may be an effective way to change it. These centers will penetrate in all the society and would be linked with each other. By focusing on them, by using the media and all the other possible means, the society will gradually turn to be a center of excellence itself.

8. Media

The media has a major role in the developing countries. For each problem, the researchers and specialists are the ones asked for the right solution. Publicizing this will lead the public to be aware of the importance of physics and other fields of science in their lives.

9. Good Users and Producer

The educational system has to produce good users for the technology and from them, we can get good producers. If the layman (ordinary person) is well trained and educated, some of them will be automatically inventers and excellent researchers. It is not logical for the persons who cannot use the technology to find new ways to solve the technological problems!

10. Science and Industry

Science develops the industry and solves its problems, while the Industry makes investments in science, and I think, this is the right circle.

But unfortunately, in many developing countries, there is no real production, just assembling of the imported parts. The industry is controlled by international companies.

The developing process of the products and the solutions of local problems depend totally on the international companies.

Sometimes, the imported solutions are not suitable for the local problems.
Even more, some of the imported or assembled products are not suitable for use in the local environments. Consequently, there is no link between science and industry in some of the developing countries.

11. Local Solutions for Local Problems

Most of the local problems cannot be solved by imported solutions. When we try to solve our problems locally, this will create researchers who will use physics and other fields of science to solve these problems. But at the same time, we have to be open-minded and learn from the entire world.

12. Minimizing the Leakage and Misuse of Resources

The aim of science and research is to improve our life-style and to find a reasonable solution for each problem; this leads to the optimization of using our resources. It is not logical to invent a way to improve our life, and at the same time, we are destroying, for instance, the environment.

13. Culture

In many developing countries, people are not accustomed to use reason or common sense to solve their problems, which makes it impossible for them to use science effectively. Many of them just move randomly, which makes all the right steps annulled by the wrong ones, and at the end the resultant is zero. The progress can not be made at once, but the process must be accumulative, and each day we make even one step further in the right direction.

14. Forces against Development (Locally & Internationally)

People who are benefiting from the current situation are usually against any change. There are many developed countries, which have limited resources or none, but import the raw materials, at a low prices, from the developing countries, and export them again as products for high prices. Some of them are against any real development in the developing countries, which may go against their benefits. Also, locally there are many agencies which are related to these developed countries or international companies, and they want the situation to remain as it is!

15. Democracy

I do not here mean by democracy the governing by the majority only, but I mean any kind of system which makes the people have essential role and freedom in choosing the person who will represent them, and when he makes a mistake, the people can judge him or fire him and replace him with more qualified one. This will reflect on all other social activities, including the scientific ones. And at the end, the people will be chosen according to their qualifications and not due to other factors. This will raise the values of work, creativity and competition.

16. Activities in National Research Center (NRC), Cairo, Egypt

In NRC, there are many efforts to improve our scientific situation, including using physics to develop our country:

16.1. Science and Applications

All the researchers in NRC have to be financed through projects that have industrial applications and real benefits for the community.

16.2. Link between Physics and Industry

NRC established an office for this purpose and search for the needs of the industry, and directs the research to these needs. Many meetings made between businessmen and companies from one side and the researchers in the different fields to develop links between each other.

16.3. Center of Excellence at NRC (ex. Nobel Project)

NRC has now a project, which is called “Nobel Project” to choose the creative researchers and facilitate them with modern laboratories, with complete services and supplies, and encourage them to make first-class researches that can serve the community, and can be published in the international journals. Most of the research will work through projects that will be judged from international referees.

16.4. Physics & Applications in Solid-State Physics Department

In our department and our group, all the research activities are directed mainly towards applications:

- We make thin films by different techniques for applications, such as: sensors, photo catalysis, solar cells, photo chromic & electro chromic etc…...
- We have a special unit which provides services for industry, by measuring the

dielectric properties, the optical properties, and provide many other scientific services.

I will mention some trends of our group work, such as: sensors & photocatalysis, as example for using physics in the developing process and applications.

16.4.1. TiO_2 as a Multifunction Material

Semiconductor materials such as TiO_2 has found extremely wide and important applications in many fields of chemical engineering and materials engineering, such as catalysis including either traditional catalysis, or photo catalysis and gas sensors. Most of these applications are a consequence of its n-type semiconducting property and realized with micro or nano structured TiO_2 powders or thin films. Therefore, preparation of high-quality semiconducting materials such as TiO_2 thin films is of great importance [1-5].

16.4.2. Experiment

A developed spray-pyrolysis setup has been designed and assembled to overcome limitations of previous systems, such as repeatability and homogeneity of the deposited films. The system is almost fully computerized and consists of the following components: PC-controlled x-y table, digital temperature controller, digital gas-flow meter and digital solution-pump. Most of these components are working alone, with built-in processors, and/or are controlled by PC. A schematic diagram of the used system is given in Figure - 1.

The TiO_2 films were deposited on 2.5x1.5x0.1 cm^3 glass substrates, after applying the conventional cleaning procedures. This type of glass (Menzel-Gläser, Germany) is stable upto more than 600°C. It has a lower cut-off wavelength (280 nm), which is far away from that of the prepared TiO_2 (325 nm), and also it is not expensive, which makes the produced films more attractive for industrial applications. The deposition parameters are: 0.8 M solution of chemically pure $TiCl_4$ dissolved in ethanol. Filtered air is used as a carrier and director gas. The solution and gas flow rates are 0.7 ml/hr and 25 l/hr, respectively, the substrate temperature range is 325-475°C and the spray time range is 5 to 30 minutes.

X-ray diffraction was used to elucidate the structure of the prepared films. The atomic force microscope (AFM) studies are carried out in the National Institute of Standards (Egypt). The deposited samples are imaged in contact mode. The images presented here are submitted to a flatness process. The crystallite diameter was measured on the original image before the flatness process. The film thickness was measured in the National Institute of Standards by Interference Microscope for samples have an edge and coated with Ag film. The gas-sensing properties of the deposited films toward oxygen, hydrogen and carbon monoxide (CO) are measured at controlled humidity (RH 35%) and the temperature of the chamber containing the sensor was maintained at the operating temperature. The changes in the sensor electrical resistance due to

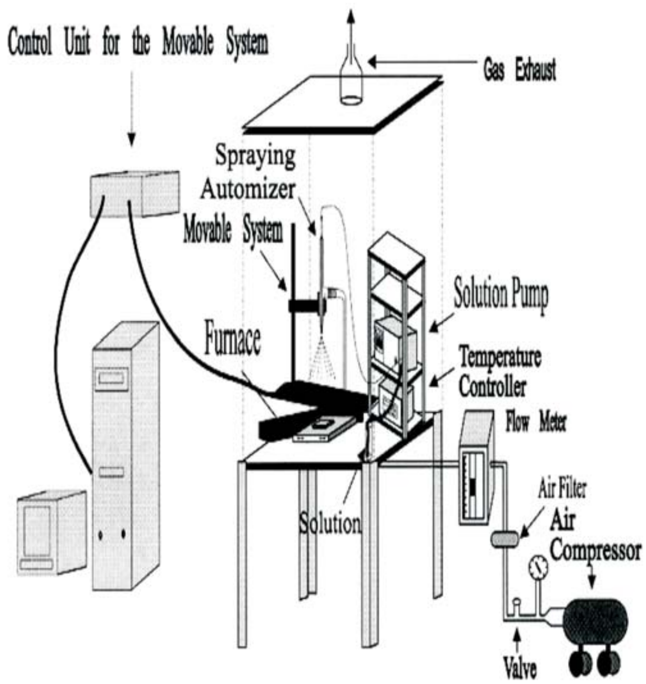


Figure - 1: The Movable and Computerized Spray Pyrolysis System with X-Y Table

variations of the surrounding atmosphere have been recorded and monitored by METEX (PC interface Multimeter Peak Tech 4370). Dry carbon monoxide gas-generation system was used to obtain CO gas from chemical reaction of sodium formate (NaCOOH, Fine chem. LTD) and sulphuric acid (H_2SO_4, 98%). The volume of produced CO is determined from the following equation:

$$2NaCOOH + H_2SO_4 \rightarrow Na_2SO_4 + 2CO\uparrow + 2H_2O$$

The Other two gases (O_2 & H_2) were also tested and fed from their corresponding cylinders.

Photo-catalysis experiments were performed in cooperation with Otto-Schott Institute, Jena, Germany. The TiO_2 films were deposited on (Menzel-Gläser, Germany) glass substrates, after applying the conventional cleaning procedures. The deposition parameters were: 0.1 molarity of the starting solution, 350 l/h air volume, 1.0 ml/min. solution-rate, 450-600°C deposition-temperature range and 5-30 min. spray-time range. Titanium (IV) isobutoxide, Ti $((CH_3)_2CHCH_2O)_4$ (MaTeck), was dissolved in a mixture of one tenth HNO_3 and nine tenth of methanol (Laborchemie Apolda, p.a.).

Table - 1: Values of Crystallite Size at (101)

Temperature (^oC)	Crystallite size (Å)
375	173
425	189
475	212

X-ray diffractometery (XRD) was used to get a more detailed view of the structure of the prepared films. Atomic force microscope (AFM) (JENAVAL, Carl Zeiss, equipped with a SIS-Ultra-Objective) was used to get information about the surface topography of the films. The UV/VIS/NIR-spectra of the samples were recorded by a spectrophotometer (UV-3101PC Shimadzu, Japan) to investigate the optical properties of the prepared films.

A computerized High-Performance Liquid Chromatography (HPLC) system LC10, from Shimadzu, has been used to determine photocatalytic activity of samples. The UV-catalytic transformation of methanol traces to formaldehyde (HCHO) in water has been used as a standard test-system for evaluating the photocatalytic activity of the films [Formaldehyde-DNPH-derivative method has been established by Kaessbohrer, Diplomarbeit FSU Jena, Germany in 1996]. A solution of 5 ml methanol in 100 ml HPLC-water was illuminated in the presence of glass slide carrying the deposited TiO_2 film (acting as a catalyst), using a Xenon lamp (280 W UVASport 400 lamp, spectral output 330-350 nm). An increase of temperature of this solution has been avoided by filtering of IR-components of the irradiation light. After 10 min., irradiation has been stopped and a special reagent dinitrophenylhydrazine (DNPH) was added to the solution. After 15 min. (reaction time) at room temperature, the resulting solution was ready to be analyzed by HPLC-technique. The concentration of aldehyde-DPNH derivatives, [39-41], can be determined with isocratic reverse-phase high-performance liquid chromatography (HPLC) with ultraviolet absorption detection (detection wavelength 350nm). A relation between the retention time and the detector counts was made. From the formaldehyde-DNPH derivative- adduct-peak (in our conditions after about 4.7 min. retention time), an estimation of the catalytic activity of the TiO_2 films was made, using conventional standard probe technique**.**

16.4.3. Results and Discussion

The X-Ray diffraction (XRD) analysis was conducted to determine the phases and the grain size. The XRD patterns for the investigated samples prepared at different deposition temperatures and constant deposition time, as well as those deposited at different deposition-times and constant deposition-temperature are shown in Figure-2.

The samples deposited at 325°C shows a broad hump at 2 (20-30), which indicates that the structure is amorphous. The XRD patterns for samples prepared at temperatures > 325°C show in addition to this, only two peaks: their intensities increase as the deposition temperature and deposition time increase. These peaks are indexed with the standard JCPDS (21-1272) and found to be corresponding to (101) and (004) anatase phase [6-8]. The phase diagram of Ti-O compound [9] reported that the rutile is formed at above 800°C in equilibrium conditions. In this work, the covered range of substrate temperature is from 325 to 475°C, which is still insufficient to grow the rutile phase. The mean crystallite size has been obtained with the Scherer relation [10],

$$D = k / (BCos)$$

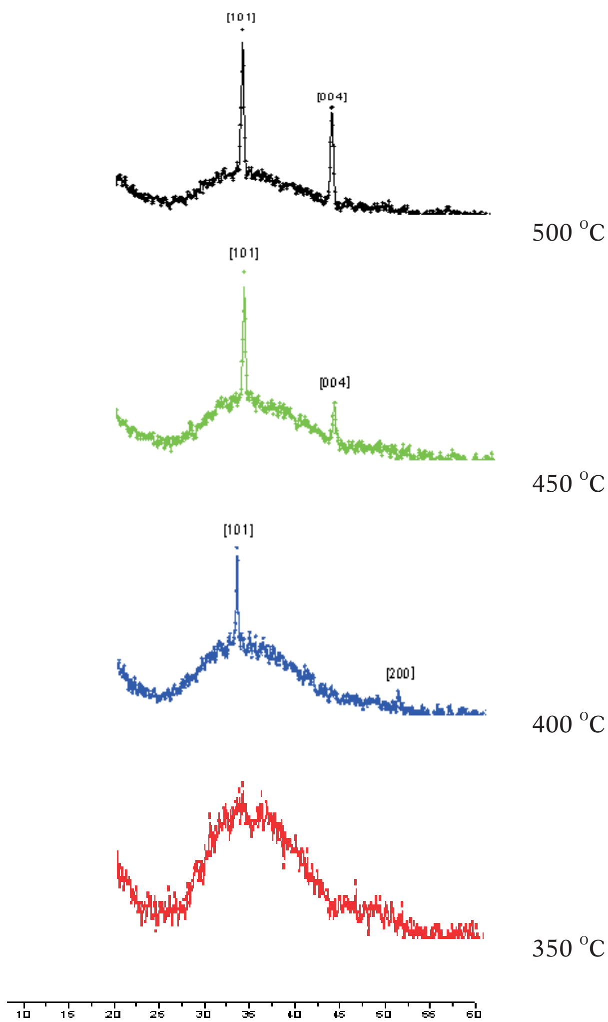
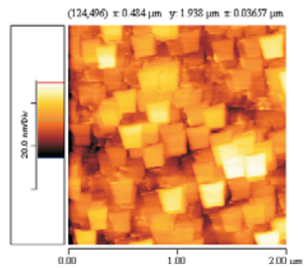
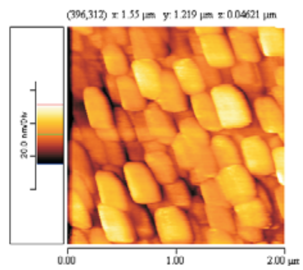


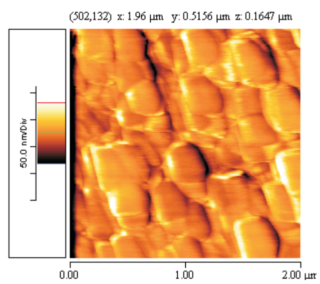
Figure - 2: XRD of TiO_2 Films at Different Deposition Temperature and 30 min Spray Time



375 °C



425 °C



475 °C

Figure - 3: AFM Images for TiO_2 Film Prepared at (375,425 and 475°C) and 30 min.

where D is the crystallite size, k is a fixed number of 0.9, is the X-ray wavelength, is the Bragg's angle in degrees, and B is the full-width-at-half-maximum (FWHM) of the chosen peak, using FWHM values of the (101) and (004) lines. The values for representative investigated samples at (101), where 2   25.5 degree, are given in Table-1. The crystallite size increases from 375°C up to 475°C.

Atomic Force Microscopy (AFM) images from samples prepared at 375, 425 and 475°C and deposition time 30 minutes are reported in Figure-3. AFM images show that the films are composed of small crystallites. The average crystallite diameters are 20, 23 and 28 nm respectively. These values are consistently larger than the size measured with XRD. As XRD is sensitive to the crystallite thickness perpendicular to the film and the AFM image show the film surface, therefore, the grains are presumably larger at the film surface than that at the inner regions.

The effect of the deposition temperature on the transmission coefficient of TiO_2 films, can be seen in Figure - 4. The transmission is slight improved by increasing the deposition temperature T_d from 500 °C to 600 °C at the same spray-time 10 min., and this is perhaps due to the improvement in the crystallinity of the films, and / or the evaporation of the undesired bi-products. The transmittance of TiO_2 films is around 85% in the visible range. Changing the deposition parameters, deposition temperature and deposition time, did not lead to any change in the energy band gap (Direct), which is almost the same for all of the prepared films, E_g (direct) 3.8 eV ($_{\text{cut off}}$ 325 nm). The $_{\text{cut off}}$ of the glass substrate is around 280 nm., so it does not affect or interfere with that of our films, and ultimately has no effect on the band gap. It was found in the literature [11, 12] that TiO_2 has a direct and indirect band-gaps, and the direct band-gap changes from 3.58 to 3.79 eV and the indirect changes from 3.05 to 3.4 eV, according to the preparation parameters and conditions. In this work, the direct band gap was found to be in the region of 3.8 eV, which is in agreement with the literature. This subject was studied in details in the literature [13,14].

16.4.4. Sensors

The sensing properties of TiO_2 films are based on surface interactions of reducing or oxidizing species, which affect the conductivity of the films.

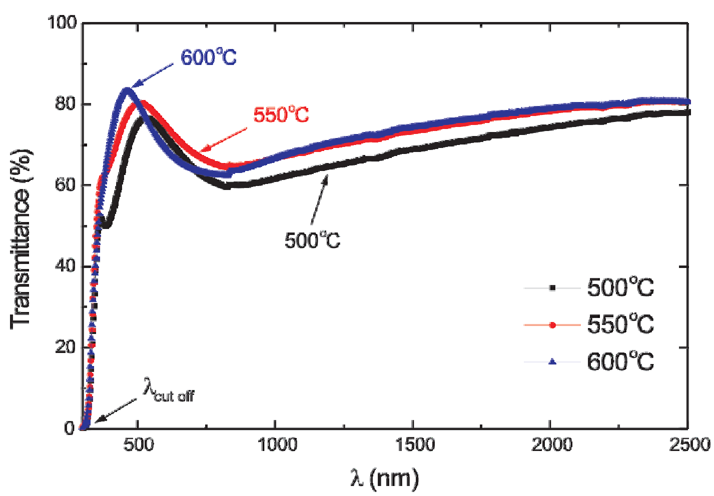


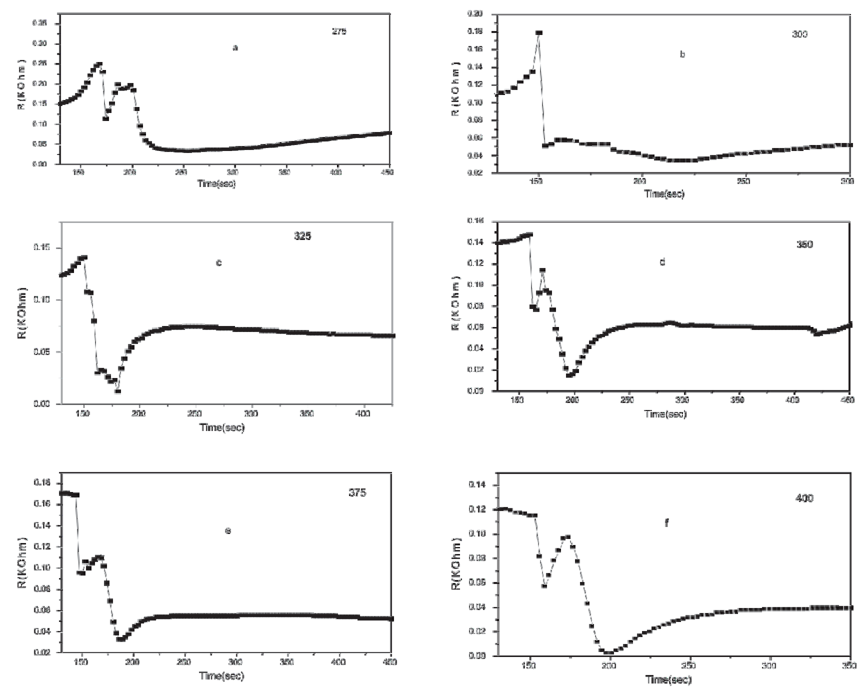
Figure - 4: Transmissionspectra of TiO_2 layers on Glass Substrates, Prepared at Different Deposition Temperatures and the Same Spray-Time (10 min.)

Effect of gases on DC electrical properties

TiO_2 films deposited at 475°C and for 30 minutes, since they are well defined crystallite shapes as revealed by AFM, are selected as a model to study the effect of reducing (CO & H_2) and oxidizing (O_2) gases on their dc resistance. This study is devoted to explore the sensing-properties of the selected samples, to be used as sensors for the mentioned gases.

A home-made measuring system provided with oxygen, hydrogen cylinders with their manometers and CO glass-reactor is used. All these gas sources are connected to the system through a polyethylene pipe-line 1.5 meter and with glass taps.

The results of the change in the film-resistance with time of the TiO_2 films during their exposure to CO, H_2, and O_2 at different operating temperatures, are shown in Figures-5, 6, 7, and the sensitivity and response time for CO and H_2 in Figures-8,9, respectively.



Figures -5: Effect of CO Gas on Resistance TiO_2 Prepared at (375°C) and (30 min) at Different Operating Temperatures from 275° to 400°c.

(The same reaction)

$2NaCOOH+H_2SO \quad Na_2SO_4+2CO+2H_2O$

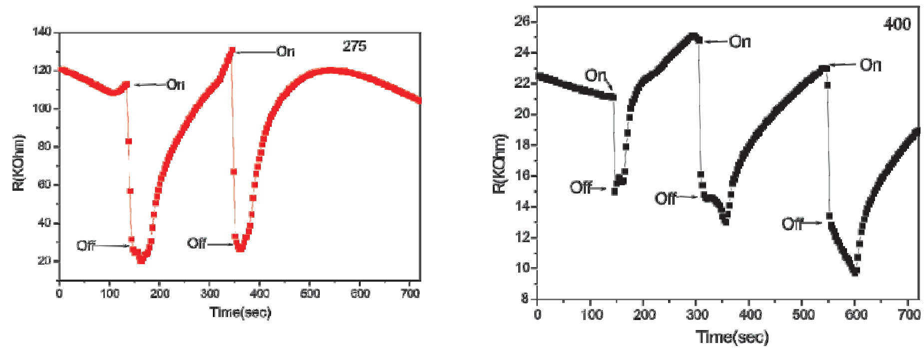


Figure - 6: Dynamic Response for H_2

16.4.5. Photo Catalysis

TiO_2 was used as a powder successfully in purification of the waste and contaminated water, but there was a problem to collect the powder again after the purification, and also to improve the porosity, which increases the photocatalytic activity PC.

By using TiO_2 thin films, produced with a non expensive technique such as spray pyrolysis, it was possible to avoid these problems. TiO_2 films showed a very good photocatalytic activity PC, which indicates that there is a chance to use these in environmental applications, such as: purification of waste (Sewage) and contaminated water (for instance by the industry).

The HCOH-adduct-peak at 4.7 min. was used as an indication of the photo-catalytic activity of TiO_2. The HPLC chromatogram of UV-irradiated sample, without using TiO_2 as catalyst, is shown in Figure - 10; with TiO_2 at different deposition temperatures and at the same spray time (t_s = 10 min.) in Figure - 11, and at different deposition time and at the same deposition temperature (T_d = 550 °C) has been summarized in Figure - 12.

As mentioned before, The TiO_2 films were deposited on (Menzel-Gläser, Germany) glass substrates. The glass substrates (after heat treatment similar to the later TiO_2 deposited films) did not show any catalytic activity.

The peak at 4.7min in Figure - 10 is like the "background" of the whole treatment, which is due to adding a special agent to "catch" the very low traces of HCHO in the liquid phase. The small peak may indicate some HCHO in the air of the lab and some oxidation from CH_3OH to HCHO by applied UV-light (without catalyst).

It is obvious that without using TiO_2 the 4.7 min. peak is very small, Figure - 10, but after using TiO_2, the peak is much larger and increases with increasing the deposition temperature, Figure - 11, and also with increasing the deposition time, Figure - 12,

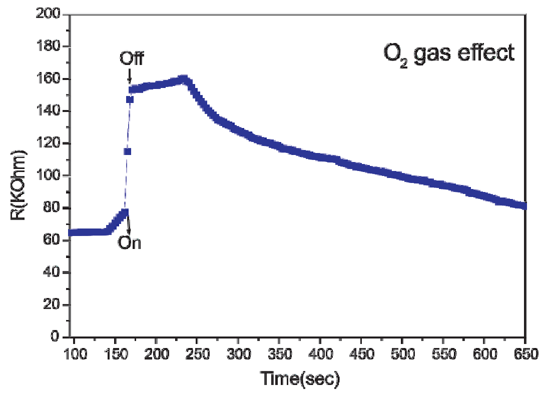


Figure - 7: Dynamic Response for Oxygen

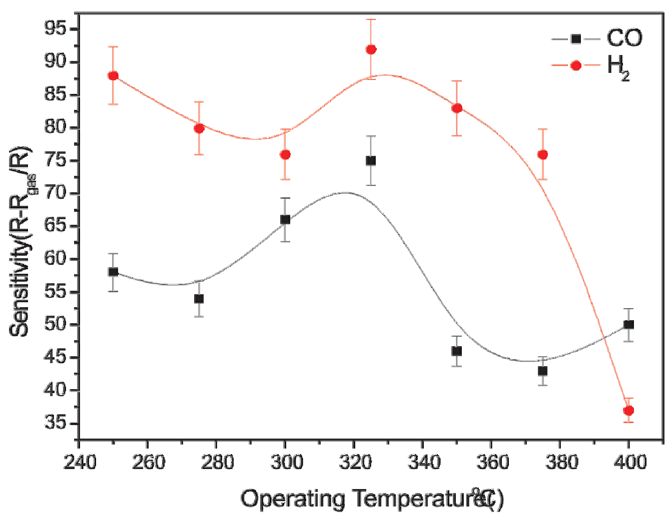


Figure - 8: TiO_2 Film Sensitivity Towards CO and H_2 Gases at Different Operating Temperatures

these results are confirmed clearly, where the HCOH-adduct-peak area is increased with increasing the deposition temperature and spray time.

The improvement of the photocatalytic activity with increasing deposition temperature may be due to the fact, at higher deposition-temperatures, the residual species evaporate as volatile gases. The deposited crystallites become closer to each other allowing film densification. At longer deposition times, the thickness of the films increases and the porosity too. That is why the effective TiO_2 material per unit area increases and as a consequence increases the catalytic efficiency of the TiO_2 films, Figures-(10-12.

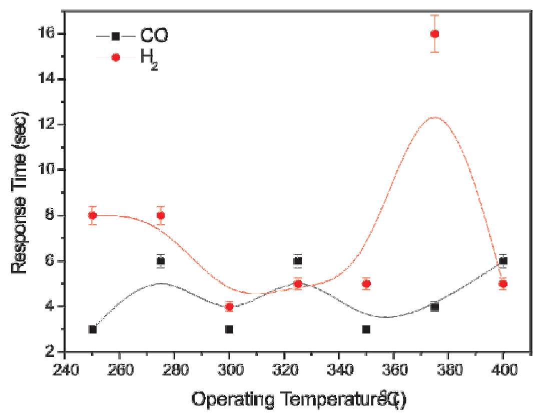


Figure - 9: TiO_2 Film Response Time Towards CO and H_2 Gases at Different Operating Temperatures

17. CONCLUSIONS

From the foregoing examples and discussion, we may conclude that the role of physics and science in developing countries is essential for the development process. To make this role effective, we need to learn from history, to discover talents of the young people, to encourage the creativity, to adopt careful planning for every thing, to make centers of excellence, making physics popular by using media, encouraging the researchers to find solutions for each problem, especially the local ones, reserving our resources and minimizing leakage and misuse, changing the peoples attitude (culture), to be aware about the forces which are against the change, choosing the right

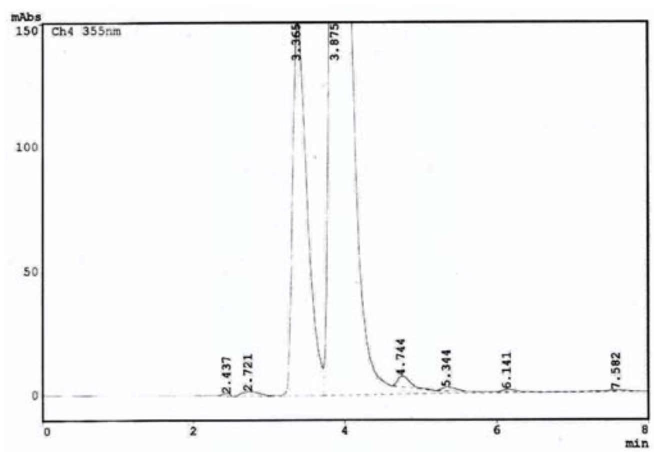
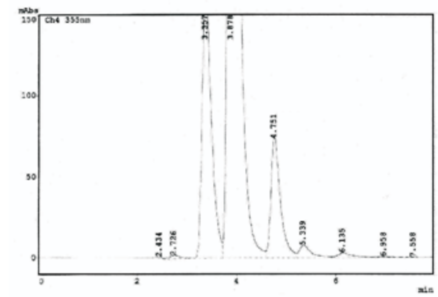
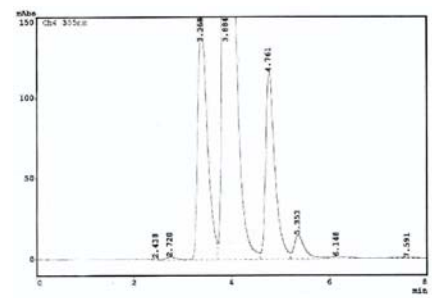


Fig. (10) HPLC Chromatogram of Aldehyde-DNPH Derivatives, Peak at 4.7 min. belongs to Formaldehyde-DNPH Derivative, without Using TiO_2



(a)



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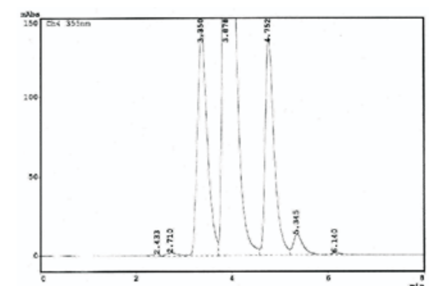
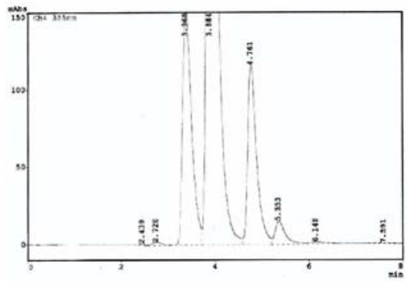


(c)

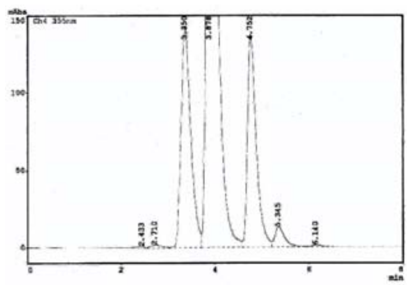
Figure - 11: HPLC Chromatogram of Aldehyde-DNPH Derivatives, Peak at 4.7 min. belongs to Formaldehyde-DNPH Derivative, with Using TiO_2 at Spray Time 10 min. and Deposition Temperatures: (a)450 °C, (b) 550 °C and (c) 600 °C

persons for the suitable positions, and encouraging competition by adopting the democracy.

