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PRESIDENT'S COLUMN

Malcolm Cooper

My three years as President of IRPS are fast drawing to a close and I am wondering what progress, if any, has occurred in this time.

One important change certainly has been that information about our membership is now much more up to date, for which thanks are due to Mic Farquharson, who invested a considerable amount of time and patience in this exercise. Importantly we have stopped spending money we could ill afford on circulating the newsletter worldwide in hard copy form, often to lapsed members who had not paid our (very modest) membership fees for a number of years. Most of you will be reading this at your computers, or will have printed it out from an email attachment. Thank you for accepting the Bulletin in this electronic form. It enables up to keep our very meagre financial resources for more useful purposes.

The downside of this operation has been the realisation that we are still a small Society and one whose membership grows older and older with each passing year. We need new blood! My plea to you is to help us recruit research students and young scientists to IRPS; your colleagues, your colleagues' students and research assistants............

Bring them to our symposia and workshops, get them to write articles on their research projects for the Bulletin and involve them in the worldwide community of radiation physics though our Society, and of course get them to become members.

Otherwise I fear there will come a time, not so far in the future, when there will be no IRPS.

Malcolm Cooper

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REPORTS FROM MEMBERS

IRPS Member Odair Dias Gonçalves

Egyptian Nuclear Physics Association

Report on Indo-US Workshop on Radiation Physics with Synchrotrons and Other New Sources

IRPS Member Odair Dias Gonçalves

Anselmo S. Paschoa, Ph.D.

Regional Vice-President, South and Central America

IRPS member Odair Dias Gonçalves has been nominated President of the Brazilian Nuclear Energy Commission (CNEN), which is the highest authority in the country as far the peaceful uses of nuclear energy is concerned. The nomination came directly from the Chief of Staff of the Brazilian Presidency. CNEN is an organ of the Ministry of Science and Technology of Brazil.

Dr. Odair Gonçalves was born in Brazil on 25 June 1952. After his graduation in Physics at the University of São Paulo (1973), he attended the Federal University of Rio de Janeiro (UFRJ), and received his doctorate degree in 1987. He also visited the Hahn-Meitner Institute in Germany (1985-1986), as a graduate student.

At UFRJ Dr. Gonçalves held the following positions:

Head of the Radiation Physics Group of the Institute of Physics (1996 -2003);

Deputy Director of the Nuclear Physics Department (1999 - 2001);

Head of the Radiological Protection Service of the Institute of Physics
(1990 - 2001);

Co-ordinator of the Experimental Nuclear Physics Research Group (1990 - 1996).

He has been a member of advisory committees, and scientific boards of several Brazilian and international research organizations.

Throughout his scientific career Dr. Gonçalves has published about 45 papers, and attended around 20 scientific meetings and conferences. Prior to his nomination, Dr. Gonçalves was a member of the experts working group which was designated by the government elected last year to evaluate the activities of CNEN and to propose new trends for the future.

Wishing success to our colleague Odair, as he is best known, the IRPS is looking forward to his continuing collaboration.

Egyptian Nuclear Physics Association

M.N.H. Comsan

Egypt

The Egyptian Nuclear Physics Association (ENPA) is a non-governmental organisation which was formed officially in 1998. The Association is engaged in a variety of nuclear physics activities and related topics, including the organizing of conferences, seminars, workshops, and meetings.

During 2003-2004 our activities include :

Organizing 4th Conference on Nuclear and Particle Physics (NUPPAC' 03) at the venue of Faculty of Science at El-Fayoum, Cairo University, 11-15 October,2003

Organizing Environmental Physics Conference (EPC' 04) in co-operation with the Faculty of Science, Minya University, 6-10 February, 2004.

Both conferences contain topics on radiation physics, or closely related subjects.

More detailed information on ENPA can be found on its web site :

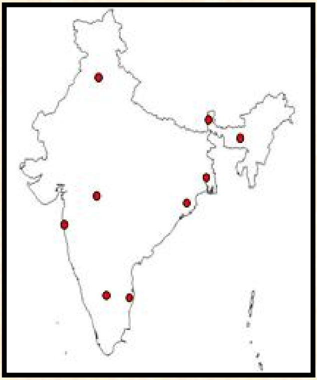
Report on Indo-US Workshop on Radiation Physics with Synchrotrons and Other New Sources

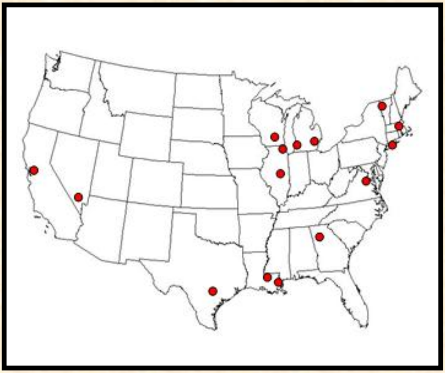
Argonne National Laboratory, U.S.A.

May 13 - 16, 2003

Organisers : Suprakash Roy and Linda Young

The Indo-US Workshop on Radiation Physics with Synchrotrons and Other New Sources was held at Argonne National Laboratory, May 1316, 2003. The purpose of the workshop was to foster collaborations between Indian and U.S. scientists in this scientific area. Twelve researchers from India were invited to attend. A similar number from outside the local area in the U.S. were invited. The maps below show the geographical distribution of the invitees from both countries.





