Proceedings of the

NATIONAL SYMPOSIUM

on

NUCLEAR ENERGY- ITS GENERATION AND APPLICATIONS

Jointly organised by

The Science Departments

(Biosciences, Botany, Chemistry, Physics & Zoology)

of

Union Christian College, Aluva, Kerala,

Indian Nuclear Society (INS), Mumbai,

&

Atomic Energy Retirees' Association, Kerala (AERAK)

Venue: MCA Seminar Hall,
Union Christian College, Aluva, Kerala, 683102

on

February 23 and 24, 2023

Sponsored by

Nuclear Power Corporation of India Ltd (NPCIL)

&

Co-sponsored by

Nuclear Fuel Complex, Hyderabad,

IREL (India) Limited,

The Indian Association for Radiation Protection (IARP), Mumbai.

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23.	Dr. A. Venugopalan	
24.	Dr. M.P. Rajan	
25.	Dr. K.G. Samuel	
26.	Shri. K.K.P. Nair	Secretary, AERAK
27.	Shri. G.M. Nair	Treasurer, AERAK

PREFACE

The United Nations recognises climate change as “the most systemic threat to humankind” and it is generally considered as the most significant and urgent sustainability challenge. Climate change is resulting from increasing concentrations of CO_2 in the Earth’s atmosphere. Given that three-quarters of anthropogenic CO_2 emissions result from the burning of fossil fuels for energy, the main focus should be on energy technologies that emit only smaller amounts of CO_2 per unit of energy produced. The International Energy Agency (IEA) has noted that achieving a net-zero greenhouse gas emission by 2050 will require doubling the generation of nuclear power worldwide.

Besides the use of nuclear power for electricity production, wider application of direct use of nuclear heat as process heat with temperatures exceeding 800^{o}C appears feasible in the future when nuclear energy will not only meet the increasing demands of electricity but will also be used for the production of fresh water by desalination and for the production of hydrogen both by electrolysis as well as by thermo-chemical splitting of water. Nuclear techniques are used to support national nutritional programmes too. Irradiation can make food safer by killing contaminants that can cause food poisoning. And nuclear techniques can check whether agrochemicals have been used properly in order to ensure that they pose no health risks. Radiology is used to diagnose and manage diseases, and radiotherapy to treat and cure them. Countries use nuclear techniques for improving their crop varieties thus achieving increased production of better food. Nuclear technique can be used to control pests that destroy fruits and kill livestock and can also be employed to derive methods to diagnose and prevent animal diseases. Sterilization of sealed medical products and utilisation of radiopharmaceuticals in nuclear medicine are important spin-offs from nuclear energy. Fresh water is a limited resource. Using nuclear science, countries can manage their scarce water resources better. Scientists use nuclear techniques to study the key threats to the marine environment and then advise countries on how to prevent pollution and to mitigate its consequences.

This Seminar, organised by the Science Departments of Union Christian College, Aluva, in association with Atomic Energy Retirees’ Association, Kerala (AERAK), will provide a forum for scientists and engineers to engage in dialogue on the role of nuclear energy in the transition to clean energy sources and its potential to contribute to sustainable development and climate change mitigation. It is high time that a realistic and objective awareness is created among the Public at large and particularly amongst the young students of Science and Engineering about nuclear energy and its applications.

This Seminar is proposed to address the myths about the use of nuclear energy especially among the younger generation. Thus, the principal objective is to highlight the proven capabilities of the science and technology of atomic energy to contribute to the enhancement of peace, health and prosperity throughout the world.

The Seminar is the culmination of the combined efforts of some of the senior faculty of Union Christian College and the Awareness Committee of AERAK. We wanted to provide an opportunity to the delegates to listen to some of the leading lights of nuclear science and technology of the country. It is a matter of great satisfaction to us that a few of the senior experts of proven achievements in various aspects of nuclear energy and its application have consented to participate at the Seminar and talk to the delegates. And we also thought it appropriate to bring out an Abstract Booklet as a record of the deliberations of the Seminar. This brief Booklet carries 26 Abstracts of the presentations at the Seminar. There are 15 Invited lectures by subject experts on various aspects of generation and application of nuclear power. These experts bring to the Seminar many years of their expertise and experience in nuclear science. There are 11 contributed Papers by students from Universities in Kerala. They also deal with topics related to various aspects of application of nuclear energy. These Abstracts are reproduced here in the form of a Booklet. It is our hope that this compilation would be found useful as a Reference Booklet by interested readers.