In National Research Center NRC, Cairo, Egypt, there are many trials concerning this matter, such as: using Physics in different applications, making a link between Science and Industry, establish a center of excellence at NRC (ex. Nobel Project). In Solid State Physics Department, we have a special unit for introducing services for the industry



(a)



(b)

Figure - 12: HPLC Chromatogram of Aldehyde-DNPH Derivatives, Peak at 4.7 min. belongs to Formaldehyde-DNPH Derivative, with Using TiO_2 at Deposition Temperature 550 °C and at Spray Times: (a) 10 min. and (b) 20 min.

and the community, also, all our research activities are directed to the applications and solving problems, specially the local ones.

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ACKNOWLEDGEMENTS

The author would like to thank the coworkers in Solid State Physics Dep., National Research Center NRC, Cairo Egypt, especially Prof. Dr. Salama Edward Demian, and Dr. Mostafa Boshta for their valuable remarks.

Special thanks to Prof. Dr. W.T. Seeber, Otto-Schott-Institut, Jena, Germany, for his support.

The computerized spray pyrolysis system, equipped with x-y table, was financed by GTZ, through a project with DAAD, Germany.

I'd like to thank COMSATS, for suggesting the subject role of physics in developing countries, and for their support and hospitality.

ROLE OF SCIENCE-CONTESTS IN GROOMING THE YOUTH OF THE NATION: EXPERIENCE OF S.T.E.M.* CAREERS PROJECT

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ABSTRACT

Sports events, such as the Olympic Games and expeditions to K2 or Mount Everest, are meant to test the limits of physical prowess and human endurance. Similarly, academic competitions, such as the International Olympiad in Biology, Chemistry, Mathematics and Physics or the Westinghouse, now Microsoft Competition and Intel, Science Fair, test the limits of creativity and ingenuity. In this paper we describe the history and our experience of the National Physics Talent Contest that was launched by PAEC in 1995, and its extension to similar contests in Biology, Chemistry and Mathematics in the form of the National Science-Talent Contest under the umbrella of the Science, Technology, Engineering and Mathematics (STEM) Careers Project of HEC. We also mention our experience of the National Engineering Competition that is being held on pilot-scale under the umbrella of STEM Careers Project.

INTRODUCTION

One of the oldest international academic competitions is the International Mathematics Olympiad that was initiated by the former East European countries in 1959. It is an annual competition, in which higher secondary- school students from around the world are given six challenging mathematics problems that only the very brightest students of this age-group can solve. Each participating country can send a team of up to 6 students. Another regular annual event, the International Physics Olympiad, was also launched by the former East European countries in 1967. In this case, each participating country can send a team of not more than 5 higher secondary level students, who are given a five-hours long challenging theoretical examination and an equally challenging five-hours long experimental examination. The first International Chemistry Olympiad was organized a year later in the former Czechoslovakia in 1968, and the International Biology Olympiad was first organized on bilateral basis between Poland and Czechoslovakia between 1985 & 88, before it was formally launched in 1989.

The National Physics Talent Contest (NPTC) was launched on a pilot-scale in 1995, by inviting some colleges of Rawalpindi-Islamabad to nominate students for this competition. This was in pursuance of the directive of the President, Islamic Republic

*S.T.E.M. is an acronym for Science, Technology, Engineering and Mathematics of Pakistan, during his meeting with the leading physicists of the country who called on him in August 1994 under the leadership of Dr. Ishfaq Ahmad, then Chairman Pakistan Atomic Energy Commission (PAEC). The Contest was launched on the national level from the following year, and it has regularly been held since then. These days, the weeklong Training Camp of the 10th NPTC is in progress at the Ghulam Ishaq Institute of Engineering Sciences and Technology, NWFP and yesterday (27 July 2005) students visited PIEAS, the Home Institute of NPTC, PINSTECH and Optics Lab in Nilore, Islamabad.

Till 2004, all expenses incurred on organizing NPTC and, since 2001, on sending Pakistani team to the International Physics Olympiad (IPhO), were met from funds generously provided by the PAEC. From 2004 onwards, the Contest was also extended to biology, chemistry and mathematics in the form of National Science-Talent Contest (NSTC) with the help of funds provided by the Higher Education Commission (HEC) under the STEM Careers Project. The main purpose of this project is to identify talented youth at a reasonably young age and to groom them for participation in the International Olympiad in Biology (IBO), in Chemistry (IChO), in Mathematics (IMO) and in Physics, and for careers in Science, Technology, Engineering and Mathematics, i.e. STEM Careers. As mentioned earlier, the Pakistani team has been participating in IPhO since 2001 and from this year in IMO. From 2006, Pakistani teams will also participate in IBO and IChO.

THE NATIONAL SCIENCE TALENT CONTEST (NSTC)

Encouraged by the success of NPTC, it was decided to launch NSTC during the fall of 2003 under the umbrella of STEM Careers Project. To begin with, some 800 higher secondary schools and colleges in both public and private sector are invited to nominate students, who have scored more than 75% marks in their secondary school certificate or O-level examinations. Federal and provincial education ministers and secretaries, chairmen of boards of intermediate and secondary education and directors of education throughout the country are requested to facilitate such nominations. The Contest is also advertised in the print-media, seeking direct applications from students with duly attested certificates from their respective schools and colleges. Students are also encouraged to send their applications on-line. Typically 2500-3000 nominations/applications are received from all over the country, with significantly more nominations from major urban centers and elite schools and colleges.

All of these students sit a Screening Test on the first Sunday of the year in 7-10 major towns of the country. This Test comprises three parts. The first part, which is compulsory for all the students, contain 20, four-part, multiple-choice questions consisting of 5 questions from each of the four subjects of NSTC. The second and third parts are specific to each of these subjects. The second part contains 50 SAT-type multiple-choice questions, whereas the last part contains 2-3 descriptive questions. Seventy points are allotted to the first two parts and 30 points are allotted to the descriptive part. Fifty students are selected in each subject for the next stages of the Contest on the basis of their performance on the Screening Test.

The selected students are invited to a weeklong Training camp during summer vacations that is hosted by the home institution of their respective field. These Home Institutions are:

1. National Institute for Biology and Genetic engineering NIBGE) , Faisalabad of PAEC, for biology
2. HEJ Institute of Chemistry, Karachi university for chemistry
3. School of Mathematical Sciences (SMS), Government College Lahore University for mathematics, and
4. Pakistan Institute of Engineering and Applied Sciences (PIEAS), Nilore, Islamabad and Ghulam Ishaq Khan Institute of Engineering Sciences and Technology, Topi, Swabi, NWFP for Physics

National Physics Talent Contest (NPTC): Being the oldest of the NSTC Contests, NPTC sets standards and new trends for the other three competitions. Its activities are, therefore, described in somewhat more details here.

The Pakistani team for participation in IPhO is selected through a series of 3 one- week long training camps. The first Training Camp, which is held during summer vacations, is first and foremost meant to give students a sense of excitement in doing physics. This is done through problem-solving sessions, followed by thorough discussions of the student's solution-strategies, hands-on experiments, visits to research-facilities, discussions with leading scientists and star-gazing in the evening. About 10-15 potential candidates for the Pakistan team are also identified through continuous testing and assessment, especially on the last day of the camp, known as the Day of Judgment, on the basis of their performance on a theoretical and experimental examination. The other days of the camp are labeled after famous physicists, such as Al- Beruni, Faraday, Galileo, Einstein, etc; whose work is discussed that day.

The second Training Camp, which is held during winter vacations, is much more focused and the 10-15 students, who are identified during the first camp, are coached in problem-solving skills and experimental techniques. Some lectures are also arranged during this Camp, in order to upgrade their knowledge of physics and clarify their concepts. About 7-8 students are selected for the 3rd Camp from students attending this Camp.

The program during the 3rd camp that is held during spring is very similar to that of the second Camp. The 5-member Pakistani Team is selected at the end of this Camp, on the basis of their performance during the camp and the result of a theoretical and experimental examination on the last day of the Camp.

Students selected for participation in IPhO attend a final Training Camp in June after their examinations and before departure for IPhO. During this final phase they practice solving problems, conduct experiments from earlier IPhO. Besides faculty members from PIEAS, Quaid-i-Azam University, and now also GIKI, alumni from earlier IPhO help to teach and coach students during all the training camps.

THE INTERNATIONAL PHYSICS OLYMPIAD (IPHO)

As mentioned earlier, IPhO was launched in 1967 by the former East European countries and, except for a gap of 5 years in between, it has been held regularly since then. This year the 36th IPhO was held from 3 to 12 July 2005 in the beautiful ancient university-town of Salamanca, Spain. A total of 342 students from 77 countries from all over the world participated in this event. Last year the Republic of Korea hosted IPhO, Singapore will be the host next year and Iran the following year. The event has already been booked as far ahead as 2022.

IPhO has no permanent secretariat or source of funding. It is managed on voluntary basis by a President, Secretary General and a Council that is elected every three years by its general body that consist of leaders from the participating countries. All the expenses for organizing the event (in the range of 1-2 million US dollars) that include full board and lodge of students and team- leaders, are borne by the host country of the event. Participating countries subsidize this expenditure through a voluntary contribution of US$ 3500 per team. Usually developing countries are exempted from payment of this amount, if they request it. A team consists of a maximum of 5 students and two team- leaders. There is no limit on the number of observers and visitors that might accompany a team, but they are charged for their board and lodging.

Soon after their arrival students are provided separate lodging from leaders and other people. Students from each country are also provided chaperons, who stay with them most of the time, so that they can't communicate with their leaders during certain times of the event. Question-papers of both the theoretical as well as experimental examinations, along with their solutions and detailed marking schemes, are prepared by the host country and thoroughly discussed during the general-body meeting of the Olympiad before students are asked to solve them. This is done to ensure that the papers are of the right standard and are consistent with the syllabus of the Olympiad. The experimental apparatus that is individually provided to each student is also thoroughly examined for any possible problems. Each country then translates the papers into its own language, while countries with English medium education, such as India, Ireland, Pakistan etc; do minor editing to ensure that the language of the papers is understandable to their students. Theoretical part of the examination carries a maximum of 30 points and the experimental part is allotted a maximum of 20 points.

Leaders and examiners independently mark the answer-sheets accordingly to the detailed marking schemes and any possible differences in their marks are discussed in 'moderation sessions. Mutually agreed mark-sheets are signed by both parties before announcing the results. Gold, Silver and Bronze medals and Honorable mentions are awarded according to laid down rules, ensuring that about 50 % of the contestants get some recognition.

EXPERIENCE OF NPTC

Over the past ten years we have been able to evolve a credible system for identifying and grooming young talent and creating their network that spreads all over the country and extends to some parts of North America. The NSTC Screening Test can also serve as a diagnostic tool for our system of education. Our method of selection was challenged only once during the past ten years by a student of Aitcheson College who survived till the very last stage of our selection process. The fact that it becomes more and more difficult to discriminate between the very good students who survive till the last stage makes it very hard for us to choose outstanding students among them. That year we also had a student in the final stages of the selection process whose parents were associated with the home institution of NPTC. Although we were conscious of this fact and endeavored to eliminate any possible bias in his favor, but knowledge of this fact might have led the concerned student of suspecting some bias. In any case our selection process was vindicated by the fact that the selected student won a Bronze Medal in IPhO that year. It might be mentioned that Bronze is the highest medal that has been won by Pakistani Team and his was one of the four Bronze medals won by our Team so far.

Many of the fifty students, who qualify in the screening test and participate in the first Training Camp, get top positions in their respective board examinations, and most of them get admission in some of the leading institutions within and outside the country. These include Agha Khan University, GIK-Institute, LUMS, NUST, NED and UETS here at home and Caltech, Harvard University, MIT, Stanford University and the University of Toronto in North America. Some of them have already completed their undergraduate studies and are either pursuing higher studies in equally prestigious institutes of higher learning, or are serving leading national and multinational organizations.

Most of the students, who attend the first Training Camp, develop close association with NPTC and with physics even if they decide to opt for careers in engineering, medicine or in some other fields. So far, only about half a dozen of them have opted for careers in physics. A few of them decided to study physics or mathematics after studying engineering for 1-2 years. One of them has already switched to mathematics, another one to physics and a 3rd one has decided to pursue graduate studies in physics after his undergraduate engineering degree. We also have an active NPTC Alumni Association that is being enlarged into an NSTC Alumni Association. Our alumni greatly help us conduct and mark the Screening Test and, especially, our IPhO alumni help us conduct the training camps.

Although only highly talented students, most of them scoring more than 90% in their SSC/O-level examination, sit our screening test but our experience over the last 10 years indicates that the vast majority of them score less than 50% on NPTC Screening Test. Analysis of NSTC results of the last two years indicate similar trends for biology, chemistry and mathematics as it might be clear from figures 1-4. Another interesting statistics is that although more than 90% of the students are from inter-science background their ratio among those qualifying the Screening Test drops to about 40% and, on the average, to about 20% of the Olympiad Team.

Performance on IPhO: Pakistan was for the first time represented in the International Physics Olympiad by in observer in 1999 when Italy hosted it in the historic university town of Padua, where Galileo taught for several years. It was in 2001 in Antalya, Turkey when Pakistani Team comprising of four students and two team leaders participated in IPhO-32. We were greatly encouraged by the performance of our first ever team in that one of our students won an honorable mention and the best performance award among the first participating countries. We greatly improved on this performance the following year in Bali, Indonesia when three of our students won Bronze medals and the other two students were awarded honorable mentions. In 2003 in Taipei, Taiwan, our team didn't perform quite that well as we got only one Bronze Medal and two Honorable mentions. We, however, got some consolation from the fact that our Bronze medalist was also awarded the best performance award among the first participating countries, the last time that we wee eligible. Our performance since then has been less than satisfactory in that we won just three Honorable mentions last year in Pohang, South Korea and only two honorable mentions this year in Salamanca, Spain.

The performance of teams from our neighboring countries, Peoples Republic of China, India and Iran, is generally outstanding as their students usually win two or more Gold medals and sometime even five Gold Medals as in the case of china this year. Students from Indonesia and Malaysia also perform much better than our students. This year Pakistani team also participated in IMO but its performance was even less satisfactory than that of the Pakistani Physics Team. The inconsistency of the student's performance on the examination boards with those of our Screening Test and the unsatisfactory performance of our students is a matter of great concern and it needs to be addressed.

Concluding Remarks: Arranging NPTC has been an exciting experience for the organizers, most of them volunteer, as well the students. According to most of the students it is an experience that they cherish and want to relive, as is evident from the number of students who come for the annual alumni reunion, some of them from as far as Karachi. Most of the alumni also form a volunteer core of NPTC that help us spread its message, conduct and mark the Screening Test and help in running training camps. Every year, some students NPTC alumni and especially IPhO alumni opt, for physics careers and a few of them decided to study physics and mathematics after studying engineering for a year. NPTC has also helped us identify highly talented students, some of whom get positions in the examination board an several of them have been offered full sponsorship for their higher studies in Caltech, Harvard, MIT and Stanford.

Although Pakistan Team has not yet been able to win any Gold or even Silver Medal, participation in IPhO has been an invaluable experience for them. They meet and make friends with highly talented students from around the world and learn about the culture and educational system. For one of our Bronze medalist, who won several distinctions in his school and in his A-level examination, it has been participation in IPhO that has taught him humility and it has inspired him to help improve the educational standards of the country.

ENVIRONMENTAL CRISIS! WHAT CRISIS?

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ABSTRACT

Much emphasis has been laid in recent years to concentrate our scientific efforts on the applications at the expense of different perspectives. The lesson of chlorofluorocarbons (CFCs) is obvious and should be learned now. It is said that the unforeseen consequences of the otherwise safe and excellent CFCs could not be blamed on the individual chemists. Petrochemical industries are playing a role of destruction of ozone at the stratospheric region of the atmosphere.

This communication is intended to find application in understanding the atmospheric events; changes in the concentration of ozone on the basis of CFCs emissions and possibly forecast the UV-B radiation reaching Arabian Sea. We also examine the status of different countries in the contribution of ozone layer depletion (OLD) and try to elaborate the prevention and mitigation procedures for this event.

This kind of exertion also appraises results in terms of physical interpretation and methodology that could be helpful in obtaining predictions useful to various organization in the public, private and government sectors.

1. HISTORICAL ASPECTS AND OZONE PROBLEM

The biological evolution can be disrupted if changes are too large or too abrupt; this fact was depicted by the mass extinctions at the end of the Mesozoic (a geologic era after the Paleozoic and before the Cainozoic) Paleozoic (the geologic era between the Precambrian and the Mesozoic) eras. That is why there is such concern today about environmental changes, caused by worldwide industrial growth.

The rapid change of the environment is a crisis because evolution cannot keep pace. We have to notice the very important point that the problem is not just change that occurs all the time, but rather the rate of change. Current estimates suggest that we are losing about 5 % of the planet's plants and animal species per decade, implying that within a few centuries, the earth will have experienced a mass annihilation comparable to the biggest one in the history of the planet. One of the examples of a human-caused environment problem is the damage to the ozone layer.

The radically new perception is that human activities may themselves be responsible for polluting the middle atmosphere or stratosphere (15 km to 65 km above sea level) of our earth and consequently for disturbing the ozone (O_3) layer balance. The strucutre of stratosphere is depicted in Figure-1.

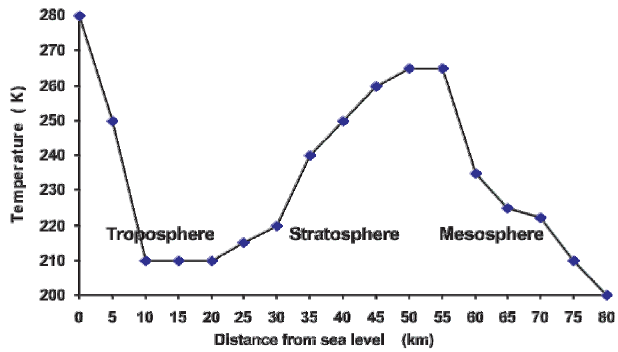


Figure - 1: Thermal Structure of Atmosphere

This is a typical temperature distribution (with height in the horizontal axis) as shown in the above illustration that exhibits the average variation of temperature with altitude within the atmosphere.

The ozone layer's modern troubles began during the year 1928 when the chemists discovered a new class of chemicals that could replace sulfur dioxide and ammonia as the basic fluids in refrigerators. This new class of chemicals that was produced by Du Pont under the trade name of "freon" became known generally as chlorofluorocarbons (CFCs) and were considered a great triumph of modern chemistry. These chemicals were safe, nonflammable, stable, un-reactive and proved ideal for different purposes [1-5].

2. SIGNIFICANCE OF ATMOSPHERIC OZONE

Although ozone forms only 10^5 % of the atmosphere, it plays an extremely important and manifold role in terrestrial life and particularly in the life of man. This feature is important for the current interest in research activity for the study of the ***vertical and horizontal distribution, the mechanism of formation and variations in the concentration*** of atmospheric ozone as a function of meteorological, cosmic and other phenomena. Interest in the ozone problem was brought out by the recognition of ozone being a highly reactive gas that is involved in a large number of chemical reactions with both naturally as well as artificially produced trace substances present in the atmosphere. Two very important aspects of ozone are listed below:

a) Changes in the intensity of UV radiation reaching the earth's surface, with the circumstances that potentially has serious effects on the biosphere.
b) Changes in the thermal equilibrium and dynamic structure of the atmosphere

which would have meteorological implications [6]

The phenomenon was so remarkable that it attracted the attention of both the scientific community and the general public. The transformation of ordinary oxygen into ozone always needs energy, whether supplied by UV radiation, or radioactive bombardments, or electrical discharge, the resultant ozone is the same [7].

These investigations led to a series of processes known as Chapman mechanism, which explained the formation and annihilation of O_3 layer. Using this mechanism, predictions were made which provided excellent agreement with observations the available [8-14]. The situation can be explained by the following reactions:

O_2 h (< 240 nm) O O Slow ....(1)

O O_2 M O_3 M Fast ....(2)

O_3 h (< 310 nm) O O_2 Fast ....(3)

O O_3 O_2 O_2 Slow ....(4)

M being a third body required for carrying off the excess energy of the association process. The rapid cycle composed of reactions (2) and (3) does not, of course, destroy O_3. Many years after the preceding initial work, it was suggested that catalytic processes can lead to the overall reaction as follows:

$O + O_3$ $2\ O_2$ ....(5)

3. ANTHROPOGENIC AND NATURAL ACTIVITIES

Ozone content in the stratosphere varies due to various natural and anthropogenic activities. Some prominent activities creating OLD are described as follows:

a) Technological

CFCs produced in various technological processes gradually migrate upward into the stratosphere. At altitude above 30 km, intense UV radiation breaks down the CFCs, causing them to release chlorine and destroying ozone, as shown in the following chemical reactions:

$CFCl_3 + h$ $CF\ Cl_2 + Cl$ ....(6)

$CF_2Cl_2 + h$ $CF_2\ Cl + Cl$ ....(7)

$Cl + O_3$ $Cl\ O + O_2$ ....(8)

It is known that although significant changes in the upper atmosphere of the earth (hereafter we shall refer to it, simply, as upper atmosphere or atmosphere, depending on the context) are primarily of chemical origin, yet physical processes considerably affect them too.

b) Supersonic Transport (ST)

As a result of prospective development of a major commercial fleet of (ST), the ozone shield is under serious threat. The NO and NO_2 appearing in the ST exhaust would be more effective because they decompose ozone catalytically and would recycle until removed from the stratosphere at the boundary with the troposphere where the hole could be continued under stress till 2050 [15,16].

c) Volcanic Eruption

Volcanic injection offers a major perturbation in aerosol surface area. The increase in aerosol surface area resulting from a major volcanic eruption can lead to profound effects on ClO_x induced OLD chemistry. Eruption of Mt. Pinatubo in the Philippines in June 1991, the largest volcanic eruption of the 20^{th} century , lead average mid-latitude aerosol surface areas. The volcanic injections of H_2O and HCl can reduce O_3 chemically. Large injection of sulfur gases, such as SO_2 and H_2S, can suppress the HO_x cycle. Dense volcanic particle layers can alter photo-dissociation rates.

d) Polar Stratospheric Clouds (PSC)

The maximum ozone depletion is located at the top of the Polar Stratospheric Clouds (PSC) layer where the Cl_x concentration is highest. Results of observations in a PSC in the outer regions of the Antarctic vortex show similarity with the observations in the Arctic:

e) Solar variations

Natural long-term cycle variation in solar UV output, which increases solar flux, dissociates ozone molecule into odd oxygen. (11 years cycle)

f) Solar Eclipses

Short-term perturbation of ozone chemistry, which has no appreciable effect on stratospheric ozone (O_3).

g) Solar proton events (SPEs)

Protons emitted during solar storms penetrated the earth's upper atmosphere.which causes generation of NO_x, and HO_x in the air which catalytically react with O_3.

g) Aurorae

Electrons in the earth's radiation belts precipitate into the upper atmosphere, where they generate NO_x in the mesosphere, which may be transported to the stratosphere. The contribution of auroral NO_x to natural ozone loss is probably < 5%.

i) Meteors

are produced by continual accretion of inter-planetary dust,and occasional influx of asteroidal or cometary debris. It is observed that aerodynamic heating of air by high-velocity meteors generates NOx which can react with ozone. Small meteoroids are stopped in stratosphe, with the negligible effect on stratospheric ozone.

j) Supernovae

are terminal stellar explosions. Supernovae emitted energetic particles and radiation penetrate the stratopshere, and generate NO_x which reduces ozone. It is said that for supernovae within 100 light years, the cosmic rays could deplete O_3 by 30 % to 80 %.

4. HUMAN ASSAULT ON THE OZONE-LAYER

The stratospheric ozone layer has remained in a dynamic equilibrium for much of geological time but, by early 1970s, scientists had discovered evidence suggesting a decline in the ozone concentration due to human interference. In particular, humans had been injecting enormous quantities of ozone-destroying substances into the atmosphere, specially CFCs as presented in the chemical reactions (6), (7) and (8). By the mid-1970s, the possible destruction of the ozone layer by the artificial chemicals had become a topic of heated controversy.

The following comparative statements for few ozone destroying substances are noteworthy:

Table - 1: Ozone Destroying Substances

Compound name	Chemical Formula	Ozone Depletion potential	Uses	1987 World Production Metric Tons	Residence Time in Atmosphere (Years)
CFC-11	$CFCl_3$	1.00	Refrigerator,aerosol,foam	298,000	65-75
CFC-113	CCl_3 CF_3	0.8-0.9	Solvent, Cosmetics	138,500	100-134
CFC-115	$CClF_2$ CF_3	0.4-0.6	Refrigerator, whipped topping stabilizers	-	500
Halon 1301	$CBrF_3$	10-13	Fire fighting	2,600	110
HCFC-22	$CHClF_2$	0.05	Refrigeration, aerosol, foam	81,200	16-20
Methyl Chloroform	CH_3 CCl_3	0.15	Solvent	499,500	5.5-10
Carbon Tetrachloride	CCl_4	1.20	Solvent	71,200	50-69

5. ROLE OF INTERNATIONAL AGREEMENTS AND CURRENT SITUATION

One of the agreements is Montreal Protocol that was presented in 1987, only two years after the ozone-hole discovery, and the participants decided to phase out CFC production. Geochemists and planetary Astrophysicists studied the chemical and physical processes and predicted the damage to the ozone layer from CFCs chemicals and detected a natural winter "Hole" over Antarctica. This hole in the layer broadened dramatically through the 1980s. Nimbus-7 Satellite measurements in the early1990s showed the winter breakdown of ozone at high northern latitudes as well. A record of winter ozone depletion over Antarctica occurred in 1993; since 1995 the depletion seem to have stabilized. Most scientists attribute the widening of the ozone hole to CFCs and its stabilization to the phase-out of CFCs . As the phase-out countries, experts in this field predict that ozone damage will begin to decline by about 2010.

The ozone issue shows that scientific data and international cooperation can be used to deal with an environmental crisis even in the nick of time. It is said that even with the complete phase-out of CFCs and other chlorine-bearing chemicals, stratospheric chlorine concentrations are expected to remain well into the twenty-first century (21^{st} Century).

The main attention of UN Conference on Environmental and Development (UNCED) was focused to the problem of reducing greenhouse gases (GHG) emissions to the atmosphere, in order to prevent potentially disastrous consequences of OLD, and global warming. Environmental Protection Agency (EPA), ESA (European Space Agency), the World over Scientific organization, NATO (North Atlantic Treaty Organization), NASA (National Aeronautics and Space Administration), and WMO are deeply concerned with the dis- balances caused to a significant extent due to human interference in the natural make-up of earth's ecosystem.

In spite of Montreal Protocol and its amendments, as early as 1990, some developing countries had actually increased their use of CFCs that originate from industrialized world. Realizing the urgency of the situation, some countries have moved up the phase-out schedules, e.g., the **12 members of European Union** promised to stop producing CFCs by the end of 1994. Even with the accelerated phase-out, the problem will still persist because of the high life-time of CFCs: about 75-110 years.[15-17].

5.1 Phase-out schedule for CH_3Br (methyl bromide) under the Montreal Protocol

Methyl bromide was officially listed as a controlled substance under the Copenhagen Amendment to the Protocol in 1992. Since then the need for faster action of phase-out has been recognised and, after the latest amendments and adjustments introduced into the Protocol under the Monteral Amendment of 1997, the phase-out progress can be seen in the table.

Phase-out of methyl bromide under the Montreal Protocol-1997.

Table - 1

Year	Developed countries	Developing countries
1999	25% reduction	
2001	50% reduction	
2002	66%	Freez at average 1995-98 base level
2003	70% reduction	Review of reduction schedule
2005	Phase-out, except for critical use exemptions	20 % reduction
2015		Phase-out, except for critical use exemptions

Many manufacturers and different companies denied the possibility. Albeit many environmentally oriented citizens called for immediate, even if economically expensive, action to save the O_3 layer. The controversy abated somewhat in the late 1970s after some action was taken to protect the ozone layer e.g., in the year 1978 the USA banned the use of CFCs as ***aerosol spray*** propellants, but it erupted again in 1980s when an ozone hole was detected over Antarctica.

We estimate that the ozone layer will continue to be depleted until at least **2050, resulting in ozone losses of as high as 15-30 %over the** norther latitudes where most of the world's population resides. During the latter half of the next century, the ozone may start to build up again, but measureable amounts of **CFCs will continue to reside in the atmosphere well into the twenty-fourth century (24th century).**

In particular, the ozone layer depletion (OLD) over the South Pole is already a serious hazard. The principal long-term effect of OLD appears to be an increase in the UV radiation reaching the earth. In our earlier findings, OLD has been reported and its effects could be observed. Thus the mentioned absorption is important in that it reduces the incidence of the **UV-B** radiation at the sea level. It is harmful both to animal and plant life. [18-21].