The scientific areas represented were :

1) synchrotron, free-electron laser sources, high-power laser sources;

2) interaction of photons with isolated systems (atoms and molecules);

3) nanostructures and complex systems studied with photon probes.

The three day workshop provided relaxed surroundings leading to many new and renewed contacts and much enthusiasm for collaborative projects. A website,

http://www.phy.anl.gov/indous

contains some additional information on the workshop.

Summary of Scientific Sessions

The scientific program started with an Introductory Session to the synchrotron sources in the U.S. and India. The science and prospects of the Advanced Photon Source (a hard x-ray facility located at Argonne National Laboratory) were described by Gopal Shenoy. This was followed by R.V. Nandedkar speaking on the Indus-1 (VUV) and Indus-2 (soft x-ray) facilities. The final talk in this session was given by Neville Smith of the Summary of Scientific Sessions Advanced Light Source (VUVand soft x-ray). Over the course of the workshop we found signficant overlap in scientific programs and unexpectedly discovered measurements at Indus-1 on optical constants of silicon and silicon dioxide that correlate to theoretical calculations being done in the United States.

The second session featured tutorials in three areas:

"Interactions of Photons with Matter" by Richard Pratt

"Future Directions in High-Field and High Energy-Density Science Using Intense,Ultrafast Lasers" by Todd Ditmire

"Application of Synchrotron Radiation Techniques to Nanoscience" by Sunil Sinha.

The objective of these tutorials was to introduce the forefronts of these specific areas to all participants and to lay the groundwork for the areas discussed later in the workshop.

The first day's work was completed with a tour of the Advanced Photon Source organized by Gopal Shenoy which included a visit inside the storage ring as well as stops at various end stations around the ring.

The second day featured two scientific themes, "Photon Interactions with Isolated Atoms and Molecules" and "Ultrafast laser /x-ray interactions".

The morning session on photon interactions with isolated atoms and molecules included both theory, ***Pranawa Deshmukh and Steven Manson***, and experiment, ***Dennis Lindle, Nora Berrah and Erwin Poliakoff***. The interplay between theory and experiment was obviously synergistic, and emphasized in all the talks.

The afternoon session switched gears to Ultrafast Laser/X-ray Interactions. The first half of the session focused on experimental studies using existing ultrafast laser or x-ray sources. The experimental work described included atomic physics, ***Steve Southworth***; radiation chemistry, ***Rob Crowell***; coherent control of x-rays, ***David Reis***; x-ray probes of excited molecular structures, ***Lin Chen***.

The second half of the session was devoted to pushing the limits of light sources.

> ***Lou DiMauro*** described understanding of the physics of attosecond light pulse generation in the far infrared.
> ***Bernhard Adams*** described a theory of time-dependent dynamical x-ray diffraction that can be used to design ultrafast x-ray optics.
> ***Srinivas Krishnagopal*** described Free Electron Lasers (FELs) and the efforts at the Centre for Advanced Technology to produce coherent terahertz radiation.
> To end the session, ***David Moncton*** described the proposed next generation light source at MIT.

The last day of the workshop focused on the understanding of nanostructures and complex materials using photon probes.

> ***Alika Khare*** discussed laser-induced thin film ablation to form subwavelength patterned structures.
> ***Franz Himpsel*** gave a comprehensive lecture on synthesis and diagnostics of nanostructured arrays using spectroscopic tools available at synchrotron sources.
> ***Bhupen Dev*** followed with a talk on synchrotron studies of thin films and self-assembled systems and x-ray waveguides.
> ***Ajay Sood*** gave a stimulating talk on carbon nanotubes and their properties at extreme pressure.
> ***Milan Sanyal*** showed how synchrotron radiation could be used to monitor growth mechanisms and thermal properties of thin organic films.

After lunch, ***Sushanta Dattagupta*** discussed a new method to monitor rotational dynamics in soft matter using at the perturbation in the angular correlation of x-rays from resonantly excited nuclear levels. Finally, ***Paul Bergstrom*** discussed the methodology and approximations involved in creating data tables across all elements for photon interactions with matter.

The workshop finished with a round table discussion for future collaborative research and followup workshops. Information was distributed on the National Science Foundation program NSF 03-559 which funds collaborations between Indian and US scientists ***(contact information, Marjorie Lueck, mlueck@nsf.gov)***. Steve Manson, Pranawa Deshmukh, Richard Pratt and Suprakash Roy, all recipients of joint Indo-US grants in the past, were present to describe their experiences. After this, a poll showed great interest in applying for grants to fund collaborative research. Although scientists from national laboratories in the United States were interested, they are unfortunately ineligible for NSF funding. There was interest expressed for joint studies in nanostructured systems, magnetic thin films, atomic physics (theory-India, experiment -US), optical properties (experiment-India, theory-US), and x-ray scattering. It was noted that many important experiments don't require high brilliance and can be conducted at the Indus-1 facility. Given the lively scientific program at Indus-1 that has developed since commissioning in 1999, exchange visits involving Indian students coming for training in the United States were deemed beneficial for both sides. Several U.S. researchers expressed interest in hosting visiting Indian students. Finally, collaborative grants via the NSF/DST mechanism require a PI in each country, which may be impractical for developers of new facilities such as FELs. In these cases, a joint contract between two laboratories (as is currently the case between CERN and CAT, India) was thought to be a better mechanism. In such a joint contract, the Indian laboratory makes a direct monetary contribution to the partner laboratory and becomes an active participant development of the foreign laboratory. Research visits are then scheduled as required.