We are thankful to our main sponsors, Nuclear Power Corporation of India Ltd., (NPCIL) for supporting this event. We are particularly thankful to NPCIL for their technical support and help. We are equally thankful to the Office Bearers of Indian Nuclear Society for providing technical and financial support for this event. They solidly stood with us and supported our efforts during the course of the Seminar activities. We are thankful to the Seminar co-sponsors, Nuclear Fuel Complex, Hyderabad, IREL (India) Ltd., Aluva and Indian Association for Radiation Protection (IARP) for their financial help in organising this Seminar. We are grateful to the management of Union Christian College for their cooperation and providing the infrastructure facility. We, specifically thank all those who have been the backbone of the event. Last but not the least, we want to extend our thanks to the technical team, admin staff, and respected professors for making this event happen so beautifully. I also cannot overlook the efforts of our volunteers and students, who worked dedicatedly for the success of this Seminar.

UNION CHRISTIAN COLLEGE

The Union Christian College (popularly known as UC college), Aluva, one of the first colleges established in the country, is turning 100 this year. The college began with 63 students enrolled in the Junior Intermediate Class in Group III, and affiliated to the then Madras University. Today, it has become a premier higher educational institution with about 2200 students, enrolled in 15 graduate and 14 postgraduate courses in diverse disciplines. The college is now affiliated to the Mahatma Gandhi University, Kottayam, with eight of its departments being Research Centres recognized by the university, providing guidance and resources to more than 120 research scholars. A sprawling green campus spread over 40 acres, the college is located on the banks of river Periyar, about 12 kilometres away from the Cochin International Airport. The college, known for its academic excellence and research potential, strives to produce intellectually competent, morally upright, and spiritually inspired citizens in the service of the nation. The college has been rated as an ‘A’ Grade institution by the National Assessment and Accreditation Council (NAAC). The college is honoured to inherit the proud heritage of accolades and endorsements from the various eminent leaders of the nation who visited the institution in the past. Mahatma Gandhi visited the college on the 18th of March 1925 and recorded in the visitors’ diary his appreciation for the ideal conditions here. The sapling planted by him on the occasion, now a mango tree,is preserved in front of the administrative block as a testimony to the Mahatma’s ideals. The college was honoured by the visit of Gurudev Rabindranath Tagore in 1922, who acknowledged in his address to the community his joy at witnessing here the quintessential spirit of his Shantiniketan. The legacy has continued since then with other luminaries like Shri. V.V Giri, Shri. Shankar Dayal Sharma, Dr. A.P.J Abdul Kalam honouring the college with their presence on various occasions. The other prominent personalities who visited the college during its fledgling years include Shri. Jayayaprakash Narayan (1954), Shri. Morarji Desai (1957), Shri. C. Rajagopalachari (1960), Shri. V.K Krishna Menon etc. The college library, which is nine decades old, has a collection of around 83,000 books.

INDIAN NUCLEAR SOCIETY

The Indian Nuclear Society is a Registered professional body of nuclear scientists, engineers and technologists in India, with its headquarters at Mumbai and branches at Hyderabad, Kalpakkam, Rawatbhata, Mysore and Norora. It has more than 5,000 life members and 80 corporate members on its roll. The Society was inaugurated in January 1988 by late Shri. J. R.D. Tata. The Society aims to promote the advancement of nuclear science and the technology together with other sciences & arts and to aid in the integration of the several disciplines constituting Nuclear Science, Engineering and Technology. The Society also aims to create awareness amongst general public about the benefits of atomic energy to mankind. The society has so far conducted twenty-five annual conferences, several seminars and speciallectures. Under its public awareness Program, the INS and its branches has conducted several one-day seminars about nuclear energy and its applications. This activity mainly organized for students and faculty of academic institutions is conducted through lectures in English and regional languages by arranging visits to the nuclear power station and by organizing open sessions and exhibitions. The INS also regularly conducts technical workshop for industry. To recognize outstanding contributions made by individuals and industries in the field of nuclear science and technology, the society has instituted annual INS awards since the year 2001.

INS organises annual conference in every year and for INSAC-22 the theme was "Nuclear Power towards Green Energy in India". These conferences bring together former and current scientists and engineers to share the new developments, breakthroughs, innovations, updates of the plant performances, challenges and way forward through talks, presentations and panel discussions. The industry partners both from private and public sector who play an important role in pursuing the country's nuclear power programme also participate to share their experiences and suggestions.

ATOMIC ENERGY RETIREES ASSOCIATION KERALA (AERAK)

Atomic Energy Retirees' Association, Kerala (AERAK) was formed in 2009 by the retirees from Department of Atomic Energy (DAE) settled down in different parts of Kerala. Started by a group of 50 likeminded and committed persons in the year 2009, this association now has multi-disciplinary members like Engineers, Scientists, Administrators and Technicians. The Organization, since its inception, is very active in social, medical and cultural fields. Besides being a forum for get-together, objectives of the association is to create awareness on the advantages and benefits of Nuclear Energy to the Public at large. There are not many nuclear institutions located in Kerala. We thought it is our earnest duty to spread awareness, exposingthe myths and fears in public psyche. For the above purpose, Association conducts awareness programme on nuclear energy at various schools and colleges of Kerala. It has a Membershipof around 300 people spread across the State. Though Kerala is considered as one of the most literate state, the educated as well as the general social strata approach nuclear technology veryskeptically. Probably, that could be one of the reasons for the dearth of nuclear institutions in this State.