6. THE MOST IMPORTANT FACTS ABOUT THE "OLD" ARE GIVEN BELOW:

a) OLD is a potential source of UV-B flux at the sea level
b) To meet this threat, we have to gauge or monitor the impact of OLD at the present day
c) For a systematic handle on the problem, we have to understand the nature of variations in the ozone concentration in the stratospheric regions of Pakistan, as shown in Figure-2.
d) We have to show by calculations that this process:
   i) posses a good degree of normality
   ii) It is reasonable from the view points of the future analysis
e) We have estimated the parameters, constructed and validated a Stochastic model,

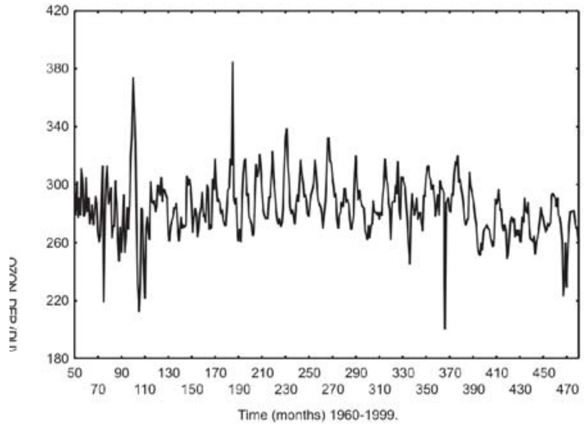


Figure - 2: Variations of Ozone Depths Versus Time, Showing that the Depletion far Exceeds the Restoration of O_3 in the Earth's Stratosphere

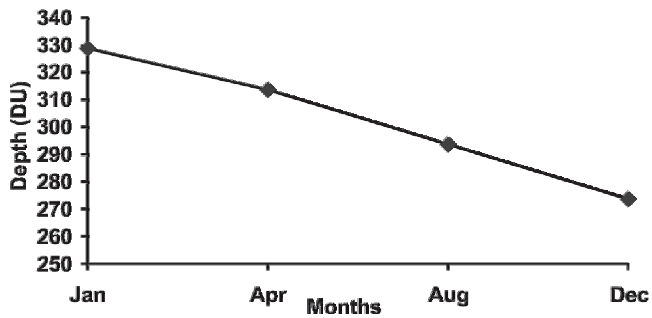


Figure - 3: Secular Trend by Least Square Method for the Year 1982

thus establishing a forecast of ozone depths for Pakistan's stratospheric regions with good accuracy

7. EFFECTS OF INCREASED UV-B RADIATION REACHING SEA-LEVEL

It is said that a small amount of UV radiation is necessary for the well being of humans and other organisms. In view of our discussion in the last section it is now an established fact that

i) Ozone shield efficiency is variable because of natural as well as artificial causes.
ii) There is danger of extinction of various animal and plant species because of OLD.
iii) A 4 % decrease in ozone content causes a 10 % increase in radiation in the range between 290 and 310 nm.
iv) Damage suffered by DNA (a genetic material found in all living organisms) from

UV radiation is cumulative, and the integrated dose over many years produces skin cancer in humans and causes mutations in the animals and plants. [1-7].

v) DNA molecules undergo most intense absorption of UV radiation in the range of 265 nm to 300 nm. Proteins have absorption maxima around 275 to 285 nm and these bands also extend to 300 nm. Plants are sensitive to UV radiation below 310 nm [19-23].

vi) The projected increase in skin cancer and cataracts is due to the increase in amounts of UV-B. UN Environment Programme has estimated that extra UV-B exposure due to 10% loss in global ozone could result in a 26% increase in the incidence of melanoma skin cancer.

vii) Increased exposures to UV-B have also been linked to increased incidence of cataracts (where the lens of eye becomes opaque) damage to corneas, and retina disease in humans. It has been estimated that a 10% decrease in ozone depth could cause more that 1.5 million new cases of cataract each year.

viii) Excess dosage of UV-B can suppress the human immune system, allowing the spread of infectious diseases.

ix) It has been hypothesized that UV-B may help activate the AIDS Virus. UV-B can destroy cells and also cause mutation

x) Abnormally high levels of UV radiation inhibit photosynthesis, metabolism and growth in a number of plants, including food crops such as soybean, potatoes, sugar beets, beans, tomatoes, lettuce, wheat, sorghum, and peas.

xi) Food chain: Marine organisms form a series through which the get energy necessary for their growth etc; this is called food chain. This entails a base that is termed as producer-level called a green plant or other auto-trough that traps energy from light (UV) and produces food substances, thereby making energy available for other (consumer) levels that are also affected by UV radiation reaching Arabian sea.[22-24].

Obviously, this situation calls for an assessment, monitoring and prevention of the incidence of decrease in the O_3 concentration.

We also estimated the effects of OLD on marine organism, such as phytoplankton, zooplankton and fish, using the time series of bivariate population of Sindh and Baluchistan coastal regions of Pakistan. Forecast using these estimates will be of use to various (private, public, and governmental) organizations. In particular, our study aims at

a) establishing OLD as a physical process
b) developing long-term prediction models
c) Examining the influences of OLD dynamics on marine organisms.

8. QUANTIFICATION OF ULTRAVIOLET FLUX

Ozone has been transported to Pakistan via vertical lifting and horizontal mixing of ozone. The effects of UV radiation are studied for marine organisms. We have selected the fish yield and the population of other marine organisms that have been correlated

$$F = \frac{Lu\min osity_{effective}}{4 \ R^2{}_{Arabian\ sea}} . \qquad \text{..........(9)}$$

$$P_n = \ 1 \ \frac{V_n}{V_t} \qquad \text{..........(10)}$$

$$P_n \ \ \text{Luminosity} = f_{effective} \qquad \text{..........(11)}$$

with the amount of UV radiation reaching the Arabian sea. Our analysis exploits Bohr's classical quantum mechanics between Pakistan air space and Karachi-Makran coasts. We know that stratosphere will act as the secondary source of UV radiation through the ozone filter. The UV flux reaching the Arabian Sea is given by

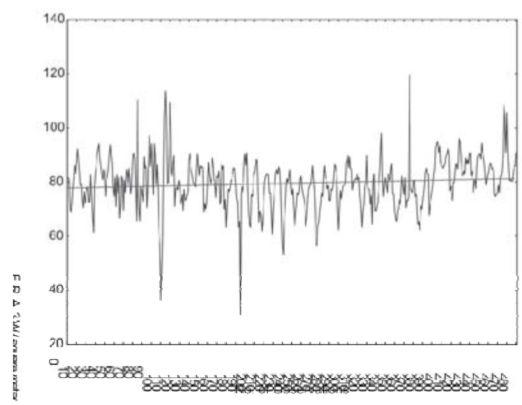


Figure - 4:Variation of UV Flux Versus Time, Depicting the Enhancement and Decrease of Flux due to Depletion of O_3 at Pakistan's Stratosphere

These equations characterise the **ozone filter** for different luminosities that have been calculated using the UV Lyman flux of solar radiation and effective luminosity reaching the Arabian sea through the ozone filter respectively. Figure-4 depicts the variation of UV-B [4-10].

Figure-5. depicts a correlation between ozone layer thickness and the UV-B reaching Arabian Sea.

Model equations for (L) and (R)

L = 251.247 0.47 *x + eps
R = 171.385 0.47 *x + eps

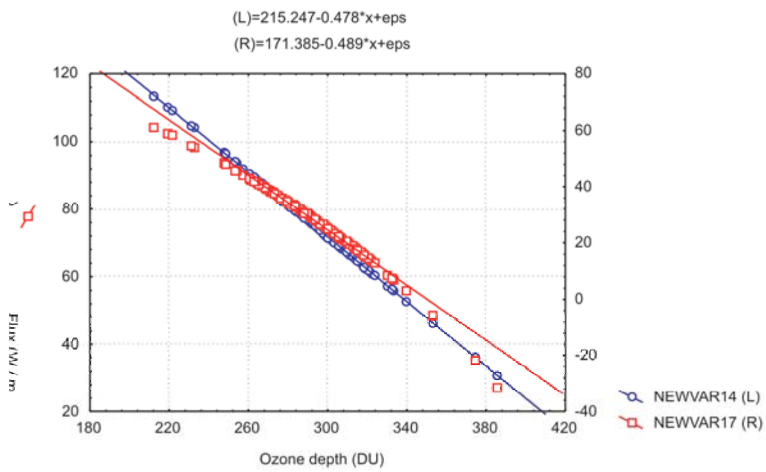


Figure - 5: Dependence of UV-B Flux on Ozone Depth

9. THE DIRECT AND INDIRECT EFFECTS OF UV RADIATIONS

Due to old on marine organisms, such as fish, phyto-plankton, zoo-plankton and fish larvae, are studied and models are constructed for the fish yield of the Baluchistan and Sindh coasts of Pakistan and other organisms.

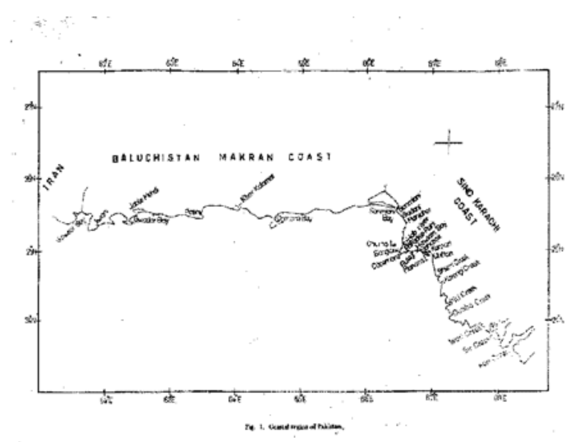


Figure - 6: Costal Regions of Pakistan

The coastal region of Pakistan is spread from 24° to 26° north and 62° to 68° east. It includes SindhKarachi coast and BaluchistanMakran coast as shown in Figure-6.

9.1 Phytoplankton (Growth and Chlorophyll)

The effects of UV-B on the growth of specific species of marine phytoplankton of tropical and temperate regions are studied.

The seasonal distribution of chlorophyll *a* shows a decreasing trend as it moves from high values above 0.4 g per litre in January to very low values of about 0.05 g per liter in May (at about 30 meters ocean depth). A correlation between the chlorophyll *a* data and our computed UV-B flux data is shown in Figure-7. [19,25].

The respective trend equations

$Y_t = 0.351 - 0.0502\ t +$

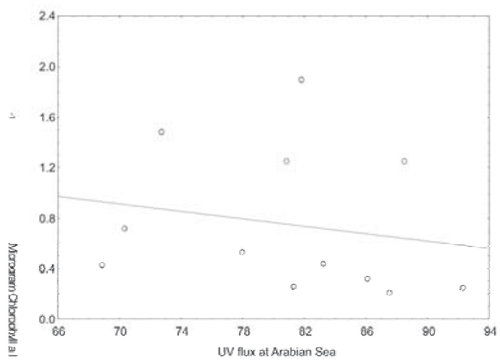


Figure - 7: Effect of UV Flux Reaching Arabian Sea on the Seasonal Distribution of Average Integrated Chlorophyll a

9 (b) Zooplankton (Larvae and fish)

In this paper we have presented a correlation structure for these two zooplankton with the UVB radiation. Trend in zooplankton production along the Karachi coastal regions is presented. The findings are based on analyses of monthly zooplankton samples collected from three different stations from January 1983 to December 1985 such as copepoda in the Arabian sea. Seasonal variation and abundance is discussed [26-28].

Model equation for three years is obtained for copepoda

$Y_t = 132.806 - 0.811\ t +$

9.3 Fish yield data for coastal regions of Pakistan

(i) Baluchistan coast
(ii) Sind coast

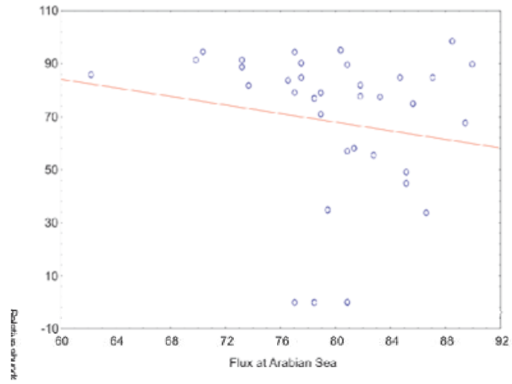


Figure - 8: Correlation between Relative Abundance and the Flux of Copepoda at Sea Surface

Relationship between UV Flux and Fish yield for Karachi-Sindh and Baluchistan-Makran Coasts [4-8].

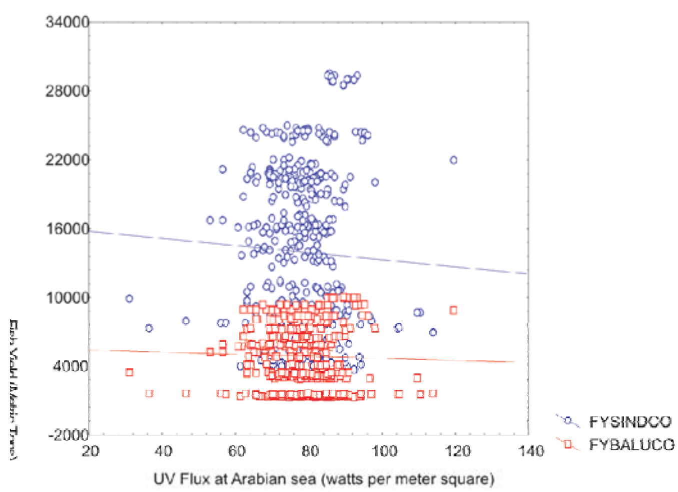
Model equations are given as

(a) For Karachi-Sindh Coast

$$Y_t = 16397.04 \quad 31.075\ t +$$

(B) For Baluchistan-Makran Coast

$$Y_t = 5571.197 \quad 08.889\ t +$$



10. CONCLUSIONS

We have seen that although volumetrically ozone contributes less to the environment, in effect, it is creating a hazard to our biosphere and crisis for our society.

Observing that many aspects of the problem of OLD are still unanswered, specially the problem of long-term predictions in the perspective of its variable dynamics, we should proceed first to search for an adequate and statistically significant approach

The combined effect is the larger exposure of UV radiation to sea surface and underneath, disturbing marine life and ecology. We have indicated that OLD is affecting the fish yield of Baluchistan and Sindh coasts of Pakistan directly, as well as indirectly, through a change in the food-chain due to the abundance of various species of phyto- and zoo plankton.

Remedial measures for OLD suggest the use of:

a) HCFCs (hydro-chloro-floro-carbons) and HFCs (hydro-floro-carbons) in place of CFC's (chloro-floro-carbons).
b) HFCs are far superior than CFCs in the sense that they are largely destroyed in the lowest region of the atmosphere.
c) In addition, HFCs do not contain chlorine and have no potential to deplete ozone, whereas, HCFCs do contain chlorine, but this remains ineffective in depleting the ozone layer as most of the HCFCs released at the ground level are destroyed in the lower atmosphere well before reaching the stratospheric ozone layer.

ACKNOWLEDGEMENT

The presenter of this work is thankful to the organizers of this seminar for invitation, local hospitality and provision of TA & DA.

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RENEWABLE-ENERGY TECHNOLOGIES FOR SUSTAINABLE RURAL DEVELOPMENT

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ABSTRACT

More than 70 % of the total 27 million Sudanese population lives in rural and isolated communities, characterized by extreme poverty and poor social and economical activities. The present electricity-distribution reflects that the Sudanese rural communities are completely out of reach of the NEG and are also being by-passed by the petroleum-product supply pipe-lines. The unavailability and the acute shortages of the conventional energy supplies (petroleum & electricity) to rural people have forced them to use alternative available energy-sources like biomass. That situation causes serious environmental degradation. Also, due to shortages of energy supply , the rural people receive poor services in the areas of : Food Security, Water Supply, Health Care, Education, and Communications.

INTRODUCTION

Poverty and iniquity in the basic services are the major components that have hindered rural development. Unless being addressed now, none of the great goals of the international & nation community viz peace, human rights, environment, and sustainable development, will be achieved or even progress. Energy is a vital prime mover to the development, whether in Urban or Rural Areas. The rural energy-registered needs are modest compared to urban once and, for proper rural development, the following objectives must be considered:

- Analyze the key potentials and constraints for rural energy development
- Asses the socio- technical information needed for decision-makers and planners in rural development
- Design, implement, and interpret different types of surveys, to collect relevant information as inputs to planners:
- Utilize a number of techniques and models supporting rural-energy planning.

1. ENERGY SITUATION IN RURAL SUDAN

The previous section indicates clearly the poor situation of conventional energy-supply to Sudanese rural people who are characterized by high dependence on biomass woody fuels, (fire-wood & charcoal). In order to raise rural living-standards, the per capita energy availability must be increased; through better utilization of the local

Table - 1: Energy requirements in rural areas of Sudan

Rural Sector	Activity
Domestic	lighting, cooking, heating, cooling.
Agriculture process	land preparation, harvesting, sowing, weaving
Crop process & storage	Drying, girding, and refrigeration.
Small & medium industries	power machinery
Wind pumping	Domestic use.
Transport	Schools, clinics, communication, radio, television, etc.

Table - 2: Energy Sources For Rural Areas

Source	Form
Solar Energy	solar thermal + solar PV
Biomass	woody fuel + non-woody fuels
Wind Energy	mechanical types + electric types
Mini & Micro Hydro	A mass Water fall + current flow of water
Geothermal	hot water

available energy resources. The rural energy-requirements can be summarized in Table- 1,including the energy cost of the materials such as cement, fertilizer, etc.

The suitable energy-source, needed for the above rural energy requirements must be of diffuse low-cost types rather than high-cost & large central installation. Also, they must be appropriate, environmentally, socially and economically acceptable. Some of these technologies are given in Table-2.

The present position for most people in rural areas for obtaining the needed forms of energy (heat, light etc.), is that the sun, in association with traditional building practices, provides environmental comfort conditions supplemented, when necessary, by fire wood. Cooking is largely by wood from forests or its derivative, charcoal. Cattle dung / agricultural waste as being used to a lesser extent. Mechanical power is provided by humans, animals, and diesel or gasoline engines. Some cooking & lighting is by kerosene. It should be recognized that this situation is unlikely to change in the next one or two decades. However , because of the need to increase energy-availability and also to find alternatives for the rapidly decreasing wood supplies in many rural areas, it is necessary that a vigorous program researching into alternative renewable energies should be setup immediately. There should be much more realism in the formulation of such a program, e.g. its no use providing a solar-powered pump at a price competitive with a diesel unit for some one who cannot ever afford a diesel engine.

The urgent problem for rural development is to increase the energy available per-capita and also for raising the people from the present level of extreme poverty and giving better basic-needs services. Another area in which rural-energy availability could be secured, where woody fuels have become scarce, is the improvements of traditional cookers and ovens to improve their efficiency in saving fuel and by planting fast growing trees for constant future fuel supply.

2. POTENTIAL FOR RENEWABLE ENERGY & APPLICATIONS

2.1 Biomass

Biomass represents quite a significant percentage of the Sudan Energy Balance. In 1995, 78% contributed in the form of woody fuels i.e. charcoal and firewood. The non-woody fuels (animal and agriculture waste) share was about 8%. A Study carried out by the Ministry of Energy & Mining in 1990/1989, indicated that:

- 96 million metric tons are available from agriculture waste, mainly cotton stalks, and peanut shells.
- 34.9 million metric tons available from animal waste.
- 3.49 million metric tons bagasse.

Table-3 and Table-4 give the estimated available amount of Agriculture and animal waste.

Utilization of both agriculture and animal waste was started long time ago for animal feedings. The technology has been improved and used in dried pressed blocks or cakes with an additional of a binding material to give the stiffness. These blocks or briquettes are currently being used in commercial industries like, bread making, brick kilns etc. It is proved that these briquettes have almost the same firewood characteristics; with regard to sizes, strength and calorific values. Another use is carbonizing the waste and then pressed with a binding material and used in form of briquettes e.g. in shape of woody charcoal. Commercial effort also being tried and

Table - 3: Agriculture Waste Ref. [6]

Wastes types	Amount Thousands ton	% for energy
Cotton stalks	292	8%
Dura	6838	3%
Millet	2381	2.5%
Peanut shells	2230	6%

Table - 4: Animal Waste

Animals	Amount million ton	%
Cows	224.5	22.5%
Sheep & goats	60.4	6%
Camels	16.4	1.6%

medium demonstration factories were being build in Rahad mechanized & Khashm Al Griba Schemes.

Another use of the non woody fuel is the animal waste and being used in biogas diagestors The biogas technology is introduced worldwide and used for cooking at family and community or group sizes. The technology is known and the construction is based on the local available skills and materials. Currently there are more than 100 units built all over the Sudan. Essential requirement is the availability of animal waste from at least 3 cows or 10-15 goats/sheep.

2.2. Solar Energy

Sudan is rich in solar energy, with daily solar radiation and sun shining availability for more than 10 hrs, through the whole year.Fig {1} shows the solar radiation distribution in Sudan. This radiation can be utilized into two ways; Thermal solar application in the form of heat and the conversion to electricity by using solar photovoltic cells. Research and development on solar energy began in Sudan forty years back at the level of the universities. Then in the 1970"s ERI was initiated. It started with manpower development and building the infrastructure. After mid 1980's and wards results of R&D had been demonstrated in small scale through foreign and local support. The Projects SREP, SEP, SWE and RSED were being implemented by ERI, MEM,FC and others related institutes (see Ref.[7] for more details). These projects demonstrated the following solar energy technologies:

- Solar lighting system
- Solar P.V. pumps systems
- Solar cooling for health care
- Solar T.V. for education
- Telecommunication
- Solar water heater
- Solar cookers
- Solar evaporators, and
- Solar distills

The above solar system has been demonstrated in actual application. Monitoring and evaluation of the above applications have been carried out. The results indicated that they have remarkable socio- economic and environment impacts. Some of this application will be discussed in more depth in section4.

Up to the end of the year 2002, Sudan used to import solar panels from abroad and mainly through NGOs, UN organs and individual private sectors, through their involvement with the Government in the bilateral agreements. In the beginning of the year 2003 and through an agreement with Republic of China, an assembly-line of P.V. production was commissioned and soon started production of P.V. Modules.

The capacity of the assembly-line is equivalent to one MGW [About 20.000 PV Module of 50wp]. The total PV system cost is reduced by 35% compared to the imported one.

2.3. Wind Energy

SUDAN is considered within the low-medium range of wind regime . The coastal site (Red Sea) is the most promising, with annual average wind-speed of 6.5 m/s . Also the North States (Karema & Dongola areas) are also good sites. They have average annual wind speeds of 5 - 5.5 m/s. Khartoum and central states have annual average wind speeds of 4 - 4.5 m/s. West States have annual average wind speeds of 3 - 3.5 m/s. The Southern States are really not suitable for wind energy application Figure-2.

Wind energy in Sudan is currently used for pumping water from both deep & shallow wells to provide water for drinking and irrigation through the use of ?windpumps. This application is presently applied in the North, Khartoum, Central Butana and Nile States. The attractiveness of windpumps is that they can be manufactured completely from locally available materials.

2.4. Mini & Micro- Hydro Plants Potential &Application

Mini & micro hydro can be utilized or is being utilized in Sudan into two ways;

- The waterfalls from 1m to 100m.
- The current flow of Nile water There are more than 200 suitable sites for river turbines applications along the Blue & the main Niles. River turbines are currently being demonstrated on the main Nile , by Atbata university and ERI. The results have so far indicated a promising future use.

2.5. Geothermal Energy

No detailed studies of the potential of the geothermal sites as a source of energy is being carried out in Sudan, but the following sites are expected to have a significant potential:

- Jabel Mara Area
- Volcanic territories
- Suwakin, red sea

Scientific field-studies are needed on the above sites to determine the possibility of geothermal utilization.

3. FORESTS ARE THE PRIMARY SOURCE OF ENERGY

In Sudan, like other developing countries, biomes is a major primary energy- supply. It contributes a share of 87% of the total energy-supply. About 70.8% of that % is in the form of wood-fuels produced by forests. Agricultural waste and animal residues contribute 7.7 % in form of non-woody fuel Figure-3 shows the contribution of different primary energy-supplies to the Sudan energy-balance [3], given as follows:

woody fuels	=	70.8 %
non-woody fuel	=	7.7%
petroleum products	=	19.4%
Electricity	=	2.1 %

The woody fuels are produced from forests in form of charcoal and firewood. The non-woody fuels are produced from agricultural residues and animal waste, in the form of charcoal briquettes. The distribution of the total consumed biomas in form of firewood and charcoal according to the energy consuming sectors, is given in Table-5.

3.1 The Sector-wise Distribution of Energy-Supplies

The contribution percentage of the woody and non-woody fuels to the sectorwise energy-supply distribution is as follows:

- Residential	84.8%
- Industrial	51.2%
- Commercial and service	35.6%
- Khalwa	97.6%

3.2. Fuel Supply through Wood

The household sector is the major consumer of fuelwood in form of charcoal and fire-wood comparison with respect to other sectors as shown below:

- 88.5 %	- Household sector
- 7.6%	- Industrial sector,
- 2.3%	- Commercial sector
- 1.6%	- Khallwa.

Most of the rural areas in Sudan are almost out of the national electric grid. They are being by-passed from the petroleum products supply-lines. They are the most being affected by the energy-crisis, which continued for the last three decades. Due to the

Table - 5: Shows Consumption of Biomas

Sector	Fuel Wood m^3	Charcoal m^3	Total	%
Residential	6148380	6070207	122118487	88.5
Industrial	1050174	11673	1061847	7.6
Commercial	31636	283899	315535	2.3
Khalwa	209044	-	209044	1.6
Total	7439234	6365779	13805013	100

Table - 6: Charcoal and Fire Wood Consumed

Sector	Charcoal 103 m^3	Firewood 103 m^3	Total 103 m^3
Rural	3630	728	4348
Urban	2451	959	3410
commercial & services	284	32	316
Industrial	12	1050	1062
Khalwa	-	1045	1045
Total	6367	3814	10181

Source: *Ref.[3]*

unavailability of the conventional energy supply, the poor rural people use the available woody fuels in form of firewood and charcoal. The rural use is mainly for cooking, lighting, and other social and economic activities. A recent study carried out [3] indicated that 85% of the firewood was consumed in urban areas and 19% in rural areas.

Some states in the Sudan are really suffering from the scarcity of woody fuels, others with deficit, while some states have just sufficient woodyfuels supply source. Khartoum and central states, are really the once that suffer from acute scarcity and that obviously expected due to the big development in agriculture and rain-fed schemes that took place in these two states.

In the last decade 1980/90, Sudan had been exposed seriously to hits by series of crises: drought, food scarcity, deforestation and poverty. That situation also caused a number of social, economic and environmental damages. These crises had shaken and weakened most of the basis infrastructure of production, services and social sectors, to such a degree that these became ineffective. The energy sector was badly affected . The forestry part is the main area that has been deteriorated, by these crises and the unresponsible practices of people. To rehabilitate and build the forestry, as a whole, and the energy part in particular, a crucial national conservation program must immediately, be implemented with the following activities:

- Implement Agr-forestry fuelwood programs in the irrigated schemes and rain- fed mechanized farms.
- Encourage building of nurseries and tree-plantation at the urban and rural levels
- Build shelter-belts and windbreaks, specially fuel-wood types.
- Encourage conservation-programs in firewood and charcoal production
- Encourage and enhance the use of alternatives woody fuels i.e. utilization of cotton stalks, peanut shells, baggasse and other residues as sources of fuels.
- Avail and supply kerosene and LPG for household energy-usage.
- Advice the use of energy-saving cooking stoves.
- Introduce alternative cooking-stoves, like solar cooker, biogas systems, etc
- Introduce solar lighting system in schools, khalwas, and social centers

particularly in rural and isolated communities, where firewood is intensively being used for providing lights.

4. ENVIRONMENTALLY APPROPRIATE TECHNOLOGIES FOR SUSTAINABLE RURAL DEVELOPMENT

The development of rural Areas is essential and economically important, since it will eventually lead to better standards of living, people's settlement and self- sufficiecy in the following needs:

- Food and water supplies
- Better services in education and health-care
- Good modes of communication

Due to the present limitations and sharp shortages/ or unavailability of both electricity and petroleum-products to rural people, some renewable-energy technologies{RET} are recommended as alternative options. The RET's are based on utilizing local by available energy-sources, material and skills. These technologies are not for complete rural electrification (although they can be so), but they are applied as energy stand-alone systems, providing energy-sources for some rural basic needs. The RET's are summarized in the Table-7 and Table-8, which provide information about capacity, total cost and components of the RETs:

4.1. Solar Home Systems (SHS)

These are used for providing electricity to Schools, Khallawa, Mosques, Churches and social clubs, Table-5 gives more details of SHS.

- About 75% of the total system cost is in local currency
- About 25% of the total cost is in USD$.
- Lifetime is 25 years or more.

4.2. Solar Water-Pump System

Used for pumping / lifting water - to supply water for drinking or irrigation.

- About 60% of the total cost is in local currency.
- About 40% of the total cost in USD$
- Lifetime is more than 20 years.

4.3. Wind-Pumping Systems

Are used for pumping/lifting water for drinking or irrigation purposes.

- 100% cost in local currency

- Lifetime is more than 15 years.

4.4. Small & Medium Wind-Generators

Used for providing electricity in the range of ups to 50 kW.

- About 80% of the total cost is in local currency
- About 20% of the total cost in USD$
- Lifetime is more than 15 years.

4.5. Solar Fridges for Medical & Food Storage

The solar fridges are used for both medical and food storage purposes. Total costs depend on the capacity of the fridge.

- About 70% of the total cost is in local currency
- About 30% of the total cost in USD$
- Lifetime is more than 20 years.

4.6. Telecommunication

Solar energy is used to power radio, faxes and telephones, etc.

- About 85% of the total cost is in local currency.
- About 15% of the total cost in USD$
- Lifetime is more than 20 years.

4.7. Energy-Saving Cooking Stoves

Cooking stoves for the use of both charcoal and firewood's.

- 100% cost in local currency.

Table - 7: Design Radiation - 5.0 Kwh/m. Sq./day

Facility	School	Mosque	Rural home	Health center	Social	O & m type
No of lamps operating hours/day	8/20 W 4	6/20 W 4	3/20 W 5	3/20 W 3	4	
Up-front Cost in US%$	1200	1200	550	550	1	
Cost components: PV Modules BOS* Batteries Running cost	 500 300 200 12	 500 250 200 12	 250 200 100 6	 250 200 100 6	 182.5	 Batteries

Table - 8

	PV pumping design radiation =5 [Kwh/sq.m/day]		Diesel pumping		Wind pumping [Design speed = 4m/s]	
Village size (hh)	50	100	50	100	50	100
Demand [cu.m./day]	15	30	15	30	15	30
Pump size [kwp]	0.75	1.0	0.75	1.0		
Total head [m]	<70	<35	<90	<90	<20	<20
Up-from cost US$	7850	9150	1200	1200	4500	4500
Cost components						
PV modules	3750	5000				
Motor/pump	3500	3500				
Insl. Material	600	650				
Running cost	-	-	500/a	1000/a		

4.8. Solar Cookers

- Solar cookers are used in rural and urban areas. 100% cost in local currency.

4.9. Alternative Fuels From Agricultural & Animal Waste

- Biogas diagestor- animal waste.
- Charcoal and briquettes- agricultural residues.

Both technologies are simple and made completely from local by available material. Main use for cooking and small industries like, brick making, bakeries, etc.

The RET's mentioned above are under testing and demonstration for the last ten years (some of them more than 20 years). The results have indicated that they are clean energy, reliable and sustainable technologies. Socio-economic and environmental studies were carried out by specialists on their applications. The output of the studies pointed out that, they are acceptable to the rural people and have made remarkable impacts on the social life, economic activities and rural environment.