Finally, participants were enthusiastic about followup workshops.

First, a workshop on "New Directions in the Study of the Interaction of Energetic Photons with Matter" is currently in the planning stages and being organized by Richard Pratt and Swapan Sen Gupta.

Second, a followup workshop on Scattering - Neutron, X-ray and Raman to be held in India was proposed by Sushanta Dattagupta and Gopal Shenoy.

Manuscripts are being solicited from speakers for publication as a Special Issue of Radiation Physics and Chemistry with a target publication date of spring 2004.

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MEMBER'S PAPER

Need to Create Regional Synchrotron Radiation Facilities

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Abstract

We address the theme of international collaborations based on accelerator sciences, citing examples of the European institutions, CERN and ESRF in particular. The progress of the Middle Eastern and the Armenian Synchrotrons are described briefly. The proposals for creation of ***Regional Synchrotron Radiation Facilities*** in Africa and Asia are presented, in some detail.

1. Introduction

Synchrotron radiation (SR) has matured into a vibrant tool in an amazingly diverse variety of science areas. The size of the synchrotron radiation user community and the range of the potential applications are growing rapidly. There are about seventy SR sources in various stages of operation, construction, or planning, in twenty-three countries: Armenia, Australia, Brazil, Canada, China, Denmark, England, France, Germany, India, Italy, Japan, Jordan, Korea, Russia, Singapore, Spain, Sweden, Switzerland, Taiwan, Thailand, Ukraine and the USA [1-2].

Let us examine the distribution of the SR facilities across major geographic regions. Europe has ten countries with synchrotrons. USA has twelve synchrotrons. In Asia there are thirty synchrotrons located in nine countries. Japan has seventeen, the highest figure for a single country. South America has one country with synchrotrons and Australia is planning its first synchrotron. The region of the Middle East has just been blessed as discussed in section 2 of this report. The continent of Africa has yet to have its first SR facility.

A comparison with the corresponding population distributions points to the need to create SR facilities in many of the countries to meet their research and development requirements. Most of the 188 countries, will not have SR sources of their own in the foreseeable future. This is due to the high costs (several hundred million US dollars) and, importantly, the technological expertise required to build such facilities. A possible way to fulfill their SR requirements is by creating ***Regional Synchrotron Radiation Facilities*** (RSRF), built and operated jointly by the participating countries. CERN, the European Laboratory for Particle Physics, in Geneva, has been providing one such means of international collaborations in Europe, since its inception in 1954. It is to be recalled that CERN brought together numerous scientists from countries that had fought each other during the two

World Wars.

The related, and a more suitable example of the European joint initiatives, is the European Synchrotron Radiation Facility located in Grenoble, France. Conceived in 1975 and supported by seventeen participating countries, this 6.0 GeV synchrotron X-ray source is constantly pushing experimental possibilities to new limits. ESRF has a core membership of twelve European countries. Each is a corporate member and pays a percentage of the construction and operating costs of the facilities. Its construction began in 1988 and the first fifteen beam-lines were opened in 1994 [3]. ESRF is one of the three most powerful hard X-ray facilities and the other two are: the 8.0 GeV, SPring-8 in Japan and the 7.0GeV, Advanced Photon Source

The price of construction of ESRF was about 550 million US dollars and the current annual budget is seventy million US dollars. ESRF has forty beam-lines. The 3,000 scientists who use the facility each year carry out basic research in physics, chemistry, materials and life sciences.

Facilities similar to ESRF can also be built in other regions of the world. We shall briefly describe the progress of the forthcoming regional facilities, including the Middle East Synchrotron and the Armenian Synchrotron as well as the proposals to create such facilities on the continents of Africa and Asia.

2. Middle East Synchrotron

On 6 January 2003, King Abdullah of Jordan laid the cornerstone for the Middle East's first synchrotron known as SESAME (Synchrotron-light for Experimental Science and Applications in the Middle East). The ceremony took place in the presence of the UNESCO Director-General Koichiro Matsuura, members of thJordanian government and international dignitaries including Werner Burkart, Deputy Director General of IAEA. Eight Founding Members have signed the statutes of SESAME and now form the SESAME Definite Council, which will provide the annual operating budget. The founding countries are Bahrain, Egypt, Iran, Israel, Jordan, Pakistan, Palestine, and Turkey.

The SESAME Project was born in 1997 when Germany decided to decommission the fully functioning 800MeV BESSY-I synchrotron worth 60 million US dollars and give it to the Middle East [4-5]. The SESAME Project was put under the auspices of UNESCO in much the same way as UNESCO assisted with the creation of CERN. The Interim Council met nine times after its formation in 1999. SESAME's Interim Council has been transformed into the definite Council, with Herwig Schopper re-elected as president, and the two vice-presidents, Khaled Toukan of Jordan and Dinçer Ulkü of Turkey, also re-elected.

Several non-Middle Eastern countries that were observers to the Interim Council (Armenia, Cyprus, France, Germany, Italy, Japan, Russia, Sweden, Switzerland, UK and USA) are expected to continue as Observers in the new Council. The remaining members of the Interim Council were: Greece, Morocco, Oman, and the United Arab Emirates who will also continue to participate. Kuwait is an Observer and Libya has requested to become one. More countries are expected to participate as members or observers.

BESSY-I was shipped to Jordan in June 2002, where it is being upgraded in the range of 2-2.5GeV. SESAME is located in Allaan, about 30 km from the capital

Amman and is expected to promote science and foster international cooperation. Planned research programs include structural molecular biology, molecular environmental science, surface and interface science, micro-electromechanical devices, X-ray imaging, archaeological microanalysis, materials characterization, and medical applications. Annual operating costs will be about 3.5 million US dollars. Research programs are expected to start in 2007 [6-7].

In passing, we note that SESAME is not the only relocated synchrotron. Japan donated a 1.0 GeV synchrotron to Thailand. Thus, Asia-Pacific became the birthplace for the era of the relocated synchrotrons. The Siam Photon Source is Thailand's first SR facility and is intended to serve scientists throughout Southeast Asia [8-9]. A Dutch accelerator and storage ring used for nuclear physics was moved to Dubna, to add to Russia's Synchrotron capability. The original facility was located at the Institute of Nuclear Physics and High Energy Physics (NIKHEF) in Amsterdam, The Netherlands. This is the 1.2 GeV, Dubna Synchrotron Radiation Source (DELSY), located at the Joint Institute of Nuclear Research (JINR) in Dubna.

3. Armenian Synchrotron

Armenia was hoping to receive BESSY-I from Germany, but Jordan was chosen to host the facility with Armenia as first runner-up. Then, Armenia switched its status from a full Member to an ***Observer*** and launched a campaign to build its own synchrotron, the CANDLE ***Center for the Advancement of Natural Discoveries using Light Emission)***. CANDLE aims to build a 3.2GeV third-generation synchrotron from scratch in the Armenian capital Yerevan and is envisaged as an international regional facility. Americans of the Armenian descent have been very actively campaigning for the SR facility in Armenia and much of the credit for kindling CANDLE belongs to a 75-year-old Iraqi-born Armenian-American property magnate in New Jersey.

In 2002 the US Department of Energy awarded half a million US dollars for the preparation of a Technical Design Analysis report for the CANDLE project. This report is under review by the National Science Foundation in Washington. Assuming a positive response, CANDLE may receive up to 15 million US dollars in aid. If this funding is secured, construction can begin in 2004 and some of the planned fifty beamlines are expected to be operational by 2007. Construction of CANDLE is projected to cost 48 million US dollars, with annual operating costs of 4 million US dollars. When constructed, CANDLE will be the only facility of its kind within a 2000 km radius, serving numerous users from countries of the former Soviet Union, parts of Europe, the Middle East and Asia [10].

4. To Launch the African Synchrotron Radiation Program

The continent of Africa is the only region, which has yet to start its synchrotron program. However, there is an excellent network of laser programs across Africa. It would be relevant to mention the ***African, Laser, Atomic, Molecular, and Optical Sciences Network*** (LAM) operating under the directorship of Ahmadou Wagué. The LAM Network has 27 ***Regional Coordinators*** across Africa and ***International Contacts*** in 11 countries outside of Africa. The LAM has held six ***International Workshops on Laser Physics and its Applications***, since May 1991. Another organization is the recently created ***African Laser Center*** (ALC). Both the organizations are working to promote the application of laser-based technologies in the fields ranging from environment to health care.

The countries supporting these programs include France, Germany, Italy, Japan, Sweden and the USA. For more than a decade, there have been a series of international meetings held regularly across Africa, covering a variety of themes such as radiation physics, cyclotrons and their applications and positron beam techniques, to name a few. There are active and well organized research groups and networks in a broad range of disciplines across Africa, which can benefit immensely by the employment of synchrotrons.

The question is not whether Africa needs SR sources, but, rather, how to acquire these sources. It is essential to focus on the need to launch the ***African Synchrotron Radiation Programme*** (AfSRP), which shall assist in co-ordinating African participationin SESAME and other synchrotron facilities all over the world. At the same time an AfSRP can play a pivotal role in creating SR facilities in Africa [11-12].

5. Asian Synchrotron Radiation Facility - a proposal

Accelerator-based sciences in Asia are as old as the subject itself and can provide the much-needed vehicle for more intensive international collaborations.

The design, construction and operation of the numerous accelerators (including the thirty synchrotrons) have led to increased activity in Asia in the fields of particle physics, nuclear physics, materials and biological sciences. With strong economic growth over the last few decades, Asian countries have increasingly promoted accelerator-based sciences, leading to an increased collaboration among these countries to share resources and expertise.

This has resulted in the establishment of new Forums including the Asian Committee for Future Accelerators (ACFA) in 1996 [13], Asian Particle Accelerator Conferences (APAC) in 1998, Asian Accelerator Schools (AAS) in 1999 [2]. The other Forums include the Particle Accelerator Society of China (PASC) [14], Japanese Beam Physics Club (JBPC) [15], Particle Accelerator Society of India (PASI) and the Accelerator Meetings in India [16]. The release of the "GLC Roadmap Report", during the ACFA Linear Collider Symposium on 12 February-2003 has been the most significant event in recent times. GLC is the proposed 500TeV Global Linear Collider, to be hosted by Japan [17].