5. MAJOR ENERGY CONSUMING SECTORS

Sudan, area wise is the largest country in Africa and, with enough water and agricultural land resources, it is still considered among the 25 most under- developed African countries. The backbone sector of Sudan economy is agriculture. It determines (as for the last 30 years) the degree of growth of the national economy.

The strategy of price liberalization and privatization in some products of Agriculture, Industry and Energy that was implemented over the last two years has, to some extent, a positive result on government-deficit and restrictions in imports & exports. The investment-law approved recently has a clear statement and rules on the above strategy, in particular to agriculture and industry areas. In case of agriculture, the strategy was encouraging and area (irrigated or rain fed) was increased. The privatization and price liberalization in the energy field has, to some extend, secured (but not fully) availability and adequate energy-supplies to the major productive sectors. Presently the situation of energy-supplies is far better than ten years ago.

5.1 Agricultural Sector

During the 80/1990 decade, agriculture contributed about 41% to the Sudan GDP. This share remained stable till 84/85, when Sudan was seriously hit by drought, which lead to food shortages, deforestation, and also by the socioeconomic effects caused by the imposed civil war. The result drooped the agriculture share to about 37%. Recent development in the agricultural sector has raised the share to 41%. This share was reflected in providing raw material to local industries and increasing export earring beside raising percentage of employment among the population.

5.2. Industrial Sector

The Industrial sector is seriously suffering from power-problems: shortages/ and unavailability. In 1994, the industrial sector was consuming 7% per cent of the total energy, distributed as follows; 57% was from petroleum-products, 44% biomass and 8% electricity[1].

5.3. Domestic Use

Household is the major energy-consumer. In 2004 it consumed 93% of the total biomass consumption in form of firewood and charcoal. In electricity, the sector consumed 60% of the total consumption and 2.6% from total petroleum products (LPG & Kerosene).

5.4. Transport Sector

The transport sector was not being productive for the last twenty years, because of serious damage that happened to its infrastructure. In 2004, it consumed about 20 %of the total energy-consumption and utilized 63% of the total petroleum- products supplied.

The gradual implementation of electricity-price liberalization has, to some extent, released the NEC from the heavy dependency on the Government subsidies, and a noticeable improvement of NEC management and electricity supplies are achieved.

6. RECOMMENDATIONS

A. Special energy-conservation program is required in the household energy-consumption.

B. Allocate officially certain lands for aforestation programs;
   i. Encourage agroforestry, tree planting and nurseries building programs, with concentration on fuelwood types.
   ii. Utilize and encourage the use of available potential of non-woody fuels, such as agricultural and animal wastes.
   iii. Encourage the use of improved cooking stoves, with high efficiency for energy-saving.
   iv. Improve the efficiency of supplies and transportation modes of woody fuels, from the production sites to consumption-areas.

C. Enhance and encourage R & D work in renewable energies, and applications, particularly for rural and isolated communities energy- supplies:
   i. Implement the RET's that prove their socio-economic and environmental acceptability.
   ii. Prepare field-studies on the potential availability of the mini and micro-hydro potential.
   iii. Prepare field-studies on the possibility of utilizing the geothermal energy in the expected potential areas.
   iv. Establish a financial system or institutes to support the promotion of RET's.
   v. Encourage and attract the interest of private and semi-private organizations to invest in RETs.

D. Implement rural electrification program, or secure adequate energy-supplies to rural people:
   i. Encourage social and economic rural activities and generate sustainable small and medium industries in rural areas, to alleviate poverty and raise the standard of living

E. The revenues of oil-export and the local availability of petroleum products must be invested and used to increase and develop the agricultural sector, for self-sufficiency in agricultural products and for export purpose:
   i. Establish and encourage agro-industry activities.
   ii. Reduce the governmental support & direct management on Agricultural schemes.

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PHYSICS OF THIN-FILM SOLAR CONCENTRATORS FOR GREENHOUSE APPLICATIONS TO PROMOTE THE ECONOMY IN EGYPT

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ABSTRACT

Fluorescent Poly (methylmethacrylate) films embedded with a commercial coumarin dyestuff (MACROLEX Fluorescent Red G) were prepared by flow-spin coating technique. The absorption and emission spectra were recorded in order to determine the dye-concentrations corresponding to the maximum fluorescence-intensity and red shift. The emission-band was optimized to match to the absorption-band of chlorophylls (650-680 nm), which is the most important wavelength-band for the photosynthesis process in plants. These films showed a remarkable stability against both photo and thermal degradation, pointing to their excellent weathering durability for using as photoselective films in greenhouse applications in Egypt.

1. INTRODUCTION

The plant growth is a matter of primary importance for maintenance of life. A great deal of interest and research are directed towards improvement in agricultural crops by modification of environmental factors surrounding the plant. Light, has long been recognized as a crucial element in plant growth [1]. Fluorescent solar concentrators (FSCs) have attracted the attention of a large number of scientists and engineers since these were first proposed by Weber and Lambe [2]. The operation of the FSC, which can be considered as a peculiar kind of light-guide, is based on the following principles. One or more high quantum- yield species are dissolved in a rigid highly transparent medium of high refractive index. Solar photons entering the plate are absorbed by the luminescent species and re-emitted in random directions. Following Snell's law, a large fraction of the emitted photons will be trapped within the plate and transported by total internal reflections to the edge of the plate, as illustrated in Figure-1, where they will be converted by appropriate photovoltaic cells [3-4]. Recently, it has been reported that thin luminescent concentrator films could be made in the form of integrated devices or as sensitive elements in the traditional four-detector differential position sensors [5- 6].

In this paper, we introduce a promising line of application of thin-film FSCs in greenhouses. Transparent PMMA films impregnated by a fluorescent organic laser-dye of red emission-spectra were prepared. As a result of small film-thickness, a large

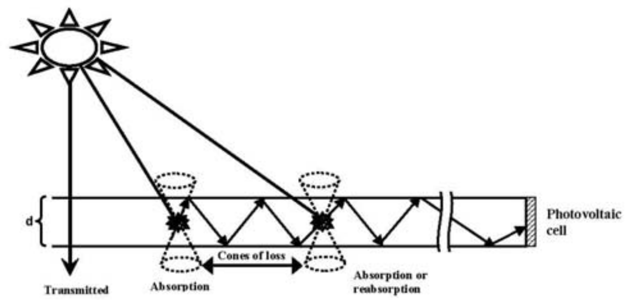

Figure - 1: Schematic Representation of Fluorescent Solar Concentrator

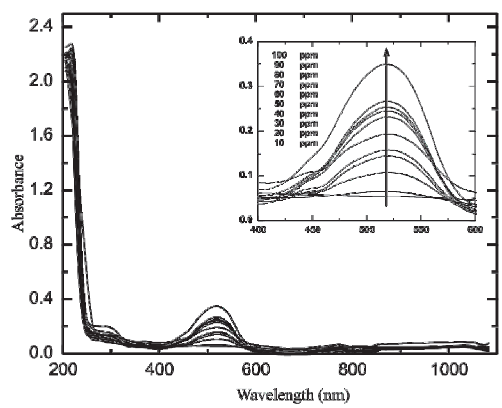

Figure - 2: Concentration Effect on the Absorption Spectra of MACROLEX Fluorescent Red G (Inset), and PMMA/ MACROLEX Fluorescent Red G Films

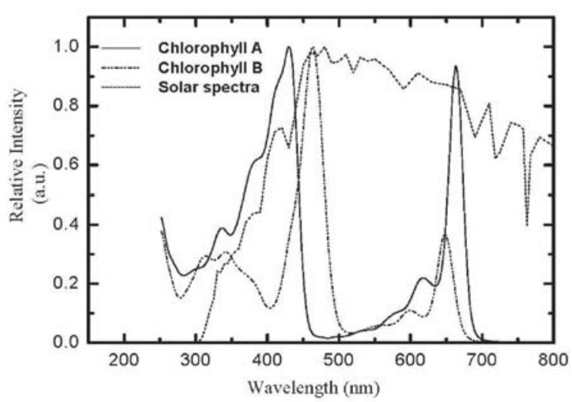

Figure - 3: The Action Spectra of Photosynthesis [7]

fraction of the emitted photons is transmitted. The dye-concentration could be optimized to match the spectral sensitivity for photosynthesis in red algae and higher plants [7].

2. EXPERIMENTAL DESCRIPTION

2.1 Material Processing

Methylmethacrylate (MMA) monomer (Merck, Darmstadt, Germany) was freed from inhibitors by distillation at 50 °C under reduced pressure, using rotary evaporator ROTAVAPOR® R-114 (BUCHI, Switzerland). The polymer syrup (PMMA-MMA) was prepared by adding 0.1 wt% AIBN initiator (Dupont, USA), to MMA. The solution was heated under reflux at 100 °C for one hour. The viscosity of the resulting syrup was determined using BROOK FIELD DV-II+ viscometer (USA); and found to be 20 cps. After cooling the syrup to room temperature, a coumarin dyestuff MACROLEX Fluorescent Red G (Bayer, Germany) was added in various concentrations (10, 20… 100 ppm). The fluorescent PMMA films were prepared by flow-coating of the solution on a polyethylene substrate, which was inclined, then the substrate was spinned in a centrifuge at 2000 rpm for 20 sec. to obtain uniform film-thickness [8]. In order to complete the polymerization of the residual monomer, the substrates were kept in an electric furnace at 50 °C for 3 hrs, after which the films were removed carefully and cut to the desired area. The film thickness, determined using Fizaue-fringe apparatus [9], was found to be of the order of 0.5-1.5 m.

2.2 Spectroscopic Measurements

The absorbance spectra of the films, as prepared were recorded in the wavelength range 190-1100 nm, using UV-VIS spectrophotometer UNICAM (Helios Co., Germany). The fluorescence spectra were recorded in the range 200-900 nm, using spectrofluoremeter (SCHIMADZU RF-5301 PC, Japan); the spectrofluoremeter is equipped with a temperature regulator. The diffused reflectance spectra were taken with a Polytec; Germany X-dap (Diode Array Spectrophotometer) in the spectral range 400-800 nm. Light emitted from a Xenon lamp source and the reflected light entering the spectrophotometer is transmitted through optical fibers. The photoresponse of the optimized film (100 ppm) towards UV-VIS light was measured using Xenon-arc lamp with the aid of photodegradation accelerator (SUNTEST XLS+, Germany); the film was irradiated at 1800 kJ/m^2.min for 24 h, which corresponds to the irradiance for about 1 year exposure to sunlight.

3. RESULTS & DISCUSSION

3.1 Absorption

The absorption spectra for all the PMMA films as prepared are shown in Figure-2 Two major bands are observed. The first one lies in the UV region around 214 nm, characterizing - * transition in the carbonyl group of PMMA. The second one appears around 520 nm, corresponding to the excited-state vibrational transition s_o-s_1 of the dye [10]. It is noted that the dye absorbs the green-yellow band, which is not utilized by chlorophylls 7 (Figure-3).

3.2 Fluorescence

The effect of dye concentration on the fluorescence-spectra of the investigated films is illustrated in Figure-4. It is observed that a maximum in the intensity is obtained for the concentration 50 ppm and the maximum red shift 623 nm for 100 ppm.

This remarkable red shift can be explained by the room temperature synchronous excitation spectra illustrated in Figure-5. One distinct maximum can be observed at the coordinates (exc., ems.) = (520, 623 nm). The broadening of the contour lines indicates a wide distribution of the aggregated dye molecules which form excited dimers (excimers) at this concentration [11].

The absolute fluorescence quantum-yield was calculated, relative to Rhodamine 101 doped in PMMA as a reference $_{f}$ 100 %), using the following equation [12] where $_{ref}$ is the fluorescence quantum yield of the reference, A is the absorbance, n is the

$$_{f} = {}_{ref} (A_{ref} /A)\ (n /n_{ref})\ (a /a_{ref}) \qquad ....(1)$$

refractive index and "a" is the area under the fluorescence curve. The Stokes shift $_{s,}$ which is a measure of self-absorption of the emitted light, was calculated from [13] where $_{em}$ and $_{abs}$ are the wavelengths at the fluorescence and absorbance maxima

$$_{s} = {}_{em} - {}_{abs} \qquad ....(2)$$

respectively. The values of $_{abs}$, $_{em}$, $_{s}$ and $_{f}$ are listed in Table-1. The observed decrease in $_{f}$ accompanied with larger $_{s}$ values at concentrations higher than 50 ppm can be attributed mainly to the formation of dimers and higher aggregates, which have small values of $_{f}$. The strength of aggregation depends mainly on nature of the dye, the host media and the other factors related to the preparation conditions. The decrease in the quantum yield at higher concentrations is caused by Foster-type energy-transfer to dimers. The equilibrium between the monomer and dimer shifts to the side of the latter with increasing dye-concentration [14]. The values of the transmittance at the emission wavelength T_{em} for different dye-concentrations, as tabulated in Table 1, reveal that all the samples exhibit high transmission, values, with a maximum value, around the concentration 50 ppm, due to its excellent fluorescence properties, so most of the effective red light can be transmitted thing promoting the growth of the plants.

3.3 Photostability

The accelerated photoresponse of the sample of 100 ppm towards UV-VIS was studied.

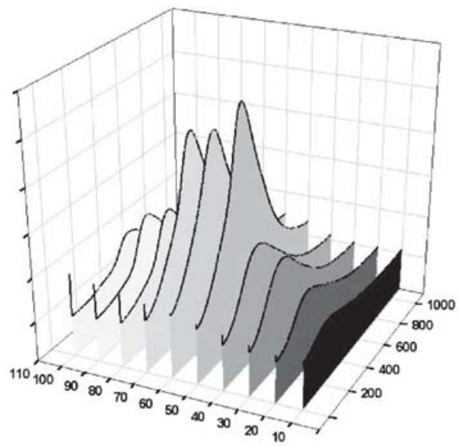

Figure - 4: Effect of MACROLEX Fluorescent Red G Concentration on the Fluorescence Spectra of PMMA Films

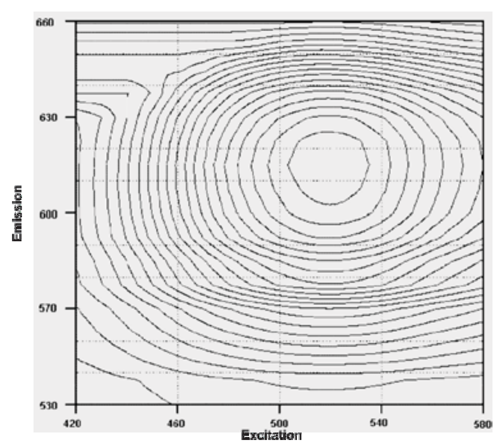

Figure - 5: Surface Map Representation of a Synchronous Excitation Spectrum of PMMA / 100 ppm MACROLEX Fluorescent Red G Film

The film was irradiated with artificial sunlight from Xenon arc lamp for 24 hours. The photodegradation P%, which is the percentage change of optical density, is plotted versus the exposure time as illustrated in Figure-6 and suggested two degradation-rates obeying second- order kinetic law.

$$P = P_o + C_1 \exp(-R_1 t) + C_2 \exp(-R_2 t) \qquad \text{..........(3)}$$

where $P = P_o$ at $t = 0$ and R_1, R_2 are the photodegradation rates of the dye.

The calculated values of the photodegradation rates are 1.6 x 10^{-3} and 8.03 x 10^{-7} respectively. This is clearly illustrates that the photo-degradation rate is decreased after two months of direct exposure to sunlight. It is also observed that the dye absorbance is decreased to 92.47 % of its initial value after the irradiation for 24 hrs, which is the period corresponding to one year exposure to sunlight. This indicates that PMMA is a good matrix to since it can protect the dye from thermal and photo degradation.

3.4 Temperature Effect

The absorption spectrum of 100 ppm dye doped film was recorded at different temperatures in the range 273-353° K. It was found that there was no major thermal effect on the dye molecules at temperatures below the glass transition temperature (Tg) of the PMMA matrix . This result is in good agreement with our earlier published work [15, 16].

On the other hand, the obtained fluorescence spectra was found to decrease to 93.35% of its initial value as the temperature increases to 353 K. The normalized fluorescence intensity against temperature is plotted in Figure-7(a). An increase in the temperature also leads to phonon-assisted relaxation processes; the electronic excitation energy can be dissipated by vibrations of the surrounding matrix and the energy-levels of the fluorescent species [17]. The energy transfer-rate, K_{ET} (T), can be obtained by Arrhenius equation [18]

$$K_{ET}\,(T) = (K_{ET})_{T}\quad Exp\,(-E_a/RT) \qquad ....(4)$$

Where E_a is the activation energy of the transfer-process and R is the universal gas constant and $(K_{ET})_{T}$ equals K_{ET} at T = . The value of K_{ET} at a given temperature is

Table - 1: The Effect of Concentration on the Spectroscopic Properties of the as Prepared PMMA/ MACROLEX Fluorescent Red G Films

Concentration (ppm)	$_{abs}$ (nm)	$_{em}$ (nm)	$_{s}$	$_{f}$ %	T_{em} %
10	517.00	578.80	61.80	15.60	94.40
20	523.00	589.60	66.60	22.80	94.97
30	521.90	589.60	67.70	33.80	96.04
40	524.00	593.00	69.00	42.90	97.11
50	521.30	597.20	75.90	90.60	97.65
60	522.10	605.20	83.10	78.40	97.60
70	520.20	609.80	89.60	75.70	97.26
80	520.60	610.80	90.20	39.70	96.22
90	519.50	615.00	95.50	34.60	94.94
100	518.80	623.40	104.60	23.20	93.98

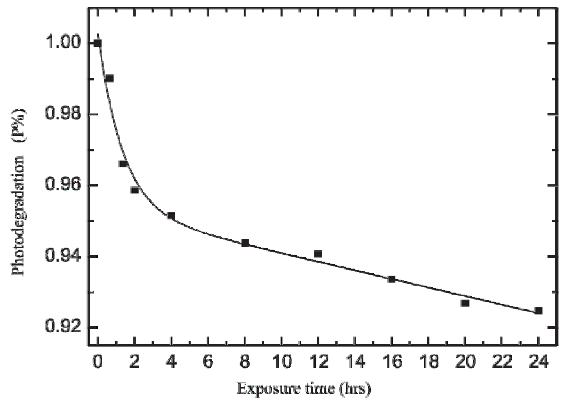

Figure - 6: The Photodegradation Curve of PMMA / 100 ppm MACROLEX Fluorescent Red G Film after Indoor Exposure to Artificial Sunlight from Xenon Arc Lamp for 24 hrs.

proportional to the relative emission-intensity of the dye-molecule (I_o/I_T) where I_o and I_T are the emission intensities at temperatures zero and T respectively. Arrhenius plot of $\ln(I_o/I_T)$ vs. $10^3/T$ gives a reasonably good linear fit and the calculated value of E_a is found to be 0.794 kJ/mol. After cooling the sample to room temperature, the fluorescence intensity retuned to its initial value; this indicates that the film exhibits excellent weathering durability in different climates, since our study covered wide range of atmospheric temperatures.

Figure-7(a) Fluorescence intensity as a function of temperature and (b) Semilogarithmic plot of emission relative intensities, ln I/I_o vs. $1/T$ for PMMA film embedded with 100 ppm MACROLEX Red G.

4. CONCLUSION

The film of concentration 100 ppm showed the closest emission band to the action-spectra of photosynthesis in higher plants, with a high transmission of red light (97.65 %) and a remarkable photoresponse towards UV-VIS solar radiation. More efforts to increase the effective transmission of red light and the stability of the films, are in progress [19]. These films can act as promising photoselective films, which would increase the irradiance level for photosynthesis in greenhouses. Also, it can be used in growing-rooms in which plants are grown for commercial purposes e.g. red algae which are of great economic importance in food, pharmaceutical, cosmetic, and industrial applications [20].

ACKNOWLEDGEMENT

The authors are grateful to Prof. Dr. M.S. Abdel-Mottaleb, Director of the photoenergy center, Ain Shams University, Egypt, for providing the facilities

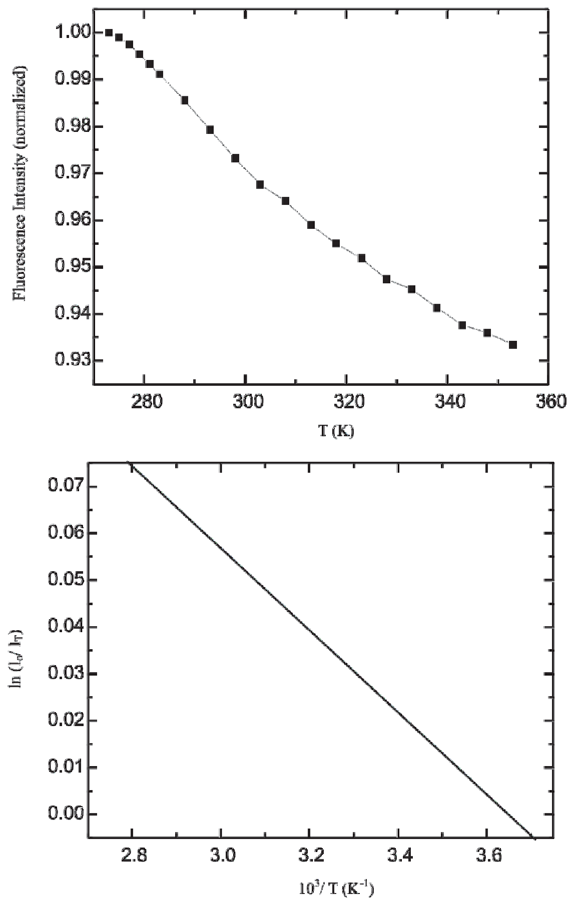

Figure7. (a) Fluorescence intensity as a function of temperature and (b) Semilogarithmic plot of emission relative intensities, ln I/Io vs. 1/T for PMMA film embedded with 100 ppm MACROLEX Red G.

needed for the measurements of the samples under investigation.

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RELEVANCE OF SPACE PHYSICS TO SUSTAINABLE DEVELOPMENT

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ABSTRACT

Observations of the heavens and the earth's immediate environment over the centuries have lead to the development of Space Physics, as we know it today. Stars, including our Sun and other heavenly bodies, were the earliest sources observed. From simple observations of the intensities and colors, the light provides information about the objects that reflect it or the sources that generate the light. Further analysis provides information on details, such as constitution of planetary atmospheres and types of materials that composes their surfaces. The sparse gas and dust that lies between condensed bodies of the universe can also be detected and identified, as it absorbs and scatters light.

Developments in space physics and associated technologies have enabled inward pointing of observational instruments/equipment to facilitate continued surveillance and monitoring of the earth and its natural resources, to support sustainable development. This paper discusses how artificial satellites orbit around Earth are providing spatial data to support up-to-date and comprehensive information-base so as to facilitate planning and decision-making.

1. INTRODUCTION

Sustainable development is maintaining a delicate balance between the human need to improve lifestyles and feeling of well-being, on one hand, and preserving natural resources and ecosystems, on which we and future generations depend, on the other.

According to the World Commission on Environment and Development (WCED), this is "development that meets the needs of the present, without compromising the ability of future generations to meet their own needs." Sustainable development implies economic growth, together with the protection of environmental quality, each reinforcing the other. The essence of this form of development is a stable relationship between human activities and the natural world, which does not diminish the prospects for future generations to enjoy a quality of life at least as good as our own. Many observers believe that participatory democracy, undominated by vested interests, is a prerequisite for achieving sustainable development.

The guiding rules are that people must share resources with each other and care for the

Earth. Humanity must take no more from nature than nature can replenish. This, in turn, means adopting lifestyles and developmental paths that respect and work within nature's limits. It can be done without rejecting the many benefits that modern technology has brought, provided that technology also works within those limits ("Caring for the Earth", IUCN,)

There are over a hundred definitions of sustainability and sustainable development, but the best known is that by the World Commission on Environment and Developments'. This suggests that development is sustainable where it "meets the needs of the present, without compromising the ability of future generations to meet their own needs."

The term refers to achieving economic and social development in ways that do not exhaust a country's natural resources. The World Commission on Environment and Development terms sustainable development as a process of change, in which the exploitation of resources, the direction of investments, the orientation of technological development, and institutional change are made consistent with the future as well as present needs.

Sustainable development respects the limited capacity of an ecosystem to absorb the impact of human activities. Development that meets the needs of the present without compromising the ability of future generations to meet their own needs. The concept should include preservation of the environment for other species, as well as for people. Some of the key parameters that could lead to sustainable development are

- Needs Assessment
- Exploitation of natural resources
- Development and use of technology
- Economic growth
- Environmental protection, and
- Quality of life

2. EARLY OBSERVATIONS OF HEAVENLY BODIES

Simple observations of the night sky provides information about (a) the positions and the movement of the planets and their moons, (b) physical properties of the sources that generate the light such as our Sun and the stars, and (c) the constitution of planetary atmospheres and types of materials that composes their surfaces. The sparse gas and dust that lies between the heavenly bodies can also be detected and identified, as it absorbs and scatters light. Extremely massive objects, such as galaxies, can even cause detectable changes in the path of light that is otherwise bound to travel in straight lines. To arrive at a sensible interpretation of the information that is raining down upon us, the behaviour of light must be carefully understood.

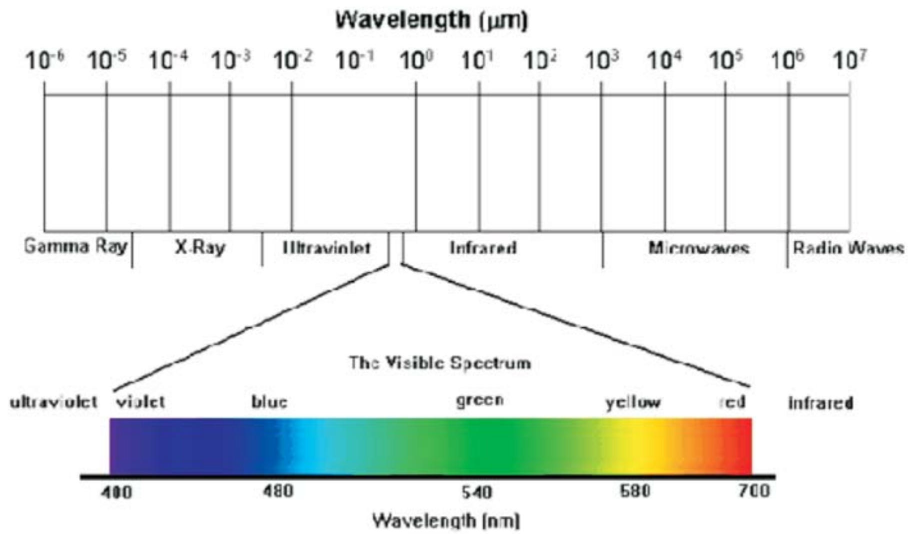


Figure - 1: Spectrum of Visible Light

2.1 The Electromagnetic Spectrum

Daylight, provided by the Sun, is composed of waves of many different wavelengths. Together they add up to white light, but the waves can be sorted according to the constituent colours. The human eye can distinguish the visible spectrum into a few hundred shades (traditionally only seven colours constitute the rainbow), but the wavelength varies continuously (see Figure-1). At the red end of the spectrum, the wavelength is about twice that of the violet end (roughly 350 nm to 800 nm). When the wavelength gets longer, beyond the red limit of our eyes, it is called infrared radiation. Heat detectors in the skin can sense strong infrared sources, such as heat from the Sun. Once the wavelength is increased beyond about one millimeter, it becomes known as microwave radiation. Beyond this region, as the wavelength increases to about one meter, it becomes a radio wave.

As the wavelength of light gets shorter, beyond the ultraviolet, to about 10 nanometers, light becomes known as X-rays. Finally, very short wavelength electromagnetic radiations, below about 10 Pico-meters are known as gamma radiation.

2.2 Gravity, Gravitation and the Artificial Satellites

The role of gravity in the universe is paramount. The establishment of heliocentric model of the Solar system by Copernicus in the sixteenth century prompted accurate observations of the motions of the planets in order to produce evidence to explain why such objects move as they do. The result of Kepler's observations was the establishment of three laws that describe how the planets orbit around the Sun. The laws are:

i. The planets orbit the Sun in ellipses with the Sun at one focus. For a circular orbit, the Sun is at the cenrre.
ii. The line joining the Sun and a planet sweeps out equal areas in equal times. This implies that a planet's speed is constant for a circular orbit.
iii. The square of the sidereal period of a planet is proportional to the cube of the semi major-axis of the ellipse.

Kepler's third law provides the starting point for a derivation of Newton's law of gravitation. It implies that the planetary speed decreases with separation from the Sun. The outer planets travel more slowly and have longer distances to travel, to complete an orbit, resulting in the strong dependence on sidereal period with distance. Since an orbit is elliptical or circular and, as such, constantly changing its direction of motion, so it must be experiencing a force to keep its motion circular or elliptical. Such a force is known as centripetal force and is directly proportional to the mass of the object. For an object to remain in orbit, it must equate the centripetal force with the force due to gravity. Newton discovered that, as the planets are attracted towards the Sun, the planets must have also been exerting force on the Sun. If this is the case, then every body must have a gravitational field proportional to its mass and the force between the two objects is proportional to the product of their masses.

3. ARTIFICIAL SATELLITES

Armed with knowledge of how orbiting bodies behave and the technology of the twentieth century, it has been possible to send artificial satellites into space and into orbits about the Earth. As far back as 1945, Arthur C. Clark, a science-fiction writer, had shown that if three satellites could be placed 60 degree apart at 23,000 miles above the Earth's equator, one could cover the entire globe and communicate between any two points. Such orbits that are housing hundreds of communication-satellites for worldwide coverage of television, telephony and data are known as "geostationary orbits".

Satellites placed in geostationary orbits rotate around the Earth at the same speed as the Earth rotates around its axis. Therefore, they appear to remain stationary above a certain point on Earth. Such an orbit is ideal for relay of telecommunications, TV broadcasts and round-the-clock observation of the Earth for meteorological and environmental monitoring.

Satellites are also placed in lower altitude orbits, providing higher signal- strength and more specific coverage. These Low Earth Orbits or LEOs are the ones wherein the first scientific satellites were launched by the space-faring nations. Pakistan's first experimental satellite BADR-1, which was also Muslim Umma's first satellite, was placed in a Low Earth elliptical orbit in July 1990. The second satellite BADR-2 was placed in higher inclination, sun-synchronous polar orbit, selected to facilitate photography of the Earth.