With all the remarkable developments cited above the International Asian Facility is somewhat paradoxical [1-2]. Here, we shall focus on the need for the creation of an Asian Synchrotron Radiation Facility . The realization of large-scale projects such as the proposed ASRF can be analyzed by examining the following factors:

(a) Technological feasability

> ASRF can start with one synchrotron. This is technically possible as several countries in Asia have the long experience and the expertise of building and running such facilities. In due course of time the ASRF may have more synchrotrons; ***Free Electron Lasers*** (FEL's); and the related projects such as the ***Energy Recovery Linac*** (ERL), which is based exclusively on proven pieces of technology.

(b) Financial Viability

Having realized the technological feasibility in Step-1, the next step is to explore the financial viability. The cost of constructing a facility similar to say, the 6.0 GeV ESRF is 550 million US dollars with annual operating costs of about sixty million US dollars. The total construction cost of the 7.0 GeV third-generation APS is 467 million US dollars and the 8.0 GeV SPring-8 is about one billion US dollars. Let us note, that the combined total GNP of the seventeen ESRF Member States is about 9 trillion US dollars, with net R&D allotment of about 190 billion US dollars. The corresponding figures for the thirteen ACFA Member Countries are 7 trillion US dollars and 145 billion US dollars respectively. In terms of percentages the ESRF member states are spending on an average over 2.10% of their GNP towards R&D.

When we compute the average percentage for ACFA member countries (minus Japan) it turns out to be 0.98%. This aspect of the expenditure on R&D has been recorded in Tables A and B. The required funds of one billion US dollars, for the proposed ASRF, can come from, by increasing the R&D allotment from 0.98% to 1.01%, an ***infinitesimal step*** towards international norms of the GNP formula (1.0% to 2.0% of their GNP towards R&D, this is discussed in detail in [18]). This is precisely the source, which can and has to generate, the funds for the ASRF.

If we include the statistics of Japan, the percentage figures for increasing the allotment towards R&D will be appreciably less. In these figures we have excluded Japan as it contributes more than half to the total GNP of the ACFA Member Countries and has the very high allotment of 2.8% towards R&D.

The primary funding for the ASRF should preferably come from other countries. We have focused on the ACFA countries in the analysis, only for convenience and significantly to demonstrate the feasibility of ASRF. In the process we have also recorded the low allotment towards R&D in most of the ACFA countries. Other countries should not miss the opportunity to participate in ACFA and the proposed ASRF.

6. Concluding Remarks and Future Outlook

In 2001 the Victorian Government (Australia) announced its decision to fund the construction of a synchrotron at the Monash University in Clayton, Victoria. The 3.0GeV BOOMERANG synchrotron facility is under the Australian Synchrotron Research Programme (ASRP) [19].

South America has two synchrotrons, the 1.35GeV LNLS-I and the 2.0GeV LNLS-II, both in Brazil. In recent years there have been several meetings such as the "International Symposium on Utilization of Accelerators", in Brazil. Such meetings can be used as platforms to launch the regional synchrotron radiation programs in South America and Central America respectively.

Finally a comment on the continent of Antarctica! Any plans for a synchrotron in Antarctica will necessarily have to pay due regards to the local environment. This has to wait till the advent of a compact/portable synchrotron. Such devices may be available in few decades, when we are able to produce energetic beams by exploiting ***alternate*** techniques to accelerate charged-particles.

The larger accelerator projects cannot be realized by single countries, and are thus a source of international collaborations. This is much more true for countries with smaller scientific and/or economic resources. ESRF and CERN are excellent examples of such collaborations. Countries from other regions should very closely examine these examples in their own perspective and work towards participating in the existing regional facilities and creating new ones where none exist.

Large laboratories not only lead to a better understanding of nature, but also pave the path for many technological and commercial spin-offs. Here, we shall cite just one example - the creation of the ***World Wide Web*** at CERN. This is one of the many examples of technology transfer from big-science laboratories to industry and finally to the public.

Such projects take a long time to mature. A pilot study for the proposed regional synchrotron radiation facilities (RSRF) should begin right away. The costs of construction are distributed over several years of planning and construction, and are to be shared by the participating countries ***via*** the GNP rule (pay in proportion to their GNP respectively) or any mutually convenient arrangement. CERN funding is based on the GNP rule whereas the ESRF is not.

As is well known, the required time for the conceptual study and planning is several years, before the actual ground breaking. This provides adequate time to the funding governments to reorient their expenditures, to enable the incremental funding of the proposed RSRF. Europe has done several such projects (ESRF; CERN to be counted in plural due to the long chain of projects; European Space Agency; European Science Foundation…).

The International Committee for Future Accelerators (ICFA) provides an excellent framework for collaborations and forums [20]. ICFA along with ACFA and its European counterpart ECFA ***(European Committee for Future Accelerators)*** provide very active forums to discuss and implement plans for further promoting collaborative accelerator-based science. Their primary purpose is to strengthen collaboration in accelerator-based science, to encourage future projects, and to make recommendations to governments. It would be meaningful to involve and utilize these organizations to expedite the creation of the proposed regional facilities.