The best-known low Earth orbit is a polar orbit, wherein satellites move from north to south and south to north. Polar orbiting satellites have the advantage of moving around the Earth fairly rapidly, which means they can sample the whole globe but will see a particular region much less frequently. Taking advantage of miniaturization in microelectronics and highly precise time-measurements available, constellations of small satellites are being effectively used for global voice and data communications. Satellites in these low-altitude orbits offer distinct advantages of higher signal strength and lower fuel weight required. Constellations of global navigation satellites, such as GPS, GLONASS and GALILEO, are also placed in such orbits.

4. SPATIAL DATA AND INFORMATION MANAGEMENT

Sustainable development requires an up-to-date and comprehensive information-base, to support planning and decision-making. Spatial data, acquired by either space-based or ground-based means, is an increasingly important part of this information-base. The Internet and satellite communication services allow for dynamic information-sharing and exchange between partners in sustainable development, thus enhancing the benefits of complementary activities within and outside various economic zones or regions.

Satellites are routinely used to assess and acquire earth's resources-data, as well as to manage natural resources and emergency situations through use of communication and navigation satellites. It has been experienced that, in emergency situations, satellites provide the bearing and perhaps the only means to establish communication, especially in remote and inaccessible areas. Thus, satellites play a vital role in ensuring sustainable development.

5. NAVIGATION SATELLITES

Global navigation satellite-systems (GNSS), including the Global Positioning System (GPS) of the United States of America, the Global Navigation Satellite System (GLONASS) of the Russian Federation and the future European Galileo and their augmentations, are a new global utility. They have high accuracy and global coverage, and can operate in any weather.

GNSS establishes a user's position, movement and time by measuring the distances to at least four satellites. Each satellite transmits a complex digital code. By comparing with the code generated by the receiver, the time to travel between the two can be calculated. Multiplying this with the speed at which the signal travels gives the distance to the satellite. Minimum of four satellites in the field of view are required to provide 3-D position of the receiver.

The receiver of the signals must know both the distance to each satellite and its precise position in space. Therefore, these satellites are in highly accurate orbit. Positioning accuracy for the user depends upon other things, such as the type of receiver, location, number and relative positions of satellites and atmospheric conditions.

Transmitting signals via satellite about a person's location, and the exact time they are sending the signal adds a new dimension to the types of applications that satellite navigation can provide. Many ships carry a GPS-based system that can send emergency distress signals showing location and time data, which enables help to reach them as quickly as possible. All types of airborne or satellite data can be combined with satellite navigation- services to generate Geo-information products and services for clients in agriculture, telecommunications, utilities, oil exploration, etc.

Benefits of GNSS are growing in areas such as, aviation, maritime and land transportation, mapping and surveying, precision agriculture, power and telecommunication networks and disaster-warning and mapping response.

The atomic clocks in the GPS satellites provide the timing for the Internet. The clocks also provide precise time-standard, which is necessary to synchronize events. Navigation satellites are an essential part of satellite mapping, telling us what part the map may refer to.

6. COMMUNICATIONS SATELLITES

Just like any other kind of telecommunication, communication-satellites are used to transmit information from one point to another. Unlike ground-based communications, however, people sending or receiving information through satellites do not have to be connected to a ground network. Communication satellites can reach people in remote villages, ships on the high seas and areas where ground infrastructure is not available, or has been damaged by a natural disaster. They can also help improve education, health-care and the standard of living, and have special potential for the least developed and backward areas. Together with ground-based networks, they provide access to the World Wide Web.

The Internet is making it much easier to spread information, and telecommunications-satellites have relayed most of the information that finds its way to its users. Satellite technology has amply demonstrated that its versatility, broad reach and speed make it the ideal conduit for the exchange of information. Satellites are used for long-distance telecommunications, connections between remote locations and for data-monitoring. Satellites have the potential to help the developing countries leapfrog several stages in development.

7. REMOTE-SENSING SATELLITES

Some of the basic requirements for sustainable development are: assessment of needs, exploitation of natural resources, development and use of technology and protection of environment. Remote-sensing satellites constitute the vehicles for use of technology and primary source for assessment of the resources. Our Earth can be observed from space by remote sensing satellites. Remote and inaccessible places can be monitored from this unique vantage point, as well as places where unexpected disasters occur. These satellites are used to help us measure and monitor the Earth's climate and environment. The unique features are;

7.1 Coverage

Most remote sensing satellites cover the whole globe, making them important for the study of large scale phenomena like ocean circulation, climate, deforestation, and desertification They also provide cost-effective monitoring of remote or dangerous areas.

7.2 Repetition

Satellites repeatedly view the same areas over long periods of time. This makes it possible to monitor environmental change, including the impact of humans and natural processes such as deforestation and desertification.

7.3 Speed

Satellites by their very nature are capable of providing data and other information rapidly in emergencies. This is specially significant for developing countries as they lack the necessary infrastructure to promptly redress the situation in case of flooding, earthquake, forest fires etc.

7.4 Consistency

All the data collected by a particular sensor on a particular satellite is collected in the same way. This makes it easier to detect subtle changes in land use over a period of years.

7.5 Accuracy

Satellite images and global positioning systems are being used to obtain accurate maps. Combined with geographic information system (GIS), these terrain maps are used as basic tools for planning and development.

7.6 Low Cost

A satellite can be used for a large number of activities for a long time. Repetitive coverage and availability of large amounts of data in a relatively short time makes the satellite-based systems low cost tools for development.

8. THE PHYSICS OF REMOTE-SENSING

Remote sensing is "the science and art of obtaining information about an object, area or phenomenon, through the analysis of data acquired by a device that is not in contact with the object, area or phenomenon under investigation."

In the same way that our eyes make visual sense of the light reflected from whatever we are looking at, remote-sensing satellites use sensors to see and computers to process, store and communicate whatever is seen on the Earth's surface from space.

The visible light that our eyes can detect is a small part of the electromagnetic spectrum that ranges from gamma rays, x-rays, ultra-violet rays, visible light and infrared rays, through the microwaves and radio waves. Each form of radiation provides different information on the subject viewed.

Cameras mounted onboard satellites record the reflected light across the whole of the visible range and with special films, thus a small part of the infrared band. Cameras, scanners or radiometers used to pick-up and record information in the visible and infrared radiation bands are passive systems. In case clouds get in the way, no radiation can reach the sensors or the satellite.

Figure - 2(a): A picture taken from a specific wavelength-band

Figure - 2(b): Same scene taken from a different band

On the other hand, radar-based system generates its own-pulsed beam of radiation and directs this onto the terrain below, registering the information reflected back. Radar is effective in all weathers and can be used both night and day. Synthetic Aperture Radar (SAR) is most successful radar-system used for all weather and day and night imaging.

It is common knowledge that light can either be reflected, absorbed or transmitted on a surface and the proportion of the three will vary at each wavelength for a given object. This is why two features may appear similar in the same wavelength-band, but distinguishable in different band. Different response curves given here further illustrate the point.

A satellite image is made up of tiny electronically produced dots, known as pixels. The area of ground seen by each pixel depends on the height of the satellite-orbit and the magnification of the lens, which defines the area of the terrain and the detail of the image. Meteorological satellites have broad field of view, resulting in low-resolution image of a few kilometers. The highest resolution digital imagery on the market is from IKONOS satellite, with one-meter resolution pixels. India's Cartosat-2 satellite is also capable of providing 1-meter resolution images. The satellites that are categorized as Military satellites or the Spy satellites are already providing images of at least twice the resolution of IKONOS.

Extraction of sensed information from the satellite images is a complex process and requires use of sophisticated computer software. The image-analysis computers are also trained to recognize 'spectral signatures' of key-features on test-sites, so that imagery can be classified into different kinds of ground cover. For example, once the spectral characteristics of a particular crop are established, the computer can cover the entire area of the crop covered by the image. If the satellite covers the same area at

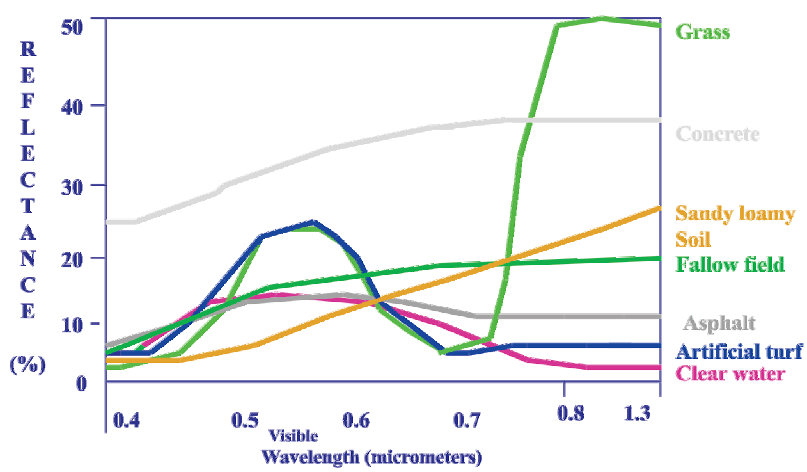


Figure - 2(c) Spectral reflectance of different object classes

a later date, one can determine any changes in the land-cover. The images can be used to extract information on the crop-yield.

Similarly, once the spectral signatures associated with the occurrence of a particular mineral are established, new sites for its exploration can be identified. Copper mines in Chaghi were discovered in this fashion.

Data from Earth observation satellites is often integrated with a wide range of other data, using Geographic Information System (GIS) techniques. In its simplest form, GIS techniques can be used to overlay map-data onto a remote-sensing image or to mask-off area of an image for analysis.

Acquisition and archive-processing of high resolution images and development of applications are a result of advanced technology and state-of-the-art techniques. These advances have been firmly focused on how the users of the data can best be served through its applications.

Remote-sensing images are a readily accessible source of information for the geologists, land-use planner and environmentalist. They are used extensively in meteorology, agriculture, damage-assessment, hydrology, land-use, environment-monitoring, etc.

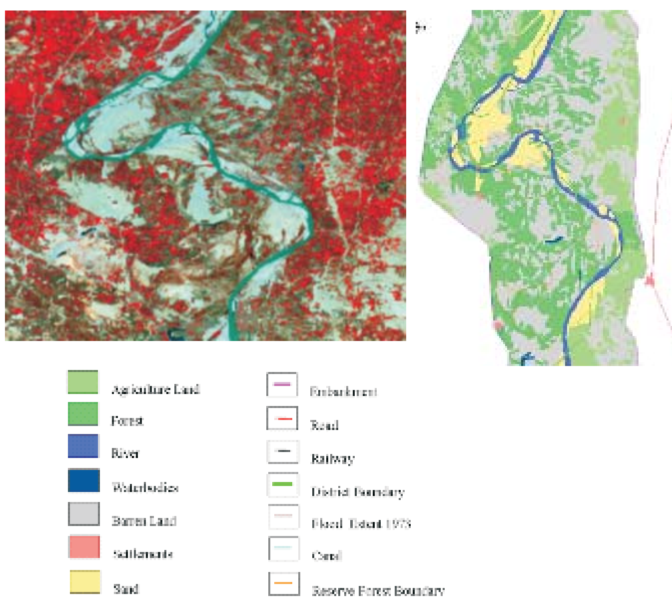


Figure - 3: Determination of Water and food distribution using satellite imagery-Naushero-Dadu District

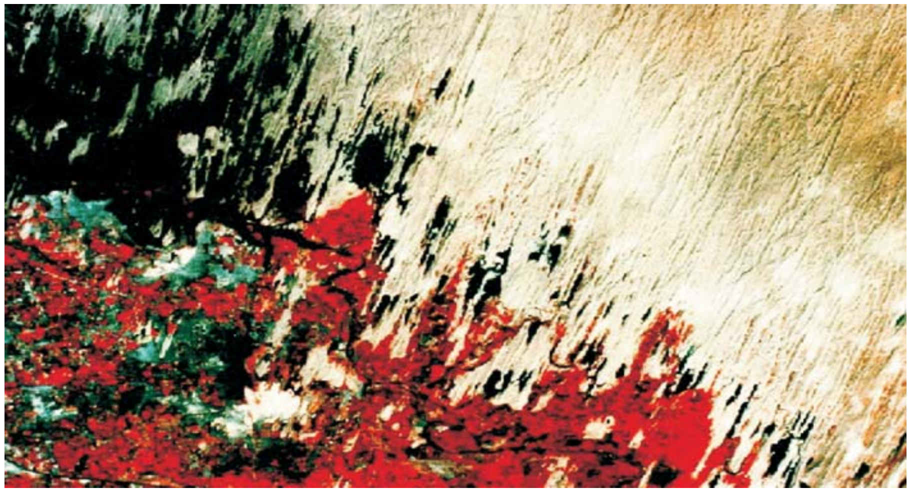


Figure - 4: Color coded dam site selection, Chotiari

9. BENEFITS TO DEVELOPING COUNTRIES

9.1 Water and Food

Fundamental to the growth of crops is water. Satellites and space-applications have demonstrated a very real capability of identifying the water-content of soil, potential new sources of water, providing an inventory of water-resources and determining water-sheds and, in general, providing a wide variety of data regarding water management.

Water-management is critical for sustenance in the arid and semi-arid areas of the developing world. Remote-sensing satellites provide the ideal tools to acquire good understanding of the various stages of water-cycle, map water- distribution and availability, measure the impact of droughts and floods, collect information on the use of water for forestry and agriculture.

Mapping of favourable landforms for ground-water exploration over vast and remote locations is best achieved through satellite remote-sensing. Repetitive coverage facilitates monitoring of short-lived phenomena, seasonal variations in soil moisture

In a developed society, an accurate knowledge of the ice-cover or the snow-cover in winter is important to assess the water likely to be available on melting, and the subsequent availability of hydroelectric power are extremely valuable. In a large majority of developing countries, the knowledge of potential water-resources means often the difference between life and death, not just improved profits.

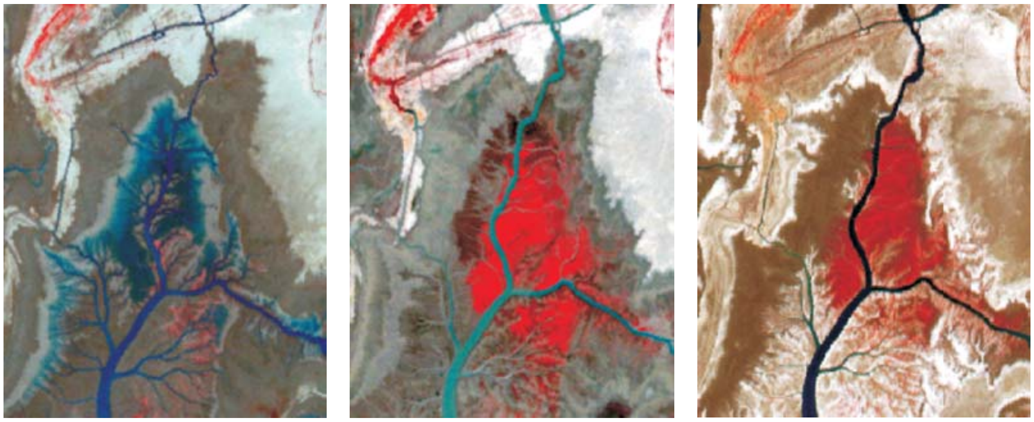
Figure - 5: 4m Resolution Satellite photo of Agricultural Land Evaluation, Jaranwala

The location of water clearly relates to where the vegetation is growing, or can grow. It has been demonstrated clearly that satellite-imagery can show where the natural vegetation exists in arid, semi-arid or remote areas. This naturally helps in the development of available resources and generates incomes. As a result, new developments in the fields of water-management and utilization take place as well as new methods for treatment of wastewater and enhancing supplies of fresh water take place.

9.2 Agriculture and Land-Use

Monitoring agricultural crop-development from space can help predict crop-output and yields well in advance. Third-world countries, mostly relying on Agriculture for their national income, have been eager to adopt space-technology applications not only to meet their growing needs for food, but also to bring prosperity to their population. Advance and timely information on the agriculture crop-output is often crucial in helping governments to anticipate food-shortages and famines, giving them ample time to take preventive measures.

Pakistan, through its national space agency, SUPARCO started using satellite data to predict wheat yield in collaboration with NASA, as early as 1972. Since then it has not only developed numerous applications but has also set up its own facilities for satellite data acquisition, archive and processing Small farm sizes and the cropping pattern pose inherent difficulties in obtaining a high degree of accuracy in the yield prediction.



Landsat TM Image of 1989 **Landsat TM Image of 1998** **SPOT XS Image of 2003**

Figure - 6: Afforestation monitoring, Mangrove Swamp, Shah Bunder

Besides agriculture, Suparco has extensively used remote sensing data for various land-use applications having economic implications and for:

i. Detecting forest cover change and degradation
ii. Locating forest fires
iii. Mapping new roads, settlements and logging
iv. Distinguishing primary or virgin forest from areas of secondary forest
v. Providing data for mapping areas where forest is under stress, for instance from infestation or drought.

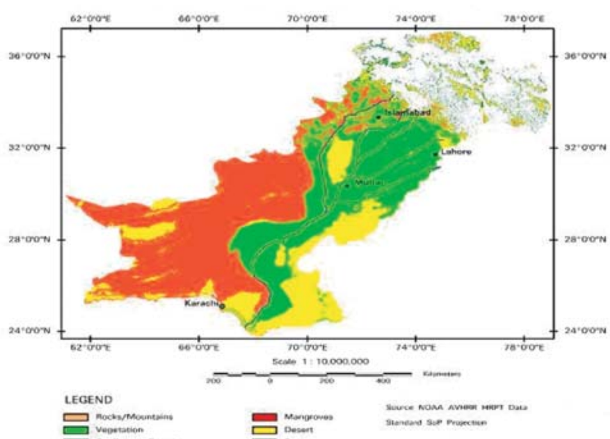


Figure - 7: Landuse Map of Pakistan Categorized by Terrain Type

9.3 Geological Mapping and Mineral Identification

Satellites have been used to locate and identify minerals from the surface geology as well as hydrocarbons. Dhodak fields and Sandak are well known examples. Though the developing countries lack the expertise to deploy the technology and the techniques to exploit the available natural resources, the finds are usually the basis for attracting capital investment in the country by way of mining and processing facilities.

Since the developing countries have abundant human resources available, discovery of mineral resources naturally leads to provision of employment and general enhancement of educational levels and training of the manpower to support the infrastructure associated with mineral recovery. It is therefore important to recognize that hand-in–hand with technological exploitation must go administrative efficiency towards enhanced indigenous capability.

9.4 Development of Human Resources

Efficient use of satellite imagery and effective utilization of available resources by the developing countries largely depends upon the skill of the managers in terms of livestock and crops, water and forestry as well as fisheries. This emphasizes the use of satellites for practical and vocational training. Such a use will make information from technical laboratories, research centers and other support sources more readily useable and the users more competent.

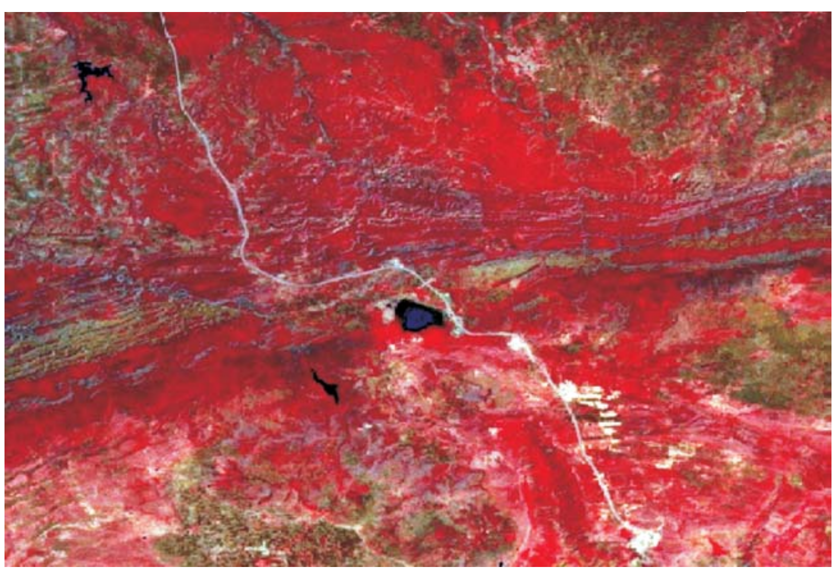


Figure - 8: M-2 Motorway with a view of the Salt Range

It is widely known that countries with large populations and large land mass with remote and inaccessible areas have been successfully transmitting instructional materials via satellites to read-out stations in villages. The advantage of such a transmission media is the availability of the educational material/instructions without the need for any ground infrastructure.

9.5 Satellite-based Village Resource-Centres

Integration of capabilities of communication and earth observation satellites to provide a wide variety of information such as land and water resources, rural employment, watershed, environment, infrastructure, agriculture etc. with ground derived and weather related information can be used to provide locale-specific advisory services. Such centers could also be used to tele-education, tele-medicine, online decision support, interactive farmers advisory, e-governance, weather, community specific advice on soil and water management etc..

9.6 Environmental Assessment and Quality of life

Scientists predict global warming, caused mainly by increasing carbon dioxide emissions from the burning of coal, oil and petrol in motor vehicles and power stations; will increase the frequency and severity of droughts, flooding and storms, threatening global agricultural production. The world scientific authority on global warming, the Intergovernmental Panel on Climate Change (IPCC), predicted in its 2001 report that rising levels of greenhouse gases like carbon dioxide will increase temperatures by between 1.4 degrees and 5.8 degrees Celsius (35 and 42 degrees Fahrenheit) by the end of the century and sea levels by between 9 and 88 centimeters (3.5 and 35 inches). Population increases would raise world emissions by 27 percent to 29.6 billion tons over the next 50 years. United States and Canada currently have the world's highest average per capita CO_2 emissions at 19.9 tons per year, 20 times more than for sub- Saharan Africa, and are expected to increase their population by 132 million during the next 50 years. Economic development in poor countries will also increase emissions. Between 1990-99 emissions in North Africa and West Asia rose by 19.7 percent and South America 22.5 percent. The continuing process of urbanization

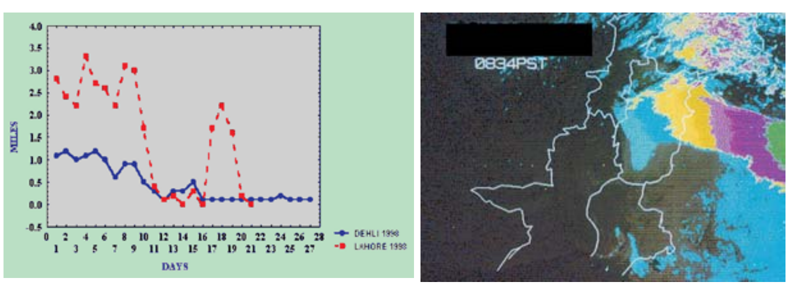


Figure - 9: Fog Analysis Using NOAA Satellite Photos

will mean that extremely large numbers of people, probably several billion, will be living in low-lying, densely populated coastal areas of the developing world, and their situation is likely to be particularly exposed.

Flooding of coastal areas, which might result partly from sea level rise and partly from increased rainfall, could lead to the simultaneous loss of cropland and urban infrastructure. This would result in food price raises, large-scale migration and possibly significant socio-political disruption.

9.7 Geospatial Disaster Relief

Space based systems have no capability to detect and predict natural calamities like dam bursts or earth quakes and their after effects. However, the remote sensing, communication and navigation satellites provide the means of assessing the extent of damage and enabling the planning of relief operations for the mitigation measures.

Recent events of tsunami, Indonesia, political instability in Darfur, Sudan and dam burst near Pasni in Baluchistan, were some of the worst disasters experienced in the recent times. Besides large-scale devastation, many people were suddenly deprived of their shelters, food, means of livelihood and other life necessities. Immediate problems were, therefore, where to build shelters, fetch fresh water, food for themselves and the livestock, fuel for cooking, medical aid etc. For the aid giving agencies or the relief workers, how to save the human lives and reduce the sufferings, rebuild infrastructure and bring life to the normal.

Figure - 10: One Metre Resolution Satellite Imagery, Survivor Camp, Africa

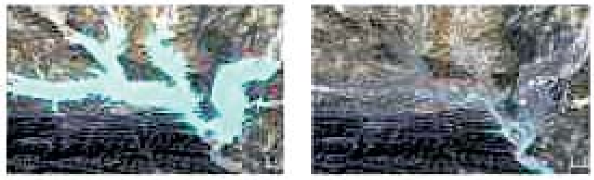


Figure - 11: Flood Monitoring, Baluchistan

First step to tackle these problems requires maps, which are often non-existent or grossly outdated, especially in remote and underdeveloped locations. Remote sensing data are often the quickest and the best source of data available in a situation like this Different sensors are particularly well suited to different geospatiale-disaster response purposes. Remote sensing technologies, such as ERS and JERS-1 radar in combination, can detect areas with available subsurface water as well as dry areas. The same data can be used to site camps in the vicinity of accessible roads and dry high grounds.

The ERS radar captures surface topography and near- surface geologic features, such as earthquake faults or buried drainage channels. The JERS-1 longer wavelength signals penetrate as deep as 2 meters in the arid regions yielding additional clues about potential water sources.

Satellite systems, such as SPOT, LANDSAT, IKONOS and Quick Bird can locate and identify vegetative cover and trees while Synthetic Aperture radar in combination, can detect areas with available subsurface as well as dry areas supporting well – drilling decisions. Severity of the events such as Pasni dam burst and the impact of the civil strife in Sudan could be assessed with fair amount of accuracy and great speeds.

Radars can capture the location of roads, rivers, etc., in support of transit and supply chain planning. High-resolution images from satellites like IKONOS and QuickBird can provide up-to 1:2000 maps of sufficient details to identify individual hutments, tents etc. Satellites thus provided a unique opportunity to catalogue the impacted areas and facilitate prompt relief and rehabilitation.

The above Earth Observation and Environmental Satellites offer infrequent images for disaster monitoring purposes, and can prove expensive. The technology has now developed and demonstrated operational launching of Disaster Monitoring Constellation of micro-satellites providing round the clock global coverage and availability of 32-meter resolution imagery within 24-hours. Algeria, China, Nigeria, Turkey and the UK have joined to undertake the project.

9.8 Health

Quality of life dictates availability of affordable services for health, education and communications. The availability or otherwise of primary health care, thus plays a crucial role in the underdeveloped and inaccessible areas, as majority of the people affected are already living below the subsistence level. Satellites for communications, remote sensing and navigation have solved the problem by providing accessibility to health care points and are used regularly for the management of complex public health problems. In Pakistan, Aga Khan Foundations has amply demonstrated the effectiveness of the system and set-up projects to restructure health resources for the inaccessible Northern Areas.

Images from remote sensing satellites are used in combination with the Geographic Information Systems (GIS) technology to map malarial incidence and to identify its links with environmental factors. The data obtained from SPOT, LANDSAT and other environmental monitoring satellites is then used to develop tools to monitor and predict epidemics.

9.9 Education, Training and Capacity-Building

For effective use of developmental tools facilitated by space physics there is a need for skilled human resources with different levels of expertise. The general public needs training to use Internet services, tele-health or tele-education facilities. At a more advanced level decision makers and managers in the local governments need to be made aware of satellite based products can be useful for urban development, crisis prevention and disaster recovery.

Training programmes and workshops in subjects such as remote sensing, satellite communications, satellite meteorology, satellite aided- search and rescue, basic space science, geographic information systems, and satellite navigation.

10. GLOBAL EARTH-OBSERVATION SYSTEM OF SYSTEMS

Role of satellites for communication, Earth imaging and area mapping in sustainable development has brought the world community together to form a Global Earth-Observations System of Systems (GEOSS). The system aims to link the multitude of devices already gathering Earth observations-from data buoys in the world oceans to thousands of land based environmental stations to more than 50 environmental satellites orbiting the globe. Creation of a single, comprehensive and sustained system of Earth observation by 60 countries to help identify and address the global environmental and economic challenges that frequently lead to unrest and instability. The plan envisages setting up of an organizational framework for a system of systems, which will supplement but not supplant each system's own mandates and governance arrangements.

Based on new and existing capabilities, GEOSS is being developed to meet national and international social, scientific, and economic imperatives by providing unprecedented access to space based, ground- based airborne, and other sources of environmental data. GEOSS aims to link multitude of devices including sea-based buoys, thousands of land-based environmental stations to more than 50 environmental- monitoring satellites orbiting the globe-and make the resulting data freely available.

The integrated facility or capability would enable worldwide weather forecast months in advance, identify and address the global environmental and economic challenges-including climate change and natural disasters, monitor large scale population movements, improve energy resource management and manage humanitarian relief efforts.

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A PERSPECTIVE ON PHYSICS-BASED CONTRACT/INDUSTRIAL RESEARCH: K.F.U.P.M. EXPERIENCE

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ABSTRACT

An overview of contract/industrial research is presented. Some important considerations are highlighted and potential challenges are discussed in the context of physics-based industrial research in developing countries. Two examples of physics-based client-funded projects, currently in progress at King Fahd University of Petroleum & Minerals (KFUPM), are presented to demonstrate the important role that physicists can play in solving some problems of the local industry.

1. INTRODUCTION

Smart minds can solve intricate puzzles and problems. Even an average physicist knows the mechanics of the ball-games and the projectile-motion. For example, it is easy to find the exact force and the angle and the point on the ball at which it should be hit to accomplish the desired result, even when there is a wind blowing in the direction of or against the motion. But, can this physicist use this knowledge to become a top player and win "Grand Slams" where he can earn a lot of money several times in any one year. Furthermore, can he be equally good, say, at playing tennis as well as golf at the same time, where in one case, the ball to be hit is at rest, while in the other case the ball is moving, frequently in the opposite direction. After all, it is simply going one step further in applying this knowledge of physics to these ball-games in real life. But it is really surprising that no physicist of any note became a top tennis or golf player in recent years. Perhaps physicists did not think about it carefully enough, or in some other cases, they might not find these ball games challenging enough.

In the context of contract or industrial research, particularly in the developing world, the situation may not be much different from the example discussed above. It appears that our physicists have not given much thought to going to local industry for developing a business-relationship, to know their problems and to try to solve them. In view of the limited resources available for research in science and technology in the developing world, finding alternative sources of funding (e.g., sponsorship from industry) is another option that should be seriously explored. Pooling the resources and collaboration in research are important considerations for making some headway in rapidly advancing and emerging technologies. This collaboration can extend beyond the local and regional levels. A person in possession of an egg in one place may look for a "surrogate" hen in another place to hatch the egg.

The present paper is intended to be an introduction to contract-research, and presents a road-map for initiating contract-research in developing countries. Challenges and problems faced during different phases of research projects and the concerns of the client are highlighted. Two examples of physics-based on-going contract-research projects at KFUPM are briefly discussed.

2. CONTRACT RESEARCH: AN OVERVIEW

Contract research basically involves direct application of the existing knowledge and, in some cases, new ideas, together with the experimental facilities and expertise (existing or proposed) in solving the problems faced by the industry, commercial organizations, government agencies, and society at large. In this endeavor, new products, devices, materials and processes may be discovered or developed. At the same time, this could involve enhancing the efficiency of existing systems or processes, developing methods for saving costs, or conserving resources and/or feed materials but without compromising the quality, and bringing possible improvements that provide benefits in education, health, and environment.

2.1 Advantages of Contract Research

There are several spin-offs of contract research. To begin with, there are funds for research work, including purchase of new equipment, conference participations and other professional visits, books and other useful published literature, and at the same time, monetary compensation for the time of the team-members spent on research. Even the institutions (universities, institutes, etc.) get their share. Furthermore, there is a considerable degree of professional satisfaction, in the sense that the research is applied in nature and is immediately useful. Accordingly, a rapid recognition within the society about the importance and the usefulness of research is expected. In addition, a significant number of research publications could also come out of such projects, since it is likely to be interdisciplinary work in nature. More importantly, there is a strong possibility of getting patents if the ideas being experimented prove successful. However, a clear understanding has to be developed with the client before publishing papers or filing patent-disclosures, since proprietary information and intellectual property rights may be involved.

2.2 A Road-Map

A road-map for initiating contract research is presented below.

i. First of all, it is important to have some information about the technical problems faced by the industry. Indeed, solutions can not be proposed if the problem is not known. This may not be easy if one does not have any prior knowledge or has not worked in that particular field. The other possibility for obtaining this information is through some inside source or personal contacts. Furthermore, professional contacts may be developed, for example, at forums such as seminars, professional-society meetings, workshops, or conferences/exhibitions. Otherwise, a formal visit to the particular industry has to be arranged, whereby one can offer to give a presentation or a seminar.

ii. Once a problem is identified, one can think out possible solutions. A preliminary proof-of-the-principle experiment may be conducted to test the idea or the solution being proposed. In any case, it is a good practice to discuss the idea or the proposed solution with one or more knowledgeable colleagues. They might bring out some questions about some aspects that may not have been considered in the first proposal.

iii. The next step is to market these ideas and the available expertise. If a contact has already been established with the particular industry, this could be achieved through visits. If, on the other hand, no contact has been established, a "Technical Memorandum" defining the problem and outlining the proposed solution, but without giving too much technical detail and without any mention of the costs, may be sent. However, potential benefits to the client have to be highlighted. This could be followed by a telephonic contact and possibly, also a visit to the site for presentation of the idea in a seminar or discussion session.

iv. Once a professional discourse has started, there may be several discussion sessions, presentations and clarifications before the client is convinced that it is a worthwhile proposition to sponsor the proposed research.

v. If convinced, the client could request a formal proposal. This would involve more technical details, scope of work, information about project-deliverables (researcher-to-client, and client-to-researcher), a definite time-frame for completion of the research work, and costs.

vi. After submission of the formal project-proposal and subsequent reviews, negotiations on the scope of work, time-frame and costs may have to be undertaken before a purchase order is prepared.

vii. The final stage would be the formal contract, with signatures of the responsible representatives of the parties involved.

2.2 Technical Memorandum

A Technical Memorandum is expected to introduce the main idea of the proposed solution of a particular problem. It has to be quite brief and should define the problem and the proposed approach to solving the problem. Some description of the work involved and the expertise and experimental facilities available may be included. The proposed solutions have to match the problems and the needs of the clients, and the expected benefits to the clients, in terms of dollar value, have to be highlighted. At this stage, no mention need be made of the cost or time-frame involved.

2.3 Proposal Development

Once an expression of interest of the client is received, a formal research proposal may be submitted. In this context, the client may initiate a formal request-for-proposal with a well-defined scope of work. On the other hand, the researcher may also propose the same on his own initiative, in which case some further meetings and discussions may be needed to finalize the exact scope of work to be carried out.

The standard format of the technical proposal includes the usual summary, introduction, objectives, discussion of the problem, approach to the problem, statement of work, project deliverables, available expertise and facilities, project team, and a time frame. The commercial part of the proposal should include the total costs, together with the itemized cost breakdown. The costs may include new equipment, materials and supplies, fees for designing of the equipment as well as fabrication and machine-shop costs, fees for the use of existing equipment, laboratory services and analyses, conference attendance & professional visits, secretarial and other support-staff, transport, photocopying and documentation costs, and fees for the project manpower and consultants, if any.

In general, it is a good idea to have an internal review of the proposal before submitting it to the client. At KFUPM, guidelines for preparation of the formal proposal are available. Furthermore, facilities for English editing and technical editing also exist. Likewise, a specialized computer code ARMSS for calculating project costs is also available. In addition, once the proposal is finalized (after English and technical editing), it is reviewed by a Proposal Evaluation Committee before it is submitted to the client.

2.4 The Contract

Soon after a project proposal is accepted by the client, a formal contract is signed. This document clearly shows the dates of the start and the conclusion of the project, and the total cost, with specific reference to the scope of work and the deliverables agreed in the proposal. A formal schedule of payments that may also be linked to project-deliverables is also agreed and included in the contract. Any changes in the contract have to be mutually agreed and documented as a "Change Order".

2.5 Monitoring the Progress: Progress Reports and Management Reviews

The progress in accomplishing the project-objectives is periodically reviewed by the respective head of the department. A one-page internal report every month, outlining the progress made and plans for the coming month, is to be submitted. Any technical or administrative problems are highlighted, so that solutions can be worked out. Some clients ask for a copy of this monthly report for their records also. A three-monthly, or, if agreed, a six-monthly progress report detailing the activities and main achievements during the specified period is prepared and submitted to the client. This document also goes through the usual English editing and technical editing.

A formal management review, in the presence of top management and some experts, is conducted once a year or once in six months where the project manager is expected to give a 20-minute presentation on the progress and problems, if any. Everyone likes to hear that things are moving according to the plan, but if some unforeseen situations arise, these can be promptly addressed.

2.6 Final Project-Report and Other Deliverables

The final project-report presents all the details of the research work and the conclusions drawn. An executive summary outlining the main findings and accomplishments, with a clear reference to the objectives of the project is usually included. Once again, a thorough review of this document is carried out internally before it is submitted to the client. Other agreed deliverables have also to be handed over to the client before the conclusion of the project.

2.7 Feedback from the Client

Formal feedback is solicited from the client, whereby he can put on record his evaluation of the project-accomplishments. If satisfied with the accomplishment, the client might like to extend his collaboration further and seek the help of the researchers in solving any other technical problems in his establishment.

2.8 Challenges in Project Management & Execution

It is obviously the joint responsibility of the project-team, under the leadership of the project manager, to ensure successful completion of the project work. The departmental and the institute administration are essentially the facilitators. The key to success lies in being SMART (Specific, Measurable, Assignable, Realistic, and Timely). Other important elements for achieving the project-objectives include good planning, motivation and inspiration, hard work, team-work, professionalism, good communications within the team, responsibility and accountability, recognition and reward. It is also important for the team to meet regularly, e. g., once in two weeks, to review and discuss progress, problems if any, and plans for the next two weeks, for example. Formal records of minutes of these meetings, task assignments, progress, problems and their proposed solutions, and plans, must be maintained. This makes it easy to assess the achievements and prepare reports. Every client wants to see the work completed successfully and on time, so timelines and deadlines for submitting progress reports and other deliverables have to be kept in view continually.

2.8.1 Potential Problems

Most of the research work in client-funded projects is multi-disciplinary in nature. So, team-members from different departments and specializations may be involved. Depending on their commitments and responsibilities within their parent departments, some team-members may have different levels of motivation and interest. Furthermore, it may not always be possible to find the most appropriate person with the needed expertise and skills for a particular task, in which case it becomes a less-than-the-ideal team. Since it is the team that takes a project to its successful conclusion, under the above-noted circumstances, it might sometimes be difficult to have harmony within the project-team, and to exercise proper control. However, this has to be taken by the project manager as a challenge, and he has to use all his management-skills to coordinate the work and steer the project smoothly.

Other important factors that could influence the outcome of the project are listed below.

i. In some cases, resource- and budget-estimates are not carefully made. Underestimates of the funds needed for the project, or underestimates of personnel or facilities required could adversely affect the pace of work and overall accomplishments.

ii. A difficult situation could arise when a team-member decides to resign from his job because he found a better opportunity elsewhere, or for a host of other reasons, and the project is still not completed. In the context of KFUPM, a large number of researchers and professors are expatriates on one- or two-year renewable contracts. So a situation could also arise where the contract of a team-member is not renewed and he has to leave the university or the country, while the project is in progress. This could put the project-manager in a tight corner if a suitable replacement is not available immediately.

iii. In some cases, the project manager may not have the authority to speedily dispense the project-funds or assign project-tasks without lengthy bureaucratic procedures. This can also slow down the pace of work and make it difficult to achieve the targets within the timelines stated in the contract.

iv. Finally, there is the issue of intellectual property rights. It is not always easy to convince the parties involved as to who should own the intellectual property or patents, if any, resulting from the project work. This has to be sorted out at the institutional levels before signing the contract.

2.9 Client Concerns

In general, countries in the developing world are consumer societies, not fully geared to Research and Development (R&D). At the same time, there is a big credibility-gap as far as the capability of scientists and researchers in the local universities or research organizations in solving real-life problems is concerned. A clear record of successful contract-research projects is needed to establish this confidence. A long list of research publications alone may not convince an industrialist to start sponsoring industrial research.

The most important element for success in obtaining client-funding, particularly in the developing world, is personal contacts. Obviously, the marketing ability of the proponent of a research project to convince the client about the possible benefits of the project and the expertise of his team to complete the work successfully will be highly effective.

3. CLIENT-FUNDED RESEARCH AT KFUPM

At KFUPM, there is a well-established Research Institute, where the main focus of activities is client-funded research. Over the years, this institute has contributed significantly in solving a wide range of problems of local industry. The institute has also successfully completed some research projects for some international companies.

3.1 Major Industries in the Region around KFUPM

Major industries in the region around KFUPM include Oil Industry (Saudi Aramco), Petrochemical Industries (SABIC), Power Generation and Transmission, Comunications, Concrete and Building Materials, Pipes Industry, and Water Resources & Desalination. In addition, some general problems of Environment, Pollution, Corrosion, Scale Formation, Energy Conservation, and Sand Movement, have been addressed to varying degrees.

3.2 Major Research Facilities

The Research Institute at KFUPM has seven specialized Research Centers, namely, Center for Applied Physical Sciences, Center for Engineering Research, Center for Petroleum & Minerals, Center for Refining and Petrochemicals, Center for Environment and Water, Center for Economics and Management Systems, Center for Communications and Computer Research, where state-of-the-art research facilities are available. In addition, most of the Academic Departments have their own research laboratories and experimental facilities. Access to all these facilities is available through a formal request. If some services, such as material characterization or analytical or other tests, are needed in a client-funded project, a fee is charged by the department concerned to cover the maintenance and running costs of instruments and the time of the experts. The Center for Applied Physics Sciences, houses a Polarized Neutron Source, six Laser Research Laboratories with a number of different Lasers and other Support Equipment, a Metrology & Standards Section, and a Chemical Analytical Laboratory. In the Physics Department, on the other hand, a Surface-Science Laboratory with XPS (x-ray photoelectron spectroscopy) and Auger

Spectroscopy facilities, a Superconductivity Laboratory, and Cryogenic Facilities, providing liquid helium and liquid nitrogen are available. If needed, samples could also be sent abroad for tests and analysis, but the fees charged may be substantially higher.

4. SOME PHYSICS-BASED RESEARCH PROJECTS AT KFUPM

Two examples of physics-based client-funded research projects currently in progress at KFUPM are briefly discussed here. One of these project deals with Catalyst Regeneration in a Glow Discharge, while the second deals with Fingerprinting of Crude and Refined Oils with Lasers. Titles of some other research proposals currently under review are also included.

4.1 Catalyst Regeneration in a Glow Discharge

Catalysts used in the oil and petrochemical industry become deactivated gradually or rapidly during operation. Various chemical and physical processes are responsible for this. One of the most important reasons is gradual deposition of carbonaceous materials (usually referred to as 'coke') on the catalyst. The main effects of formation of over-layers of coke on catalysts are a loss of the active-surface area, a decrease in diffusivity, presumably through choked pores or deposits at the pore mouth, changes in the selectivity of the catalyst, and an overall decrease in the catalytic activity. The catalyst also become deactivated because of poisoning due to sulfur, H_2S, etc. Metal agglomeration may also occur in the case of supported catalysts. Consequently, it becomes necessary to frequently replace the catalyst or to reactivate it.

Replacing the catalyst is usually quite expensive. Thus, effective methods for restoring the activity of the used catalysts have to be found. Basically, the coke must be removed. However, this should be accomplished without altering the internal structure of the catalyst. Other steps include redistribution and re-dispersion of large metal agglomerates into smaller particles over the substrate. Similarly, selective removal of strongly adsorbed inhibitors reactivates the poisoned catalysts.

The standard industrial procedure for removing the coke is thermal regeneration, where the carbonaceous deposits are oxidized in air, using catalyst-bed temperatures of 400-800 $^{\circ}C$. While this method does remove the coke, the process can be accompanied by some irreversible changes in the internal structure of the catalyst.

An evolving technology uses glow discharge in oxygen to regenerate coked catalysts at lower temperatures [1-2]. O-atoms in the glow discharge are believed to be mainly responsible for this. Basically, the process involves creating a high density of O-atoms and then facilitating reactions of these O-atoms with coke that lead to the formation of CO, CO_2, and other gaseous products that could be easily pumped out.

At KFUPM, we have recently demonstrated enhanced generation of O-atoms using a glow discharge in Ar-O_2 gas mixture, and the accompanying enhanced yields of CO and CO_2 gases as signatures of enhanced decoking [1]. The prospects of achieving decoking at considerably lower temperatures, thus preserving the internal structure of the catalyst, offer a significant advantage in terms of short process-times, typically less than an hour compared with many hours, and even up to several days, in the conventional system. This can result in considerable savings in the regeneration costs. However, some specific issues, such as the regeneration steps involved including oxidation and/or reduction needed, and disposal of the heat of reaction, are to be addressed.

This is clearly a multi-disciplinary project involving a considerable knowledge of physics, chemistry and chemical engineering. Indeed, the project team consists of experts from all these fields. The physics part involves optimizing of glow discharges used here primarily to dissociate O_2 molecule to O atoms. The electrons in the plasma accomplish this through collisions. For example, for a discharge in pure O_2, we have a process

$$e^* + O_2 \quad 2\,O + e$$

where e* represents a high-energy electron, while e is an electron of much less energy. The highly reactive O atom attacks carbon to form CO and C O_2 that could be pumped out. Thus,

$$O + C \quad CO$$

$$O + CO \quad Co2$$

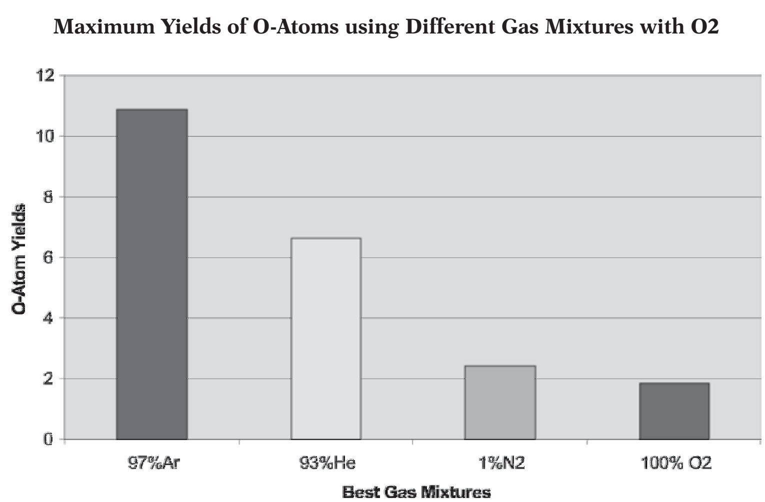

Figure - 1: Relative Maximum yields of O-Atoms from Glow Discharges in Different Gas mixtures and Compositions [1]

Discharges in pure O_2 and different gas mixtures, including Ar-O_2, He-O_2, and N_2-O_2 were investigated for maximum O-atom yields. Figure-1 shows the relative maximum yields of O-atoms as a function of different compositions of these gas mixtures [1]. It is apparent that the Ar- O_2 gas mixture produces substantially higher levels of O atoms.

The next question to be addressed was whether the higher yields of O-atoms actually lead to faster decoking. Figure-2 shows the relative CO yields as signatures of decoking for different gas mixtures. Once again, the discharge in Ar- O_2 gas mixture proved quite useful, with a significantly higher yield [1]. The same was confirmed by monitoring the residual carbon content using X-ray photoelectron spectroscopy (XPS).

The project involves quantitative analyses for establishing what other steps are needed to completely restore the activity of the catalysts. A series of carefully planned experiments are being conducted together with various analytical and catalyst-reactivity tests for this purpose.

4.2 Fingerprinting of Crude and Refined Oils

This project involves laser-based time-resolved fluorescence spectroscopy. It is well known that crude oils and even refined oils coming from different oil-wells in different regions of the world have different physical and chemical properties, particularly different molecular structure and mineral contents. The difference can be clearly seen when spectra are recorded in different time-windows after exciting the material with a laser pulse in the UV region [3]. This method was successfully applied to distinguish crude oils from different regions of Saudi Arabia. Even the refined oils could be tested

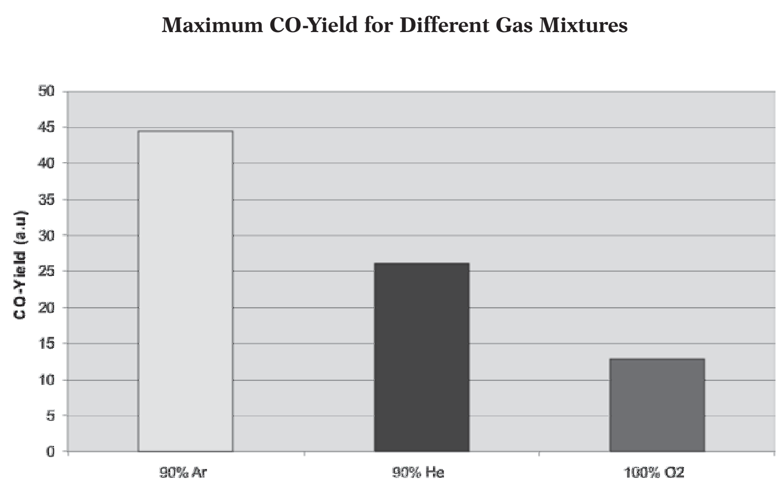

Figure - 2: Relative Maximum Yields of CO from Glow Discharges in Different Gas Mixtures and Compositions [1]

with this method. In fact, our researchers got a US Patent # 6,633,0431, " Method for characterization of petroleum oils, using normalized time-resolved fluorescence spectra" in October 2003, for this technique.

In addition to these two projects, several research proposals are under review for possible funding. These include: Ultrasonic Mapping of Formation Damage [4, 5], Laser-Based Monitoring of Atmospheric Pollution, Photo-Acoustic Detection of Gas Leaks [6], Conversion of Methane to Higher-Value Products [7], and Energy-Efficient Electro-Chromic Windows for Buildings [8]. In fact, there are numerous other possibilities of putting our knowledge of physics to industrial use.

5. CONCLUDING REMARKS

A case has been presented above for physics-based industrial research in the developing world. Starting with an overview and a road map for contract research, some important considerations and potential challenges are highlighted. Two physics-based client-funded projects, currently in progress at K.F.U.P.M., are included as examples to demonstrate the important role that physicists can play in solving some problems of the local industry.

ACKNOWLEDGEMENTS

The support of KFUPM is gratefully acknowledged.

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THE ROLE OF LOW-ENERGY PARTICLE ACCELERATORS IN PHYSICS

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ABSTRACT

The important role of low energy particle accelerators in the development of modern physics and training experimental physicists is highlighted. The different types of accelerators, such as tandem Van de Graaff, cyclotron and electron accelerators, and their applications in various fields are described. The need for establishment of particle-accelerator facilities in developing countries is emphasized.

INTRODUCTION

Physics has played a very important role in the development of science and technology for the benefit of mankind. Newton's Laws of motion, the laws of thermodynamics, Faraday's laws of electromagnetism, embodied in Maxwell's equations, relativity ($E = mc_2$) and the postulates of quantum mechanics have contributed a lot to the welfare of human society, through nuclear technology, semiconductor technology, superconductor technology, laser technology, space technology and information technology. Particle accelerators have played a fundamental role in the development of various sectors of modern physics, such as nuclear physics, solid-state physics and atomic physics. Particle accelerators have also come to play an important role in health and industry. The present paper describes some details of the development of modern physics, which has been achieved through use of low-energy particle-accelerators, providing ion- beams of energies lower than 100 MeV. The progress in various technologies has been possible only due to considerable research work in the applied sciences. The paper also highlights the technical expertise gained by scientists working around the different types of accelerator-facilities. Three different types of accelerators, namely, tandem, cyclotron, and electron accelerators, are described and their applications in industry and health are given. The goals for the establishment of accelerator research facilities in the developing countries are outlined.

PART 1: DEVELOPMENT OF MODERN PHYSICS

Particle accelerators have been instrumental in the development of modern physics, particularly nuclear physics, for which particle accelerators have been primarily constructed. Particle accelerators have also been used for research in the field of solid-state physics and atomic physics. The following sections give a brief review of the research carried out with the help of particle-accelerators in different fields of modern physics.

I. NUCLEAR PHYSICS

Particle accelerators have been used in the following different areas of nuclear physics:

A. Nuclear Structure Measurements

The information on the following aspects of nuclear structure has been acquired in the last seventy years for the stable and long-lived nuclei, as well as thousands of nuclei produced artificially in the laboratories through accelerators:

i. The values of energies, spins, parities, and electromagnetic moments of the energy levels of nuclei;
ii. Decay schemes of energy-levels, through gamma and particle emission;
iii. Measurements of energies, life-times, spin-parity values and decay-modes of isomeric states.

B. Models of Nuclear Structure

The measurements of the various quantum-mechanical characteristics of the nuclei in the periodic table led to the establishment of very popular nuclear-structure models of nuclei. It is important to remark that a nucleus constitutes a many-body problem, with rather un-precise knowledge of nuclear force. Therefore, it is very difficult to calculate various characteristics of nuclei. It is natural to resort to phenomenological models in order to explain and predict the behaviour of the nucleus when subjected to its interaction with other nuclei.

i. Nuclear Shell Model

The nuclear shell model was proposed by M. G. Mayer, and independently by O. Haxel, J. H. D. Jensen and H. E. Suess in 1949. According to this model, each nucleon in the nucleus moves independently in a potential-well, representing the effect of the presence of other nucleons. In order to reproduce magic numbers correctly, the inclusion of a spin-orbit term is needed in the potential. The inclusion of a residual potential term is also needed for a better agreement of the experimental values with the calculations based on the model. The model is very successful in explaining the ground states and excited states of nuclei, their decay probabilities to the lower states and magnetic moments of the ground states of nuclei. The model is also called non-interacting Fermi gas model.

ii. Collective Model

Certain nuclei have large values of quadrupole moments in their ground-states and exhibit vibrational and rotational types of spectra, with large spins and large values of decay probabilities. These characteristics cannot be explained on the basis of shell model. Aage Bohr and Ben R. Mottelson developed the collective model of the nucleus, to explain the spheroidal shapes of nuclei, and to rotational and vibrational spectra of nuclei. This was achieved by including a long-range quadrupole type of potential term in the shell-model potential for explaining the correlated type of nucleon motion. The collective type of properties could also be explained by using a deformed shell-model potential and the model is called unified shell model or Nilsson shell model.

iii. Super-fluid Model of the Nucleus

It has been observed that even-even A nuclei have more binding energy than odd A and odd-odd A nuclei. This has been explained on the basis of pairing energy between two nucleons having the same j-value, but one with magnetic number m and the other with magnetic number –m. The motion of the pair is correlated and it has a large spatial extension. The shell model is essentially a non-interacting Fermi gas model. The inclusion of the pairing energy results in a lower state, called super-fluid state, in analogy with the lowest state of electron gas in a conductor resulting from the pairing model of Bardeen, Cooper and Schrieffer. This state is characterized by an energy-gap and a critical temperature. The model explains low-lying excited states in even-even nuclei and magnitudes of stripping and pick-up reactions, such as (d, p) and (d, t) reactions.

C. MEASUREMENTS OF NUCLEAR REACTION

Important information on the nature of nuclear interactions has been obtained through nuclear reaction measurements. The following different types of nuclear-reaction characteristics have been studied.

i. Total Cross-Sections

The total cross-section is a measure of removing particles by a nucleus from the incident beam, through different types of interactions. The total cross-section consists of several components, such as elastic, inelastic, fission, and rearrangement cross-sections.

ii. Differential Cross-section

The particles removed by the incident beam appear in different directions with respect to the direction of the incident beam. The yield of reaction-products in a particular solid angle, with respect to the direction of incident beam, is expressed in terms of a differential cross-section.

iii. Double Differential Cross-section

The yield of reaction-products, as a function of angle and their energy, is expressed in terms of double differential cross-section i. e. per unit solid angle and per unit energy. This information constitutes useful data for nuclear-reactor design calculations and provides information on nuclear reaction mechanism.

iv. Excitation Functions of Isomeric States

Certain energy-levels have measurable lifetimes, in the range of nanoseconds to several years. These states are called isomeric states. The yield of these states as a function of incident-beam energy is called excitation function of the production of the isomeric state. In practice, the isomeric states for practical applications have their lifetimes in the range of several minutes to several years. The studies of the excitation functions of isomeric states are important from the point of view of their application in medicine and provide useful information on reaction mechanism.

v. Polarization of Reaction Products

It has been observed that the un-polarized incident beam gets polarized in the elastic scattering process. This polarization is measured when the scattered beam is re-scattered from an un-polarized target. The polarization of the beam is manifested through unequal intensity of the scattered beam on the left and right sight of the direction of the incident beam. This phenomenon shows that nuclear interaction has a spin-orbit coupling term in the nuclear potential. The polarization studies are useful for providing information on the spin-orbit term of the optical model potential.

D. NUCLEAR REACTION MODELS

The information on different aspects of nuclear reaction, gathered from experimental data in several laboratories of the world, has been explained on the basis of the following nuclear reaction models.

i. Compound Nucleus Model : Breit-Wigner Resonances

This model of nuclear reactions is attributed to Neils Bohr. It assumes that the incident particle is captured by the target nucleus. The incident particle looses all of its energy, through interaction with nucleons inside the nucleus, and forgets its identity. After a long time on the reaction-scale, enough energy is gained by a component in the nucleus, which lies above its binding energy and it is emitted from the nucleus. The model explains the fine-structure in the excitation function of a nuclear reaction. The width of the level is a measure of the lifetime of the compound nucleus. If the incident beam has a fine energy resolution and the experimental instrument energy resolution is good, then one observes fine resonances in the yield of a reaction. Such narrow resonances, which have Lorentzian shape are known as Breit-Wigner resonances. This is explained in terms of well-defined quasi-bound states in the compound nucleus. These resonances have been classified as s-wave, p-wave and d-wave resonances, corresponding to $L = 0$, $L = 1$, and $L = 2$ partial waves, respectively, giving appropriate angular momentum value for the compound nucleus. These levels are characterized by well-defined energy-widths and energy-spaces. When energy-resolution of the incident beam or that of experimental energy measuring set is greater than energy widths, one gets average cross-section measured over several resonance and one speaks in terms of strength-functions of the reaction. The information on these levels formed by slow neutrons is very useful for the reactor-design calculations.

ii. Statistical Model of Nuclear Reactions

This model is based on the concept of the compound nucleus model of a nuclear reaction. When the compound nucleus excitation-energy is high, there are several open channels and the decay of the nucleus into different exit-channel is treated on statistical basis, depending on the energy, nature and orbital angular momentum value of the emitted particle. The statistical decay probabilities are calculated on the basis of optical model, taking into account the conservation of spin and parity values in the reaction.

iii. Optical Model

According to the optical model, a nucleus is considered as a cloudy crystal-ball, which partly reflects and partly absorbs the incident radiation. The nucleus is replaced by a central complex potential and a spin-orbit term is also included in the potential, to account for the polarization of the scattered beam. Wave functions of the complex potential are used for the elastic scattering, reaction and total cross-sections and polarization calculations. The model was invented to explain giant resonance in neutron total cross sections of several nuclei, measured as a function of energy.

iv. Direct Nuclear Reaction Model

In the direct nuclear reaction model, the incident particle interacts with one nucleon or a cluster of nucleons outside the closed shell of the nucleus while passing across the nucleus. The angular distribution of the light particles is peaked in the forward direction and, in some cases, in the backward direction. The reaction involves a few degrees of freedom and it is treated as a perturbation on the elastic scattering. The optical model wave-functions are used for calculation of the matrix elements of the interaction in the exit channel. The reaction is used for obtaining information on the spin and parity values of the energy-levels and their configurations.

v. Pre-Equilibrium Reaction Model

Compound nucleus in equilibrium shape is formed after a series of interactions of the incident particle with the nucleons of the target nucleus. However, it is possible that the reaction gets completed in a process of a few interactions before the compound nucleus is formed in full equilibrium. Such a mode of a reaction is called pre-equilibrium reaction model and results in excess of the hard component of reaction particles.

E. NUCLEAR FORCES

The most useful information on nuclear forces has been obtained through the study of the nuclear structure properties of nuclei, particularly two-body, three-body and four-body systems and measuring n-p and p-p scattering cross-sections. Nuclear force has a short range of about 1 fm and is attractive. However, at distances shorter than 0.5 fm, it is strongly repulsive. Nuclear forces are spin-dependent and are of tensor nature. Nuclear forces have also a very small weak component, which does not preserve parity. Nuclear forces are also parity dependent and iso-spin dependent. Nuclear forces show charge independence and charge symmetry properties. Charge independence leads to another important quantum-mechanical property of a nuclear level, known as isospin, which is predominantly conserved in nuclear reactions. A small violation results from the change in wave functions of nucleons due to Coloumb forces.