The world is moving closer, economically, intellectually and scientifically. In a few years there will be not one but several regional SR facilities across the world. These could set a trend for several other disciplines such as ***High-Energy Physics, Space Exploration, Energy and Fusion Research***, to name a few.

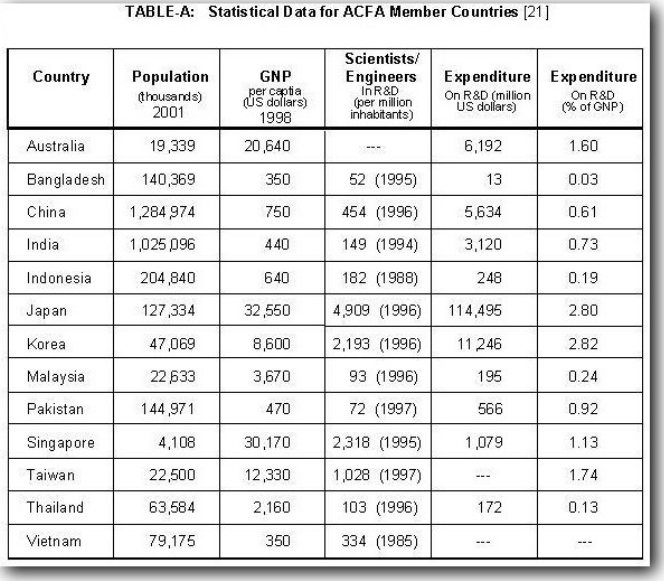


TABLE-A: Statistical Data for ACFA Member Countries [21]

Country	Population (thousands) 2001	GNP per captia (US dollars) 1998	Scientists/ Engineers In R&D (per million inhabitants)	Expenditure On R&D (million US dollars)	Expenditure On R&D (% of GNP)
Australia	19,339	20,640	---	6,192	1.60
Bangladesh	140,369	350	52 (1995)	13	0.03
China	1,284,974	750	454 (1996)	5,634	0.61
India	1,025,096	440	149 (1994)	3,120	0.73
Indonesia	204,840	640	182 (1988)	248	0.19
Japan	127,334	32,550	4,909 (1996)	114,495	2.80
Korea	47,069	8,600	2,193 (1996)	11,246	2.82
Malaysia	22,633	3,670	93 (1996)	195	0.24
Pakistan	144,971	470	72 (1997)	566	0.92
Singapore	4,108	30,170	2,318 (1995)	1,079	1.13
Taiwan	22,500	12,330	1,028 (1997)	---	1.74
Thailand	63,584	2,160	103 (1996)	172	0.13
Vietnam	79,175	350	334 (1985)	---	---

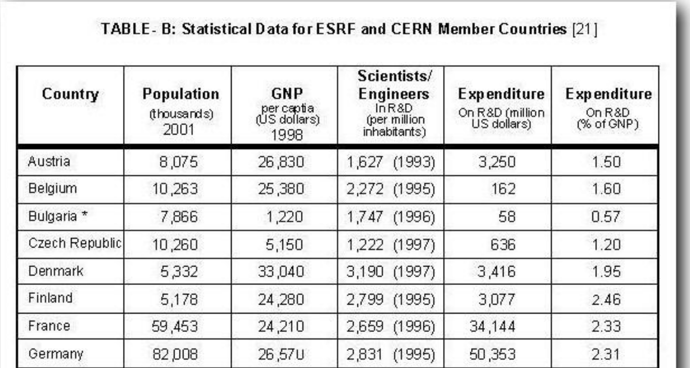
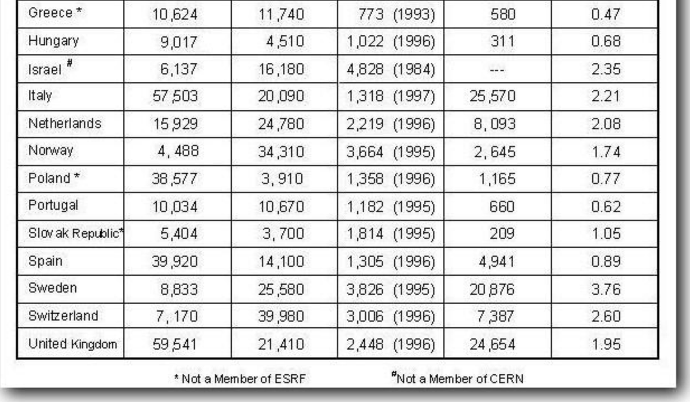


TABLE- B: Statistical Data for ESRF and CERN Member Countries [21]

Country	Population (thousands) 2001	GNP per captia (US dollars) 1998	Scientists/ Engineers In R&D (per million inhabitants)	Expenditure On R&D (million US dollars)	Expenditure On R&D (% of GNP)
Austria	8,075	26,830	1,627 (1993)	3,250	1.50
Belgium	10,263	25,380	2,272 (1995)	162	1.60
Bulgaria *	7,866	1,220	1,747 (1996)	58	0.57
Czech Republic	10,260	5,150	1,222 (1997)	636	1.20
Denmark	5,332	33,040	3,190 (1997)	3,416	1.95
Finland	5,178	24,280	2,799 (1995)	3,077	2.46
France	59,453	24,210	2,659 (1996)	34,144	2.33
Germany	82,008	26,570	2,831 (1995)	50,353	2.31



Greece *	10,624	11,740	773 (1993)	580	0.47
Hungary	9,017	4,510	1,022 (1996)	311	0.68
Israel #	6,137	16,180	4,828 (1984)	---	2.35
Italy	57,503	20,090	1,318 (1997)	25,570	2.21
Netherlands	15,929	24,780	2,219 (1996)	8,093	2.08
Norway	4,488	34,310	3,664 (1995)	2,645	1.74
Poland *	38,577	3,910	1,358 (1996)	1,165	0.77
Portugal	10,034	10,670	1,182 (1995)	660	0.62
Slovak Republic*	5,404	3,700	1,814 (1995)	209	1.05
Spain	39,920	14,100	1,305 (1996)	4,941	0.89
Sweden	8,833	25,580	3,826 (1995)	20,876	3.76
Switzerland	7,170	39,980	3,006 (1996)	7,387	2.60
United Kingdom	59,541	21,410	2,448 (1996)	24,654	1.95

* Not a Member of ESRF #Not a Member of CERN

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PAPER

Palm Oil Deterioration Induced by Ionizing Radiation

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ABSTRACT

X-irradiated Palm Oil of the Elaeis guineensis specie was studied by assessing the effect of the radiation on the peroxide, iodine and fatty acid values of the oil. These were compared with values of fresh and thermoxidized palm oil. Results showed a rise in the peroxide value by as much as 52.5% for thermoxidized oil and 25.2% for x-irradiated oil; and iodine values similarly increasing by 6.4% for thermoxidized oil and 3.5% for x-irradiated palm oil respectively, while the acid value increased by as much as 460% and 683% for thermoxidized and x-irradiated samples respectively. These are strong indications of the deterioration of the oil, the attendant consequences of which are discussed.

Keywords: Palm oil, Radiation, Toxicity, Deterioration, Thermoxidized, Iodine, Peroxide

INTRODUCTION

Palm oil from the Elaeis guineensis specie forms a substantial proportion of the edible and non-edible vegetable oils required for domestic and industrial consumption in Nigeria (Ekpa et al, 1996). It is also a significant part export for some countries in the world.

The physical and chemical properties of palm oil have been reported to be determined by the nature of the constituent fatty acids making up about 95% of the glyceride molecule (Norris, 1965). The oil contains saturated and unsaturated fatty acids including palmitic, stearic, lauric and myristic acids as saturated constituents, with linoleic and oleic forming the bulk of the unsaturated aids (Ekpa & Ekpe, 1996; Ebong et al, 1999; Ayorinde et al, 2000). The wide range of uses to which palm oil is put, is as a result of the high proportion of fatty acids and other physical and chemical properties (Hassan, 1988).

Palm oil has been reported to be relatively stable to oxidation (Gapor et al, 1989) due to the presence of high concentrations of potent anti-oxidants like tocopherols and tocotrienols. Despite this, it has been reported that fluorescent light has deteriorative effects on palm oil (Ekpa & Ekpe, 1996), as does heat (Ebong et al, 1999). Generally, oxidized oils have been reported to have high saturated fats content (Osim et al, 1994).

X-rays have been utilized in port security (Cooper, 1998; Luggar, 1998; NRPB, 1996) over the years. One question, which readily comes to mind in the event of palm oil being a part of the materials under such security examination, is whether the oxidation of the oil by irradiation adversely affects its natural constituents, and if it does, to what extent.

Toxicity of thermally oxidized palm oil has been extensively investigated (Rand et al, 1988; Honstra & Sundram, 1989; Osim et al, 1994; Isong et al, 1997; Owu et al, 1998 and Osim et al, 1999), but such data is not available on the toxicity of irradiated palm oil. The present work is aimed at acquiring some data on the toxicity of irradiated palm oil and to proffer solutions to the above questions.

MATERIALS AND METHODS

Fresh ripe fruits of the oil palm tree were collected from Apiapum, Nigeria, processed the same day to reduce the degree of degradation, by the method described by Ekpa et al, (1994). The palm fruits were boiled in water for 30 minutes, then mashed by pounding in a wooden mortar with a pestle, while still hot. The oil was extracted by hand squeezing the mesocarp, clarified by heating with one-third its volume of water after which the oil on the surface was drawn and dried by heating in an air circulating oven at 105 °C for 5 minutes. The method of extraction here is typical of those used in processing palm oil both for export and local consumption in Nigeria.

A third part of this quantity was analyzed for the three parameters under consideration in this work - peroxide value, iodine value and the acid value. The other two-thirds of the obtained volume was divided equally for thermoxidation with a domestic flame at normal cooking temperature, and for irradiation using low energy (50 KVp) X-rays from a three-phase high-frequency x-ray generator model GEC R501 at exposure factors of 300mA, 0.02 secs (6 mAs) and a source to detector distance of 90 cm.