F. NUCLEAR DATA FOR APPLICATION

The useful information gained through nuclear reactions, in general, and targeted measurements, in particular, using particle accelerators has resulted in the form of nuclear data-files as follows:

i. Neutron Nuclear Data-Files, for the design of fission and fusion reactors.
ii. Nuclear Structure Data Files
iii. Nuclear Data Files for Dosimetry
iv. Charged Particles Nuclear-Reaction Data Files for Medical Radioisotope Production

These Data Files are maintained by IAEA at Vienna and at Brookhaven, USA.

II. SOLID-STATE PHYSICS

In solid-state physics, accelerators have been used for research in the study of irradiation effects in solids, studies of ion-implantation in semiconductors and metals and ion-channeling in crystals.

A. Irradiation

Ion-irradiation damage-effects in fuel elements of structure components of fission and fusion reactors and the first wall of fusion reactor have been studied, using particle accelerators. These relate to void formation, volume swelling and embrittlement of the fuel elements. The areas of interest are measurements of displacement cross-section, anisotropy of damage, threshold energy of displacement, damage-recovery or annealing as a function of temperature. Study of recombination of defects and magnetic relaxation properties are also carried out, using accelerators. The irradiation is also used for studying the performance of semiconductor devices, solar cells, changes in the refractive indices of glasses, optical wave-guides and other optical components in irradiation environments. Ion channeling is used for the detection of defects in crystals.

B. Ion Implantation

Ion-implantation in semiconductors, particularly silicon for production of n-type and p-type materials, is widely carried out with the help of particle accelerators. Research on the removal of irradiation-damage effects caused by ion-implantation as a function of annealing through different temperatures is also done. The examples are the use of ion- implantation for making Metal Oxide Semiconductor Field Transister (MOST). Ion implantation of non-semiconductors is used to change the surface-properties, such as hardness, chemical activity, electron work-function, and critical temperatures of superconductors.

III. ATOMIC PHYSICS

Beam-Foil Spectroscopy

Particle accelerators have been used to study various atomic levels, their decay-schemes and for obtaining information on the lifetimes of atomic levels, using beam-foil spectroscopy. The ions of atoms under study are accelerated and made to pass through a thin carbon foil, to form highly charged ions. The decay spectra are measured, using photographic plates, or a Perkin-Elmer spectrometer, or a Jarrella-Ash spectrometer, which allow measurements down to 500 Angstrom or Seya-Namioka spectrometer, which is a vacuum spectrometer and allows measurements down to 300 Angstrom Very useful data on spectral emission of atoms has been obtained, which were not obtainable on the basis of conventional technique.

IV. EXPERTISE GAINED BY WORKING AROUND ACCELERATORS

Accelerator facilities can provide an opportunity for gaining a wealth of both theoretical and technical knowledge.

A. Technical knowledge

It is possible to get expertise in the fields given below.

1. Accelerator Technology
The following fields of accelerator technology are accessible for learning:

a. Ion-sources technology
b. Magnet-fabrication technology
c. Electromagnet lenses technology
d. High-voltage technology

2. Experimental Techniques
Experimental physicists and technical persons can gain expertise in the following fields:

a. Detector fabrication techniques
b. Fast and slow pulse-processing techniques
c. Target-preparation techniques
d. Vacuum techniques
e. Data-reduction and analysis techniques
f. CAMAC modules-based data-acquisition techniques

g. On-line multi-parameter data-acquisition and off-line data analysis techniques

B. Theoretical Expertise.

It is possible to get expertise in the following areas of theory-related problems

A. Monte-Carlo Codes for multiple-scattering corrections and detector-efficiency calculations.

b. Physics –based computer codes for fitting experimental data and extraction of physical quantities of interest. These include computer-codes for statistical model, pre-equilibrium model, and direct-reaction model calculations

PART 2: DESCRIPTION AND APPLICATIONS OF PARTICLE ACCELERATORS

i. Tandem Van De Graaff Accelerator

The tandem Van de Graaff accelerator constitutes one of the most popular and versatile low-energy particle-accelerators for research in basic and applied sciences.

Pelletron® systems: 162 sold or in manufacture

Argentina	1	Korea	3
Australia	4	Lebanon	1
Austria	2	Mexico	1
Belgium	2	The Netherlands	1
Brazil	3	Norway	1
Canada	2	Taiwan	2
Denmark	1	P.R.C.	9
Finland	1	Poland	1
France	4	Spain	1
Germany	6	Sweden	4
India	3	Switzerland.	1
Israel	1	U.K.	6
Italy	1	U.S.A.	68
Japan	32	+2 in-house systems	

- Component sales in 40 countries
- Major system sales in 27 countries

Pelletron use:

- General research:	3 MV and below:	82
	above 3 MV:	25
- Production MeV Implanters* (to 4 MeV):		9
- Ion Microprobes:		26
- RBS surface analysis:		35
- Accelerator Mass Spectrometry:		32
- Isotope Production:		1
- Upgrades of home built or older accelerators (sub-systems):		32

**22 additional pelletrons equipped for research MeV implantation*

Figure - 1

The usefulness of electrostatics accelerators lies in their ability for very fine-tuning of the ion-beam energy. A tandem Van de Graaff accelerator is an electrostatics accelerator, which uses a negative ion source at the ground potential lying outside the high-voltage terminal. The negative ions at the ground potential are accelerated by the high-voltage positive potential of the terminal. Once the ions enter the terminal they are converted into positive ions by allowing them to pass through nitrogen gas or through a thin carbon foil. The positive ions are accelerated again when they go outside the terminal to the ground potential. Thus, instead of one stage acceleration in a Van de Graaff accelerator, ions are accelerated in two stages in a tandem accelerator. Thus a 5 MV tandem accelerator can provide protons of 10 MeV maximum energy and 15 MeV alpha particles. The high voltage terminal is enclosed in a high-pressure tank containing H_2S gas at 7-10 atmosphere pressure. A large variety of ions in the periodic table are accelerated for various types of reaction studies. National Electrostatics Corporation (NEC), USA, has built Tandem accelerators, with terminal voltages from less than 1 MV to more than 25 MV. It has the monopoly of manufacturing tandem accelerators, known as Pelletrons these days. Information on the existing systems in various countries and their use obtained from NEC is given in the appendix.

- **162 Pelletron systems manufactured for use in 27 countries**
- **1 MV to 25 MV terminal potential - Tandem and single ended**

Applications Include:	
PIXE	Nuclear Structure Research
RBS	Implantation
Channeling	Ion Beam Enhanced Adhesion
Microprobe-PIXE	Materials Detection
Microprobe-RBS	MeV X-ray Generation
Mass Spectrometry-AMS	Neutron Generation
Nuclear Reaction Analysis	Free Electron Laser
Hydrogen Profiling	Anti-Proton Coooling
Elastic Recoil Detection	Education

NATIONAL ELECTROSTATICS CORP.

Figure - 2

Tandem accelerators are widely used for research in basic and applied sciences. These accelerators are now commonly used for the characterization of materials through several techniques, such as proton-induced X-ray emission (PIXE), nuclear reaction analysis (NRA), elastic recoil detection (ERD), and Rutherford backward scattering (RBS). One of the most popular uses of 3-5 MV tandem accelerators is for the analysis of environmental samples and detection of rare isotopes through accelerator mass-spectrometry (AMS).

ii. Cyclotron

A cyclotron is another class of popular accelerator, which has been used for research in nuclear physics. C. O. Lawrence invented the cyclotron. This accelerator avoids the requirement of a high voltage terminal for accelerating particles. It builds up the energy of ions by imparting energy to them in small increments in several steps. Ions are forced to move in circular paths by the application of magnetic field perpendicular to the plane of the motion of ions. A cyclotron essentially consists of two dee-shaped electrodes lying very close to each other. A high-frequency voltage is applied across the two electrodes. If the time of travel of the ion in the dee is equal to half of the time-period of the applied frequency, then particles will always be accelerated while passing trough the gap. This frequency of applied voltage is directly proportional to the applied magnetic field and the charge on the ion and inversely proportional to the mass of the ion. The frequency of the field gets out of the resonance when the mass of the particle increases through the relativistic effects. With a fixed frequency cyclotron, the proton and alpha particle energy is limited to about 40 MeV. For Higher energy cyclotrons, one modulates the applied frequency and these cyclotrons are called variable energy cyclotrons. In the period 1930-1960 when the electrostatics accelerators were not well developed, cyclotrons were used for nuclear reaction studies. Cyclotrons are still used for research in nuclear physics where there is need for high beam-currents and no restriction on the energy-resolution. Cyclotrons are widely used for production of medical radioisotope for use in PET and SPECT. Two Companies, known as Advanced Cyclotron Systems in Canada and IBA in Belgium, are producing dedicated cyclotron systems for use in medicine.

iii. Electron Accelerator

There are two types of electron accelerators, namely linear accelerators and circular accelerators. Linear accelerators are more complex in technology. Circular accelerators, known as betatrons and microtrons, are very common for applied purposes. In a betatron variable magnetic flux applied perpendicular to the plane of motion of electrons provides accelerating force through induction and a variable annular magnetic field serves as a guide-field to force the particles to move in circular paths. A microtron has a central homogeneous constant magnetic field and a cavity for providing energy to electrons. Electron accelerators find wide applications as listed below:

i. Welding
ii. Radiography or defectoscopy
iii. Adsorbents for collecting uranium from sea water
iv. Immobilization of bio-functional components
v. Electron-beam curing of coated surfaces
vi. Radiation treatment of sewage sludge
vii. Food irradiation
viii. Sterilization of medical supplies
ix. Wire and cable cross-linking
x. Vulcanization of rubber
xi. Ink production .for news papers, by degradation of Teflon through irradiation

Goals Of Accelerator Facilities in the Developing Countries

The establishment of low-energy particle-accelerator facilities in the developing countries is important for imparting experimental and theoretical physics knowledge to physicists. The existence of the facilities will contribute to producing medical physicists and knowledgeable technical manpower for efficiently handling the accelerator facilities in hospitals and industry. The facilities will go a long way in helping the indigenous Ph. D program within a country. The presence of good accelerator facilities will help in developing regional and international collaboration in scientific research. It will help to improve the quality of teaching physics at college and university levels.

PHYSICS OF NANOPHOTONICS: PRINCIPLES, MATERIALS & FABRICATION PROCESSES, AND EMERGING APPLICATIONS

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ABSTRACT

Nanophotonics primarily is based on ultra-small structures, constituting active as well as passive devices and components, that enhance optical interactions and efficiency of the optoelectronic and photonics processes. Broadly speaking, nanophotonics can be categorized on the basis of its applications, constituent materials, device-functionality and its characteristics, the underlying physical principles and concepts, materials and fabrication technologies. In this paper, some applications of nanoscale photonic structures (building blocks) and a few emerging micro/nano devices, such as ultraviolet/deep ultraviolet (UV/DUV) light emitting diodes (LEDs) and photonic crystals based emitters, are reviewed in somewhat detail. Difficulties associated with the UV/DUV AlGaN-based materials-growth as well as its device-processing related challenges are discussed. Photonic crystals (PCs) are discussed which may enhance or inhibit light-matter interaction by orders of magnitude, enabling the optical properties of devices' to be controlled externally by low-power optical or electrical control signals. Further, an overview of various areas of nanophotonics, such as light- propagation and scattering in photonic crystals, active and passive devices, related optoelectronic materials and nanoscale photonic devices are briefly mentioned. Finally, current voltage (I-V), light-current (L-I) characteristics of some UV/DUV light-emitting devices are also discussed as well as the PC's based LEDs with their possible applications in optical communications, and information systems.

1. INTRODUCTION

During the past few years there has been a remarkable convergence of physical sciences and engineering, under the broad umbrella of nanophotonics [1]. Indeed, there is an obvious synergy among these apparently disparate disciplines when the length scales of phenomena and structures approach the nanoscale dimensions. The emerging efforts in harnessing the connectivity of the nano-length-scales and the cross-disciplinary "nano-bio paradigm" promise considerable excitement for scientists and engineers, and tangible prospects of revolutionary applications for technologists as well as clinical practitioners [2]. While intricate, precise and integrated systems approaches for complex bio-nano-structures with nano-scale precision and accuracy are still evolving, sufficient progress has been made to demonstrate proof-of-concept devices or applications based on functional nanostructures and 1-dimensional PCs, such as multi-quantum based resonant periodic gain and eventually microcavity VCSELs structures [3-7]. Today, one may have very genuine concerns when producing ultra-compact, low-power optical devices, which are highly sensitive, down to the level of single photon detection or emission, to the level of computation by molecules. Presently, efforts are being made to understand the behavior of light in periodic media i.e., what happens in periodic sub-wavelength structures, and, at the other end, what happens at a molecular level when molecular arrays or clusters interact, as very little is known about the light/matter interaction with such structures [8]. Emerging Si nanophotonics is an area where enormous progress has been made during the past few years. Currently, however, most of the proposed and demonstrated devices are either passive or are based on compound semiconductor materials and therefore remain discrete and not monolithically integrable with current CMOS (complementary metal oxide semiconductor technology).

From the system-integration perspective, there is a need for active silicon devices that can be coupled to external optical fiber links. Silicon as an "optical material" has unique advantages, as it is transparent in the range of optical telecommunications wavelengths, and is extremely mature in terms of microelectronic processing-technology. There has been a wealth of research and development that has mainly focused on passive integrated silicon devices; e.g. silicon singlemode waveguides with less than 0.5 μm cross-sectional dimensions have been developed with low loss of the order of 0.1 dB cm-1 [9]. Multiplexers and demultiplexers using resonant structures, such as ring resonators, are the impressive achievements [10]. Among other

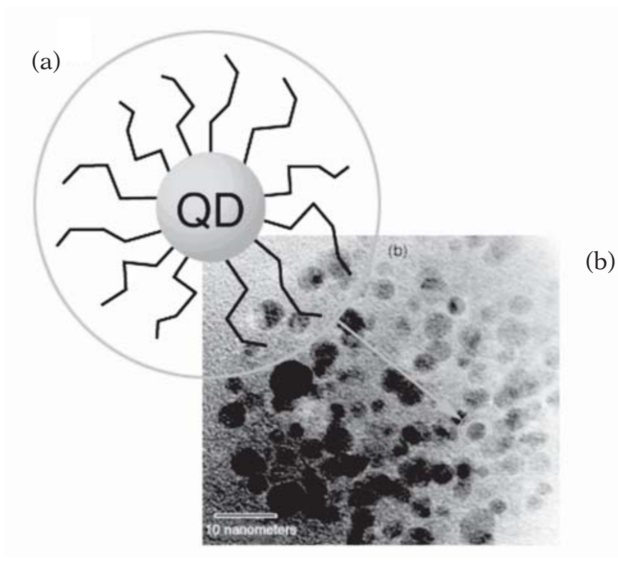

Figure - 1: (a) A Nanometer-Scale Quantum Ball Made by Bonding Quantum-Wires to the Surface of Quantum Dot. (b) A High Resolution TLM Image of Quantum Dot

nanophotonic units and assembly are nano-dots, nano-structures and nano-fibers. Today semiconductor-based micro/nano devices are already driving the field of interest under the broad umbrella of nanophotonics. It embraces both active and passive device structures in the high refractive-index semiconductors, epitaxial semiconductor structures that contain quantum-dots or quantum-wires and inorganic semiconductor nano-dots (quantum-dots) that may be embedded in organic semiconductor structures, to obtain desired functionality such as electroluminescence. Such nano-dots often have diameters of ~1 nm producing light emission wavelengths that are predominantly determined by that characteristic dimensions via electronic confinement. The length extensions to form nano-wires with similar diameters are quite feasible, and epitaxial semiconductor multilayer structures that constitute quantum wells or superlattices, have routinely layer thicknesses in the range from sub-nanometer to a few nanometers and are therefore within our domain of interest. A nanometer-scale quantum ball, similar to the stringy Koosh Ball, made by bonding quantum wires to the surface of a quantum dot is shown in Figure-1(a) and a high-resolution transmission electron microscopy image of quantum dots at (b) [11-12].

Quite recently, nano-fiber strengthened carbon nanotube yarn are spun by introducing a tight twist as the nanotubes. The method taps the secret of spinning discovered in the late stone-age; a tight twist produces a tough fiber. Nanotubes are rolled-up sheets of carbon atoms that can be narrower than a nanometer and stronger than steel by weight. Multi-wall nanotubes contain several layers of successively larger tubes. Two orthogonal carbon nanotube fiber super-capacitors woven into a textile and an SEM image of the carbon nanotube yarn are shown in Figure-2, (a) and (b). It has been established that it was possible to spin forests of multi-wall nanotubes into multiple yarn that is as strong as 460 mega-Pascal, which is close to the strength of fibers used in bulletproof vests. The technique produces yarn that can be knotted and that preserves the nanotubes' useful electrical and optical properties [13]. It is well established that nano-dot is used for light-emission/amplification/detection and nano-structures for light manipulation and processing. In general, there are two distinct methods for building nano photonic devices. One is the so-called "top-to-down" approach that often

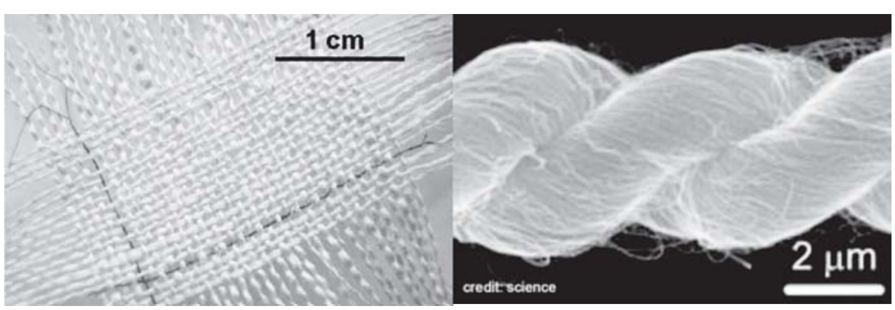

Figure -2: (a) Showing Two Orthogonal Carbon Nanotube Fiber Super-Capacitors Woven into a Textile. (b) An SEM Image of the Carbon Nanotube Yarn

involves semiconductor lithographic techniques. This approach is expensive and yet can produce large area structures with few defects. The other is the "bottom-up" approach, which typically relies on self-assembly or programmed assembly techniques. This method is cheaper, yet it's not as easy to build complicated devices over a large area and with little defects. It is worth mentioning that a nano-photonic program must invest in nano-spectroscopy, as the device size is ~ nano-meter scale.

Recently, a new set of light-emitting nano-materials, methods for nano-assembling and templating nano-dots, and tools for nano-spectroscopy have been developed [14]. Significant efforts have been devoted to understand the "nano-crystals and -fibers for an enhanced optical functionality" a thrust area, where the assembly of nano-clusters on silicon surfaces" and "polymer-based nonlinear nano-photonics" are created. Further, within the area of photonic crystals and optical communication devices, a research effort has been focused on the nano-crystal quantum-dots as active media for photonic crystal lasers and amplifiers. Fabrication and testing of nanostructures for photonic crystals is also under investigation. An SEM image of a photonic crystal on AlN is presented in Figure-3, [15]. It is believed that this progress would set a solid foundation for achieving end-goals of high-speed optical switching and an enhanced optical functionality. Latest optical methods have traditionally been one of the most important approaches for characterizing chemical and biological systems. With the development of new laser-based tools, it is now possible to study the motion of individual atoms and molecules. Apart from being an indispensable tool for characterizing and understanding the functionality of nano-systems on a molecular level, nanophotonics also holds the potential for manipulating and controlling chemical and biological processes. Using optical methods, it is possible to build nano-

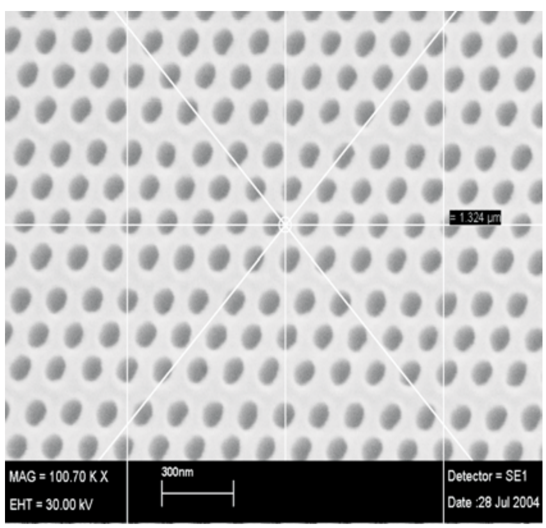

Figure - 3: SEM Images; Top View of PCs on AlN with Periodicity a = 250 nm and Hole

scale structures, to manipulate single molecules, to control the functionality of biomolecules, or to control the exchange of energy between individual molecules [16]. Therefore, one really needs to understand the emerging area of nanophotonics because, in order to fabricate test-structures it is necessary to predetermine parameters. The permutations are infinite; there are millions of molecules and different atoms and legends that one may attach to them. The way one observes the order is also nearly infinite. Therefore, one would need a window of parameters to help target various molecular samples into something that can give information on device-relevant properties. There are several challenges involved in developing fabrication techniques. For example, besides yield and reliability, power-consumption as well as cost are also equally important considerations. A challenging task is to work with molecules embedded in a matrix in a way that can be reproduced by the tone, thus giving an advantage over current technologies. The current nanophotonic fabrication methods are based on an expensive and highly toxic process (high-tech at a high price) such as Metal Organic Chemical Vapour Deposition (MOCVD).

In this review paper, a detailed description of the nanophotonic materials design and development, device concept with fabrication techniques on two dimensional nanophotonic active and passive devices like UV/DUV light emitting diodes and 2D

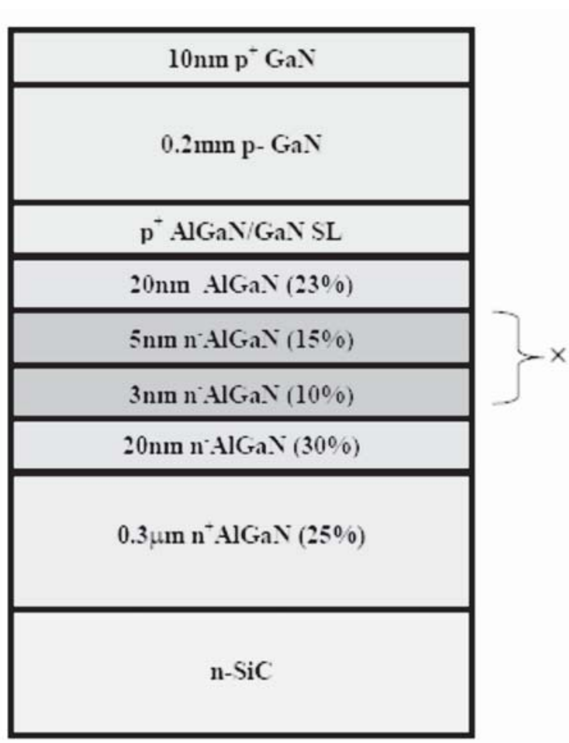

Figure - 4: Nano-Layer UV-LEDs Strucutre

photonic crystals will be discussed in detail. The results on the characterization of the processed devices based on their possible applications in optical communication, networking, information system and biophotonics will also be discussed.

2. EXPERIMENTAL DESCRIPTION

The recent progress in laser diodes (LDs) and light-emitting diodes (LEDs) based on III-Nitrides wide-bandgap semiconductors is very impressive and place such devices as strong candidates for bio-chemical detection, high-density data storage, air-water purification and solid-state lighting technology, and it adds a new dimension in nanophotonics. Due to their low power-consumption [17] and high conversion efficiency, smaller size, and long lifetime, as compared to conventional lamps, the LED-based lighting system would advantageously replace conventional incandescent as well as florescence lamps for general lighting. In addition, visible emitters with high external efficiency are currently in high demand for a variety of applications, including flat panel display, high data-storage, printers, and optical interconnects in computers.

High-efficiency ultraviolet (UV) emitters are particularly sought for applications, including detection of chemical and biological agents and medical applications. High intensity and high speed UV-LEDs could also be used as transceivers for covert non-line of sight (NLOS) optical communication. However, while the internal quantum efficiency (QE) of visible LEDs is close to 100%; most of the light is lost due to the parasitic absorption of lateral guided modes in the semiconductor materials and only about $1/(4n^2)$ of the light emitted radiates through the top and the bottom [18]. A relatively simple nano-layer structure for UV-LEDs with active layers of ~3 nm QWs and 5 nm barriers layer is shown in Figure-4. For nitride materials, only about 5% of

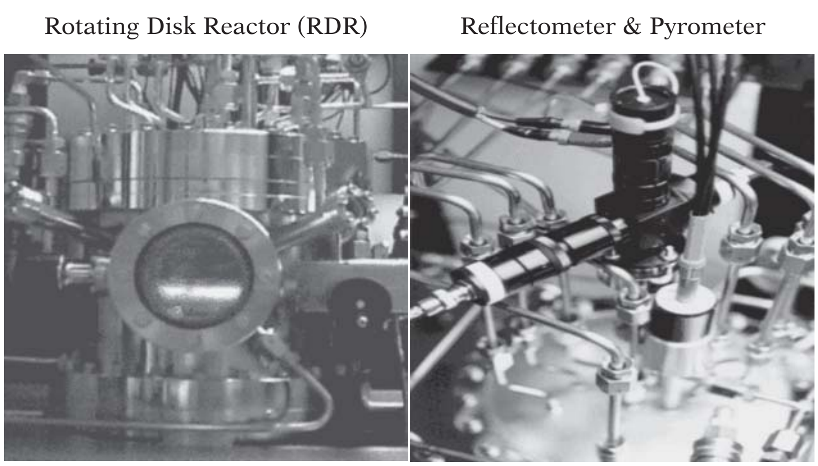

Figure - 5: A Photograph of a MOCVD Reactor and In-Situ Monitoring System [Courtesy Emcore Corporation]

the blue/green light (refractive index n ~ 2.4) and about 4% of the UV light (refractive index n ~ 2.6) generated in the active region is extracted from the top and the bottom surfaces.

The fabrication of the emitter structures starts with the deposition on the basal plane sapphire substrate by MOCVD; an example structure is described below. A high quality AlN epilayer with a thickness of about 1 m was grown as the epitaxial template for the subsequent device layers. On the AlN epilayer, a 1.5 m Si-doped *n*-$Al_{0.6}Ga_{0.4}N$ was grown as the *n*-type contact layer. Following is the AlGaN-based active region. A *p*-$Al_{0.7}Ga_{0.3}N$ layer was employed as an electron-blocking layer to effectively block the electron overflow. The structure was then completed with 60 Å Mg doped *p*-$Al_{0.6}Ga_{0.4}N$ and 150 nm heavily doped p-Al0.1Ga0.9N as the *p*-contact layer. It is found that a typical circular LED dimension with diameter < 300 m has a better current spreading as well as small thermal resistance.

Large-size LEDs with interdigitated electrodes are fabricated to overcome the current-crowding effect [19]. The fabrication starts from the deposition of Ni/Au transparent layer and the mesa etching to expose the *n*-$Al_{0.6}Ga_{0.4}N$, followed by Ti/Al metal deposition for the *n*-contact and Ni/Au for *p*-contact with rapid thermal annealing at 600 °C for 2 min. A photograph of a MOCVD reactor and in-situ monitoring system is shown above in Figure-5.

In order to avoid the absorption by the top p-type cladding and contact layers, the metallic current spreading layer, and the wire-bonding pads, deep-UV LEDs are commonly grown on the transparent sapphire substrate and light is extracted through

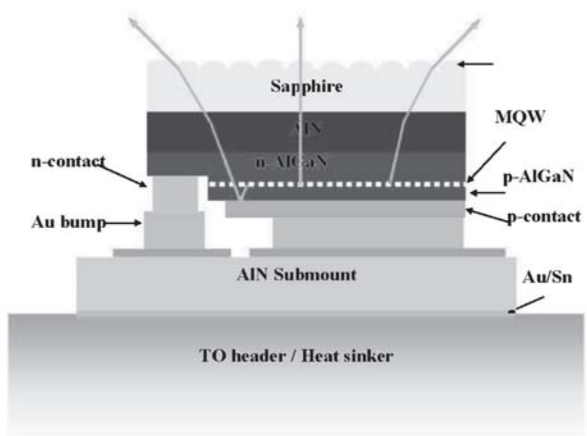

Figure - 6: A Schematic of a Flip-Chip Bonding of a Deep-Ultraviolet LED

AlN layer and sapphire substrate with flip-chip bonding. One of the major challenges involved in the working of the UV/DUV emitting devices is the thermal management of the processed devices. When the chip-scale devices are probed for I-V and L-I characteristics after processing, it is indeed very difficult for the device to withhold a high injected current. Quite recently, a state-of-the-art top of the line, chip-scale device thermal-management related technology of flip-chip bonding (FCB) has been introduced [20]. It is because of FCB that a chip-scale device may reach to a peak maximum current of ~ 350 mA without failure. Therefore, the processed chip-scale LEDs were flip-chip bonded with Au-bumps onto ceramic AlN sub-mount, and finally mounted on to TO headers and heat-sink for the measurements and operational tests. A detailed schematic diagram of the FCB chip-scale UV/DUV LED is shown in Figure-6 [21]. As mentioned earlier, flip-chip bonded LEDs allow light extraction from nitride semiconductor (n 2.5 for GaN) into the sapphire substrate (n 1.76) instead of into air, and an increase in extraction efficiency can also be expected.