(a) Determination of the Peroxide Value

The peroxide value was analyzed using such materials as acetic acid (as purchased), potassium iodide, sodium thiosulphate (0.1M), 1% starch solution, chloroform (as purchased), 250 ml flask, measuring cylinder, pipettes and burettes and conical flasks (250 ml). Using the method described by Paquot, (1979), the peroxide value was obtained from

$$\text{Peroxide Value (Meq/kg of Fat)} = \frac{(a - b) \times M \times 10)}{W} \qquad (1)$$

where M = Molarity of $Na_2S_2O_3$
A = Volume of test $Na_2S_2O_3$
B = Volume of blank $Na_2S_2O_3$
W = Weight of the oil sample

(b) Determination of the Iodine Value

The iodine value of a substance is defined as the weight of halogens expressed as iodine absorbed by 100 parts by weight of the substance. The iodine value was determined by the Wijs' method described by IFFO (1998) in which the test sample was dissolved in a solvent and Wijs' reagent added. After about one hour reaction time, potassium iodide and water were added to the mixture. Iodine liberated by the process was titrated with sodium thiosulphate solution.

(c) Determination of Acid value

The acid value of the oil samples was determined by dissolving 2g of each sample in 2ml of neutral alcohol in a measuring flask to obtain a solution, which was titrated with 0.1M sodium hydroxide in triplicate, using two drops of phenolphthalein as an indicator (Paquot, 1979). The calculation was used

$$\text{Acid Value (mg NaOH/g Fat)} = \frac{40 \times M \times V}{W} \qquad (2)$$

where 40 = Molecular weight of NaOH
M = Molarity of alkali
V = Volume of alkali used in titration
W = Weight of oil sample used

RESULTS

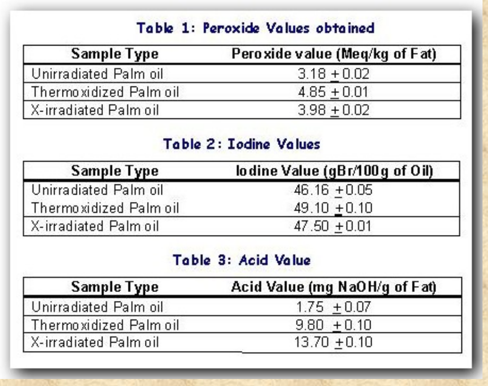

Table 1: Peroxide Values obtained

Sample Type	Peroxide value (Meq/kg of Fat)
Unirradiated Palm oil	3.18 ±0.02
Thermoxidized Palm oil	4.85 ±0.01
X-irradiated Palm oil	3.98 ±0.02

Table 2: Iodine Values

Sample Type	Iodine Value (gBr/100g of Oil)
Unirradiated Palm oil	46.16 ±0.05
Thermoxidized Palm oil	49.10 ±0.10
X-irradiated Palm oil	47.50 ±0.01

Table 3: Acid Value

Sample Type	Acid Value (mg NaOH/g of Fat)
Unirradiated Palm oil	1.75 ±0.07
Thermoxidized Palm oil	9.80 ±0.10
X-irradiated Palm oil	13.70 ±0.10

DISCUSSION AND CONCLUSION

Fresh palm oil has been reported to be beneficial to the human body with respect to overall heat production and morphology of tissues (Osim et al, 1994). It has also been shown that fresh palm oil does not elevate free fatty acid content in such organs as the brain and testis of experimental animals (Osim et al, 1992), evidently plays a beneficial role in reducing the thrombotic tendency of platelets, has no effect on blood pressure (Owu et al, 1997), is believed to increase the efficacy of protein biosynthesis favorable to sex hormone function (Isong et al, 1997), plays a part in the reduction of blood levels of cholesterol and offers protection against oxidative damage of the liver (Ebong et al, 1999), is cytoprotective against aflatotoxin ß1 induced fatty degeneration and necrosis (Maduka, et al. 2001).

However from our results we note an increase in all the parameters under examination as a result of heat or x-irradiation. The peroxide value increased by as much as 52.5% for thermoxidized oil and 25.2% for x-irradiated oil. The iodine values similarly increased by 6.4% for thermoxidized oil, and 3.5% for x-irradiated palm oil respectively. The acid value increased by as much as 460% and 683% for thermoxidized and x-irradiated samples respectively.

X-rays are highly penetrating radiation depositing heat energy in the medium as an end product (Meredith & Massey, 1977). Though the quantity of heat is small, its presence and effects cannot be over looked (Mbenkum & Egbe, 1999). It may be a contributing factor to the hydrolytic cleavage of the Carbon - Carbon double bonds of constituent unsaturated fatty acids or both (Ekpa & Ekpe, 1996).

The formation of and increasing quantity of the peroxide value is a strong indication for continuous deterioration of the oil. Peroxides are strong oxidizing agents (Martin and Harbinson, 1979) considered in some quarters as dangerous specie in living tissue

(Yarmonenko, 1988). The peroxides and their oxidative products are also associated with the off-odours of some oils (Lavers, 1991).

The increased iodine value may lead to a rise in the plasma iodine values. These increases are however small enough to be ignored, especially in the case of the irradiated oil. Usually, excessive iodine in the body could lead to development of goiter and the enlargement of the thyroid gland (Guyton & Hall, 2000).

The formation of free fatty acids is generally responsible for the soapy taste in some oils. The astronomical rise in the acid value due to irradiation may suggest that exposing palm oil to x-radiation for whatever reason may render it unsuitable for domestic use and some industrial applications.

These results suggest a significant increase in the toxicity of x-irradiated palm oil. It may therefore be right and useful to suggest that palm oil should be excluded from the list of items scanned with x-rays at the entry and exit points of sovereign nations.

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