Now the need for the improvements of extraction-efficiency is much greatest, especially, for deep UV LEDs (~300 nm or less) based on III-nitride wide-bandgap semiconductor, which presently have low quantum efficiency (QE). Much efforts have been expended in improving LED QE, including the use of photonic crystalline schemes [22] and novel geometrical designs aimed at enlarging escape window/cones of emitted light [23], modifying spontaneous emission by resonance cavity [24], or two dimensional (2D) photonic crystals (PCs) [25]. PC's have recently attracted much interest since the pioneering work of Yablonivitch [26]. Periodic index variations, such as arrays of holes, are typically etched in semiconductors to realize 2D PCs that forbid certain electromagnetic radiation in the lateral direction creating so called photonic bandgap (PBG) in the plane. This can be exploited to confine light-propagation to only

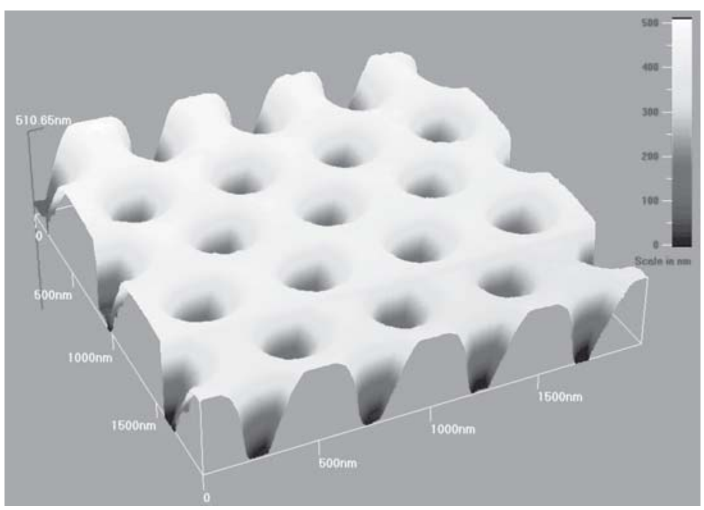

Figure - 7: An AFM Image of a 2-D Photonic Crystals

the vertical direction and thus enhance light extraction efficiency in LEDs and LDs. Ideal PBG is achieved by periodicity in 3 dimensions but for extraction efficiency in LEDs, it is sufficient to eliminate light propagation in the horizontal plane with the use of 2D PCs. The PBG is determined by lattice periodicity "a" and the diameter "d" of the air holes. As mentioned earlier, all the III-nitride structures used were grown by metallorganic chemical vapor deposition (MOCVD) on sapphire substrates. The Pc's are fabricated using electron beam lithography and ICP dry etching. Triangular lattice patterns of the circular holes with different diameters d from 70 to 170 nm and different periodicity "a" from 120 to 300 nm were defined in an area of about 14 m X 14 m on poly-methylmethacrylate (PMMA) initially spun on the nitride samples. The samples were then developed in a solution of methyl isobutyl ketone (MIBK) and isopropyl alcohol (IPA). Subsequent dry etching was performed for 50 seconds using ICP. An AFM image of 2D photonic crystals is depicted in Figure-7. The active region for the blue LEDs was an $In_{0.2}Ga_{0.8}N/GaN$ single quantum well (SQW). A conventional broad area LEDs of 350 x 350 m^2 were fabricated by standard photolithography and ICP dry etching. The active region for the UV LEDs was an $Al_{0.12}In_{0.04}Ga_{0.85}N/Al_{0.3}In_{0.04}Ga_{0.75}N$ double quantum well (DQW). Beside blue LEDs, PCs were also incorporated on UV LEDs with slightly different structures and wavelengths. The mesa of the LEDs was defined by e-beam lithography and etched by ICP dry-etching. A p-contact pad with 65 nm side length was deposited on the LEDs mesa. To improve the electrical transport, 15 nm wide n-type Ohmic contacts were also deposited on the mesa along with 120 x 120 nm^2 n-contact pad. Further details of the fabrication procedures are described elsewhere [27]. In another

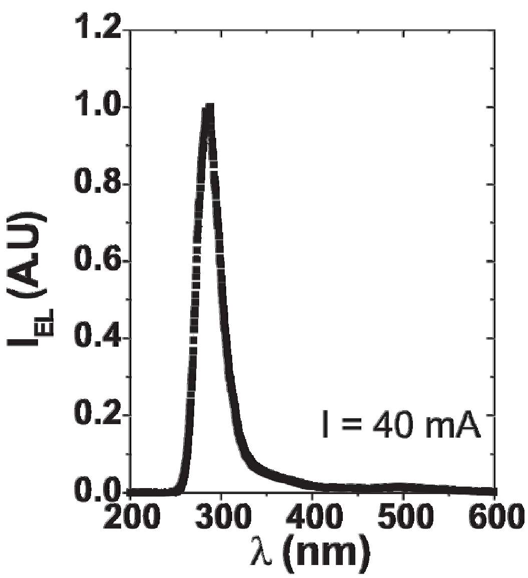

Figure - 8: The EL Spectrum of the 285 nm Deep-UV LED. The Inset Shows the Optical Microscopy Image of the Circular LED Taken from Sapphire Side

investigation, PCs of circular holes with varying diameter d = 150 nm to d = 500 nm and periodicity a = 310 nm to a = 710 nm were also fabricated on the LED everywhere, except the contact pads using e-beam lithography and ICP dry etching as described above.

3. RESULTS AND DISCUSSION

In order to characterize the processed UV/DUV devices (~280 nm), the electroluminescence (EL) and spectra of a representative LED under 40 mA DC drive current is shown in Figure-8, along with optical microscope image of the flip-chip bonded disk LED. The emission has a 280 nm peak with a full width at half maximum (FWHM) of 28 nm.

The LED has a relatively large forward voltage of 9.5 V at 20 mA, which is attributed to a low conductivity of high Al-content n- and p-AlGaN layers as well as poor Ohmic contacts. Reducing the *n*- and *p*-contact layers resistivity and improving the *n*-AlGaN Ohmic contacts, should improve the I-V characteristics, including VF and diode series resistance. Under DC driving, the LED has an output power of 0.22 mW at 20 mA, which is quite impressive. Now, on the other hand, the surface morphology of the etched nitride PCs was characterized using scanning electron microscope (SEM) a.

SOME RECENT DEVELOPMENTS IN THE APPLICATIONS OF LASERS

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ABSTRACT

Lasers can help to achieve the lowest as well as the highest temperature in laboratory. On the lower side, it has made possible the creation of the new state of matter, the Bose-Einstein condensate in a gaseous cloud of atoms at temperatures less than 10^{-7} deg K. This has led to ATOM LASER. On the high side, one can achieve temperatures as high as 100 million deg K, thus giving rise to conditions similar to the interior of a star. This makes it possible to investigate inertial fusion and high temperature Physics. At still higher laser power of the order 10^{21} watts per cm sq, achievable with femtosecond laser pulses, nuclear particles, can be accelerated to high energies, giving rise to table-top particle accelerators.

INTRODUCTION

After the invention of the laser in 1960, it used to be a common phrase that "laser is a solution looking for problems". Over the years, it has come upto the expectations of the scientific community and solved so many problems that it may take several hours to describe even some of the most important applications of lasers. One unique feature of lasers is the very large temperature-range that can be achieved by lasers in the laboratory, from nanodegree Kelvin to about one hundred million degree Kelvin. Figure one shows the temperatures that can be achieved using lasers alongwith the related applications. At both ends of the temperature-range, a new state of matter is being produced, high- temperature plasmas on one end and the Bose-Einstein condensate at the other. High- temperature plasmas are used to investigate the possibility of fusion reactor for the production of energy. The Bose-Einstein condensate has given birth to the atom laser for the creation of coherent matter waves. In between these extreme temperatures, we have many interesting applications like atom optics, medical applications, surface treatment of materials, laser material-processing, to name a few. We will discuss some of these applications in simple language for the benefit of the general readers.

BOSE-EINSTEIN CONDENSATE AND ATOM LASER [1-6]

The fundamental particles can be classified into two types. The particles with integral multiple of ½ spin are called Fermions (electron, pi-meson, mu-meson) and those with integral spin are called Bosons (photon, Cs^{128}, He^4, etc). Fermions obey Paulis exclusion principle, which states that no two particles can have the same quantum numbers and therefore it is not possible to have more than one Fermion in the same quantum state. On the other hand, Bosons obey the Bose-Einstein statistics and any number of particles may occupy the same quantum state; indeed larger the number of Bosons in a quantum state, the more attractive it becomes. One manifestation of this statistics is the laser, where a very large number of photons occupy the same mode and display coherence.

The necessary condition which must be satisfied by the Bosons is that the product of the number-density of particles and the de Broglie volume must be greater then one; simply speaking, the interatomic distance in the gas must be smaller then the de Broglie wavelength. The de Broglie wave length is given by the Plancks constant divided by the momentum of the particle. The momentum is product of the mass and velocity of the particle. According to Maxwell's kinetic theory of gases, the velocity of particles in a gas is proportional to the square root of the temperature. The velocity versus temperature curve for a typical atom is shown in Figure-2. At the temperature of 5000 °K, the speed of the atom is a few kilometers per second, which reduces to about one kilometer per second at room temperature, while at a temperature of one nanokelvin this is only a few millimeters per second. Figure-3 shows the de Broglie wavelength as a function of temperature. Indicated on the figure is also the temperature at which the de Broglie wavelength becomes comparable to the interatomic spacing of the atomic gas. Therefore, to achieve the necessary condition for the Bose-Einstein Condensation the gas has to be cooled to a very low temperature, approaching nanokelvin.

As stated above, the velocity of particles in a an atomic gas depends upon the temperature, higher the temperature higher is the velocity. Therefore in order to cool down the gas, its atoms must be slowed down; this is achieved by bombarding the atoms in an atomic beam by photons in the laser beam traveling in a direction opposite to the atomic beam. As shown in the Figure-4, when the frequency of the laser beam equals one of the absorption frequencies of the atoms the photon is aborbed by the atom and the momentum carried by the photon, although very small, is imparted to the atom in the direction of the laser beam. The absorbed photon is very quickly emitted in a few nanoseconds by the atom, by spontaneous emission process, with equal probability of photon emission in all directions. Under saturation condition, the atom absorbs another photon immediately and the process continues. Since the emitted photon can assume any direction, there is a net momentum-transfer to the atom in the direction of the laser beam after a very large number of photons have been absorbed. This results in slowing down of the atoms. However, as the atom slows down, its absorption frequency shifts because of Dopplers effect, therefore the laser frequency has to be tuned continuously till the desired effect is achieved. For a typical atom, about thirty thousand photons have to be absorbed for the atom to come to rest over a distance of about half a meter in around one millisecond. Since the absorption and emission of photon by an atom is statistical in nature, therefore, a small amount of random momentum is acquired by the atom as it cools down. This random momentum sets a lower limit to the temperature that can be achieved by this process and is equivalent to a temperature of about 100 microkelvin. In order to achieve further cooling, more sophisticated laser process called the Sisyphus cooling and evaporative cooling, using magnetic field, have to be used. The evaporative cooling is very similar to the process whereby a cup of coffee cools down or the cool feeling which one experiences when spray is applied to a part of the human body. In order to stop the slowed atoms from running away, they are first confined by an optical trap consisting of six laser beams called the optical mollases and then confined by a magnetic trap for evaporative cooling, as shown in Figure-5, after the lasers have been switched off. The potential of the magnetic trap is set at a value allowing more energetic atoms to escape from the trap first and then less energetic atoms to follow, as the potential is gradually lowered till the desired temperature is achieved. At such a low temperature, the atoms have the natural tendency to form a solid; however, by suitable choice of the interaction-time-scales and other parameters, it is possible to keep the atoms in gaseous form.

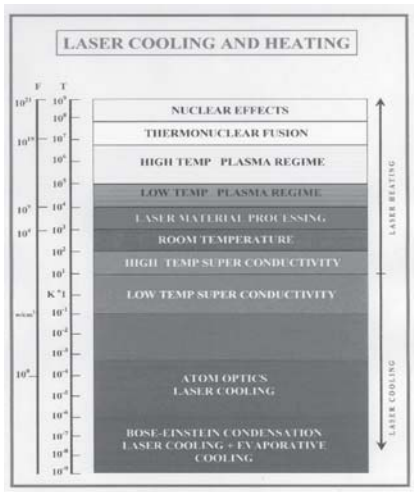
When the right conditions of atomic density and temperature have been achieved, the wavefunction of individual atoms becomes larger than the interatomic spacing and start to overlap with each other, and the atoms tend to loose their identity, behaving as if they were a single entity governed by the same wavefunction. This may also be expressed in a slightly different way. At room temperature, atoms in a gas can occupy any one of the very closely spaced quantum states available. However, at very low temperatures, almost all the Bosonic atoms can only fall into the lowest energy quantum state, thus creating Bose-Einstein Condensate in Figure-6.

In order to observe the Bose-Einstein condensate, it is allowed to expand freely by switching of all lasers and the magnetic fields and a snapshot of the velocity-distribution is taken by recording the transmitted intensity of a very short-duration laser pulse tuned to the absorption frequency of the atoms in the cloud. Three such snaps taken at different temperatures are shown in Figure-8. Figure 8(a) shows the velocity distribution of the atoms before the formation of Bose-Einstein condensate, this is a round representation of Maxwell distribution of velocities. As the temperature falls down to 200 nanokelvin, the velocity-distribution shows a drastic change, a sharp peak appears on top of the Maxwellian distribution as shown in Figure-8(b). Further decrease in temperature gives rise to a more pronounced sharp peak, dominating a much smaller Maxwellian distribution in Figure-8(c). The fraction 'F' of atoms in the Bose-Einstein condensate depends upon the temperature and is given by

$$F = 1 - \frac{T}{T_c}^{3/2}$$

where T_c is the critical temperature at which B-E condensation sets in.

The atom laser consists of the Bose-Einstein condensate confined by two magnetic coils, as shown in Figure-8. The magnetic field generated by these coils interacts with



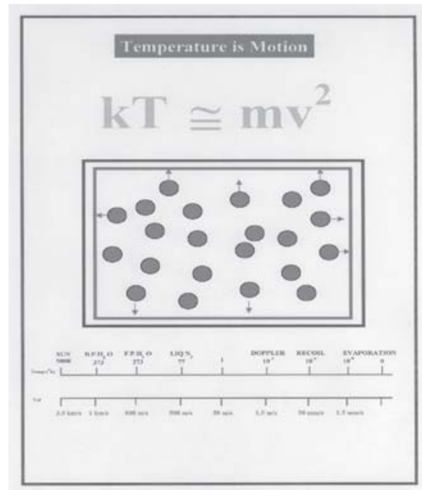
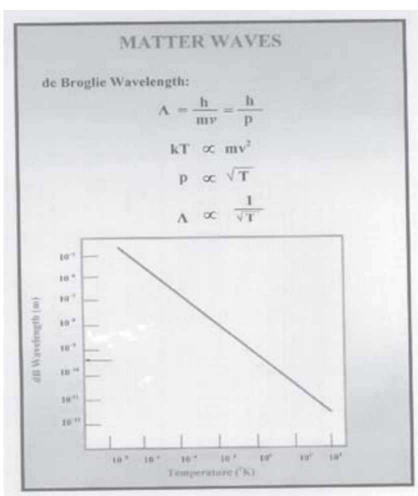


Figure - 1: Indication of the temperature, T, that may be achieved by using laser radiation fluence , F, from 1-10^{21} Watt/ cm.^{2}

Figure - 2: The velocity of typical atoms in a gas at different temperatures



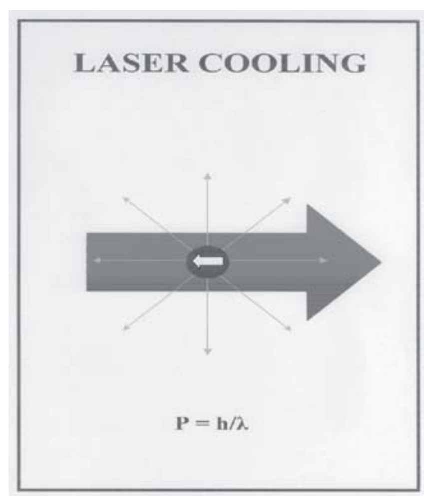


Figure - 3: De Broglie wavelength as a function of temperature. Size of an atom is also indicted in the figure

Figure - 4: Schematic showing the slowing down of an atom by the absorption of resonant radiation from a laser beam traveling in a direction opposite to the atomic beam

the magnetic moment of the atoms in the condensate, either to produce a confining or repulsive configuration. When the magnetic field is switched off the condensate leaves the cavity under the force of gravity. This constitutes the atom laser-beam, which indeed is coherent matter wave, as was shown when these waves interfered to produce interference pattern as shown in Figure-9.

PROCESSING OF LASER MATERIAL [7]

Because of low beam-divergence (10^{-3} m radian) the laser beam can be easily focused down by a lens to a spot size of few tens of micrometer in diameter. This makes it possible to concentrate laser power and generate fluence in the range 10^5 - 10^8 watts per cm square, using kw lasers. At such high power-density, it is possible to weld, cut and drill all types of materials. Lasers have also been used to modify the surfaces by such effects as transformation-hardening, alloying, glazing, etc., as shown in Figure-10. Processing of material, using lasers, has become common practice world-wide. Materials like iron, copper, tungsten, Aluminum, several centimeters in thickness, have been cut and welded by lasers at fairly high feed- rates. Laser can also be used to create intricate patterns, marking and engraving on all types of materials. Lasers can be used to produce microholes in most of the materials, specially very thin membranes.

Here we shall describe only a very important application of laser for cutting cardiac stents[8-12] from very thin (0.1 mm) stainless steel tube of 1-3 millimeters in diameter and 10-30 millimeters in length. Usually, a low-power Nd: YAG laser (10-50 watts) operating in single mode and at high repetition frequency (1-4 kHz/s) is used to cut a very intricate pattern in the tube. After cutting the stent, it is cleaned ultrasonically and electropolished to remove burrs and round off the edges and sharp points. The process of electropolishing also creates an oxide layer on the surface of the stent, which protects the tissue from the heavy ions in the metal. Finally, the stent is heat-treated to remove all sorts of stresses. The strut-dimension of a stent is usually about 100 micrometer and the spacing between the struts may range from 10-100 micrometers.

The stent is used to open up a blocked artery in the heart by providing support to the artery by its scaffolding action, when it is balloon expanded inside the artery, beyond its plastic limit, thus causing the stent to maintain the expanded shape.

A prototype stent cut from a stainless tube at NESCOM, Pakistan, is shown in Figure-11. It is about 18 mm in length and 2 mm in diameter.

NUCLEAR FUSION [13-17]

The energy requirement of the world is expected to increase by an order of magnitude during the next fifty years. To meet this challenge, one has to look for energy sources that are not only technically and economically feasible, but also environment- friendly. The energy generation based on fossil fuels has already caused considerable damage to

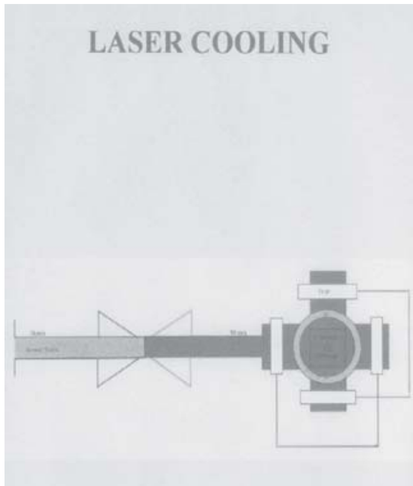


Figure - 5: Overall schematic of the cooling and trapping process of the atoms in an atomic beam. Atom are trapped first by a set of six mutually orthogonal laser beams (optical molasses) and subsequently trapped and cooled by magetic field

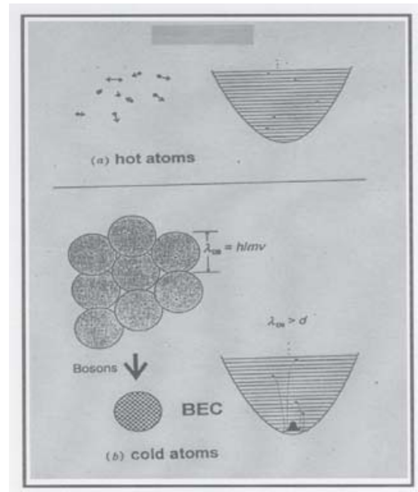


Figure - 6. Hot atoms of a Bosonic gas can occupy any of the quantum states available (a) but the cold atoms can only occupy the lowest energy state (b) (Courtesy wieman)

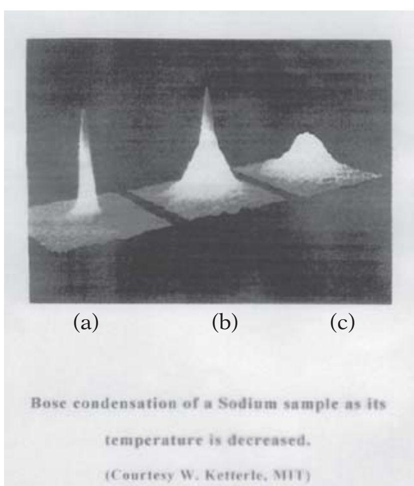


Figure - 7: Change in velocity distribution of the atoms as the temperature passes through the critical value for Bose- Einstein condensation (from right to left) (Courtesy Cornel).

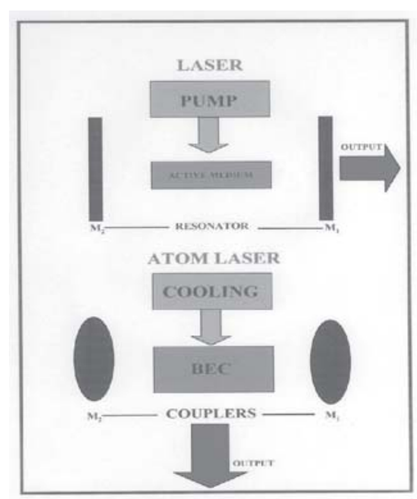


Figure - 8: Schematic representation of a laser and an atom laser.

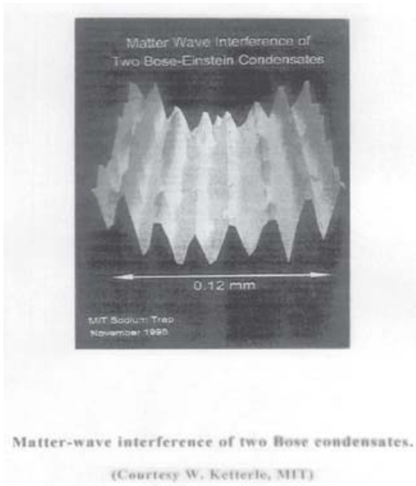


Figure - 9: Fringe pattern produced by the matter wave interference of two Bose- Einstein condensates (Courtesy ketterle)

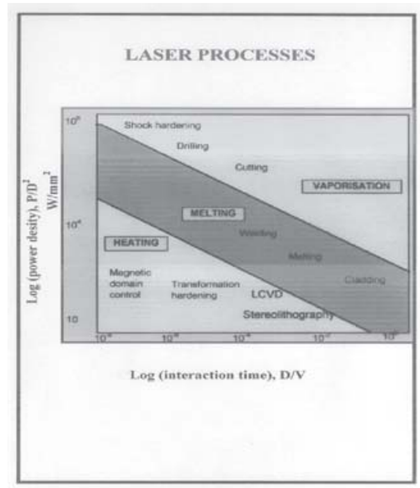


Figure - 10: Laser fluence and the interaction time required for different laser material processes. (Courtesy steen)

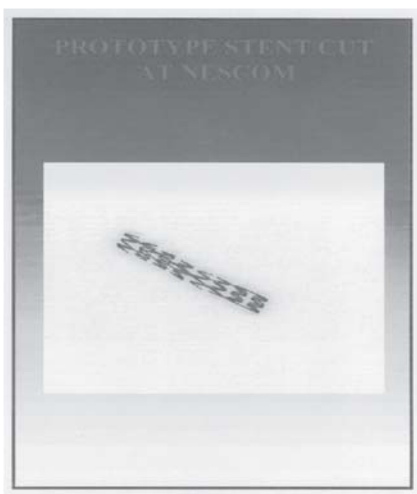


Figure - 11: Prototype stent cut from a 316- L 2mm diameter, 0.1 mm thick tube by a Nd: Tag laser at the laser processing facility at NESCOM

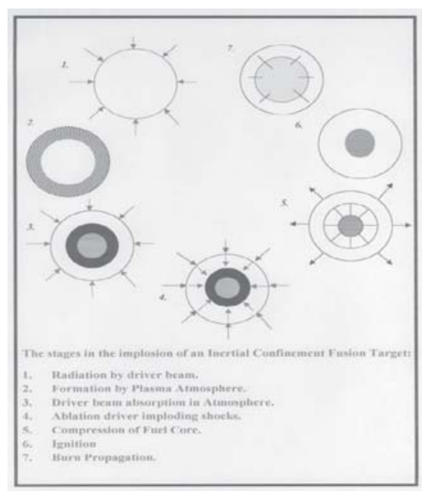


Figure - 12: Schematic showing the interaction of a number of symmetrically focused beams from a powerful laser on a D-T target. The D-T fuel pellet is both compressed and heated by the laser beams

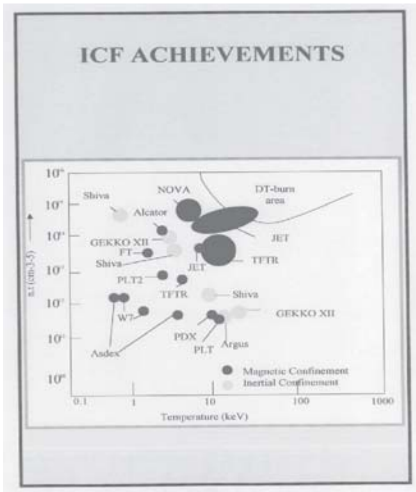


Figure - 13: Achievements so far made both by the magnetic and inertial confinement schemes. Critical area for efficient burn of the fuel is indicated at the top right hand corner in the figure

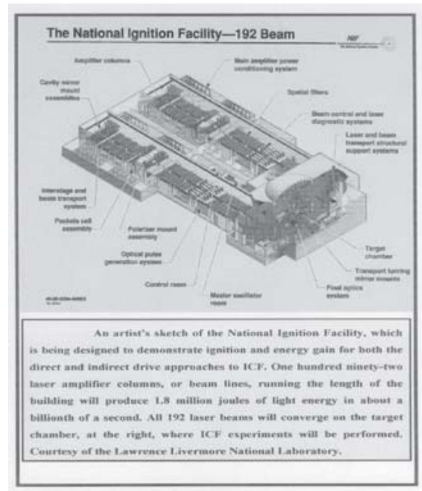


Figure - 14: An artist view of the National Ignition facility USA which is expected to go into operation in 2007

the environment, in the form of greenhouse effect and would not be the favoured source of energy-production in future. The Chernobyl disaster and other similar accidents have created opposition and misgivings in the public mind for energy production by nuclear fission. Besides the limited uranium resources worldwide, the nuclear-waste management problems will also pose a severe constraint on this type of nuclear technology. Of the remaining technologies, the hydroelectric resources have already been very nearly fully utilized. Moreover, only one percent of the total energy produced is contributed by this source. Although production of electricity by wind is on the rise, but it has only a limited utility. This leaves us with two other important means of energy production: the Solar Energy and the Nuclear Fusion. Despite an overall improvement in the cost of solar-energy production over the years, it still is not competitive. Furthermore, upto 5% of the total world land area may be required to meet 30% energy-demand of the world by this means. Fusion is, therefore, the only source of energy production that can meet the modern requirements of being environment-friendly, having negligible waste management problems and have an inexhaustible resources in the form of water.

Nuclear fusion is also nature's preferred way of energy-production. All stars, including our sun, owe their brightness to fusion. In nuclear fusion (unlike fission), two light nuclei (say Hydrogen or Helium) enter into a nuclear reaction to produce a relatively heavier nucleus with the release of energy. When two nuclei of deuterium (Hydrogen with mass number = 2) fuse together, the energy released is equal to 4.2 MeV. Similarly, when a deuterium nucleus combines with a Tritium (Hydrogen with mass number = 3) nucleus, the amount of energy released is equal to 17.58 MeV. However, the nuclei are positively charged particles and experience tremendous repulsive coulomb force as they approach closer to each other at distances near about the nuclear radius (> 10^{-13} cm). Therefore, for the nuclear reaction between two such nuclei to take place, a lot of kinetic energy must be supplied to the nuclei to overcome the coulomb barrier. For example, for hydrogen nuclei, the energy required is nearly 0.28 MeV. This energy can be imparted to the nuclei either by applying high voltage, as in particle accelerators, or by heating the gas in plasmas. Once the nuclei have acquired enough energy, they can enter into fusion-reaction to produce useful energy. The nuclei heated to very high temperature (of the order of several million degree centigrade) are moving at very high speeds (>10 km per second) and it is quite likely that they may escape the interaction region without producing a nuclear reaction. This would be a net loss of energy. In order to make nuclei undergo useful nuclear reaction, they must be confined in space for a certain time, given by the Lawson's Criterion which states that the product of particle density, n, and time, t, must be equal to 10^{13} for D-D and 10^{16} for D-T fusion reaction, i.e. a plasma with number-density equal to 10^{13} particles per centimeter cube must be confined for a time equal to 1 second for the fusion-reaction to take place. Two schemes for confinement have been applied successfully: the inertial confinement by the lasers and the magnetic confinement. Here we shall briefly describe only the inertial confinement scheme.

INERTIAL CONFINEMENT

In this scheme, the deuterium or a mixture of deuterium and tritium nuclei are first compressed to very high densities ($\sim 10^{23}$/cc), using implosions produced by powerful laser beams and then heated to very high temperatures (millions of degree centigrade) by the same laser in a very short time ($<10^{-9}$ sec), so that the nuclei have no time to disperse before undergoing a useful nuclear fusion reaction as shown in Figure-12. It is the inertia of the particles which is responsible for the confinement, and hence the name inertial confinement. The density required is about 1000 times the liquid density. The most powerful Laser NOVA at the Lawrence Livermore National Laboratory USA can deliver ten laser beams, each with 10 k joules energy, in less than one nanosecond (10^{-9} second) at the target. The total power in these laser-pulses is about 10^{15} watts, i.e. about a million times more powerful than the power generated at Tarbela.

When a small pellet (~ 1 mm diameter) of deuterium is irradiated by this powerful laser pulse, extremely hot and dense plasma is produced. A burst of neutrons coming out from the dense plasma is a manifestation of the fusion-reaction taking place inside the interaction region. Results obtained are very encouraging. Similar experiments have also been conducted in China, Japan, Russia and France. However, a lot more effort is required to develop a laser-based system for practical power-production by fusion. Present status of nuclear fusion programme is shown in Figure-13.

A much more powerful laser-system, having 192 beams with total energy of 1.8 Megajoul, is under construction at the National Ignition Faculty USA (Figure-14). When ready in 2007, the laser would be used to study the basic fusion-physics and the suitability of the inertial confinement scheme for fusion reactors .The laser would also be used for the stewardship of the nuclear stockpile in the USA.

CONCLUSIONS

Some of the important applications of lasers, have been presented. The atom laser can revolutionize work in many fields, as did its optical counterpart during the last forty years. High-energy beams of nuclear particles can be produced, using femtosecond terawatt lasers. In addition to basic physics which would be possible with these table-top accelerators, it may also lead to the production of nuclear radioisotopes for medical and research purposes.

ACKNOWLEDGEMENT

Several figures appearing in this article have been taken from published articles of other authors. This is gratefully acknowledged.

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