We thought, it is our earnest responsibility to make the Kerala public aware about the myths and realities of nuclear technology so that we also will be able to harvest the benefits of nucleartechnology. Several Seminars, Symposiums, Workshops, Lectures and Debates were conducted to achieve these objectives at different Higher Educational Institutions such as Higher Secondary schools, Science and Engineering Colleges, other centres of education. ThisTwo-day Seminar is a part of such efforts.

Our major objectives are:

1. Creating a post retirement joyous togetherness of the retirees and their families
2. Create awareness on the merits and demerits of nuclear technology by way of conducting awareness debates and discussions to the Keralites, especially the students and teachers in graduates and post graduate science colleges.
3. Function as a liaison office to solve the personal issues of retirees and their family especially in health and financial matters related to pension etc.
4. Conducting Webinars on topics in nuclear technology and safety. So far, more than 25 webinars have been conducted with the active participation of students from science and engineering colleges.

न्यूक्लियर पॉवर कॉर्पोरेशन ऑफ इंडिया लिमिटेड
(भारत सरकार का उद्यम)
परमाणु ऊर्जा विभाग
NUCLEAR POWER CORPORATION OF INDIA LIMITED
(A Government of India Enterprise)
Department of Atomic Energy

Nuclear Power Corporation of India Limited (NPCIL) is a Public Sector Enterprise under the administrative control of the **Department of Atomic Energy (DAE)**, Government of India. NPCIL is responsible for design, construction, commissioning and operation of nuclear powerreactors. NPCIL is a MoU signing, profit making and dividend paying company with the highest level of credit rating (AAA rating by CRISIL and CARE). NPCIL is presently operating 22 commercial nuclear power reactors with an installed capacity of 6780 MW. The reactor fleet comprises two Boiling Water Reactors (BWRs), 18 Pressurised Heavy Water Reactors (PHWRs) and two VVER reactors of 1000 MW capacity each at Kudankulam. NPCIL has 9 more reactors under construction with a total capacity of 7500 MW. The vision of NPCIL is “To be globally proficient in nuclear power technology, contributing towards long term energysecurity of the country.” And the Mission is ‘To develop nuclear power technology and to produce nuclear power as a safe, environmentally benign and economically viable source of electrical energy to meet the increasing electricity needs of the country'. Its main objectives are:

- To increase nuclear power generation capacity in the country in keeping with the growthof energy demand in the country.
- To continue and strengthen the environmental protection measures relating to nuclearpower generation
- To continue and strengthen the neighborhood welfare programme/CSR activities forachieving inclusive growth of surrounding population.

NPCIL has more than 52 years of experience in safe operation of nuclear power plants, with the motto of ‘Safety first and Production next'. The Environmental Management System (EMS)and Occupational Health and Safety Management System (OHSMS) as per ISO-14001: 2004 and IS-18001: 2007 respectively, are maintained at all the stations. NPCIL units have receivedseveral safety awards from various national agencies like AERB, NSCI, Gujarat SafetyCouncil, National Safety Council-Mumbai and DGFASLI.

NUCLEAR FUEL COMPLEX (NFC), HYDERABAD

The **Nuclear Fuel Complex** (NFC) was established in 1971 as a major industrial unit of India's Department of Atomic Energy. NFC is the only ISO certified organisation in the worldtoday to have comprehensive manufacturing cycle from ore to core, involving processing of both Uranium & Zirconium streams under one roof. It is a nuclear plant specialized in supply of nuclear fuel bundles and reactor core components. NFC is a unique facility where natural and enriched uranium fuel, zirconium alloy cladding and reactor core components are manufactured under the same roof. Natural uranium, mined at Jaduguda uranium mine inthe Singhbhum area of Jharkhand state, is converted first into yellowcake (U3O8) and then touranium oxide (UO2) assemblies. Uranium dioxide pellets contained in zirconium alloy tubes with both ends hermetically sealed.

Nuclear Fuel Complex supplies zircaloy clad uranium oxide fuel assemblies and zirconium alloy structural components for all 14 operating atomic power reactors in India. The Complexis engaged in the manufacture of various Zirconium alloy reactor core structures like Pressure Tubes, Calandria Tubes, Garter Springs, Reactivity Mechanism Assemblies for the PressurizedHeavy Water Reactors (PHWRs) and Square Channels for the Boiling Water Reactors (BWRs). NFC is also engaged in manufacturing fast reactor components. The expertise gained in manufacturing Fast Breeder Test Reactor (FBTR) sub-assemblies was successfully translated to develop technologies required for manufacturing core sub-assemblies and components required for the forthcoming 500 MWe Prototype Fast Breeder Reactor (PFBR) at Kalpakkam, Tamil Nadu. Its products such as seamless tubes of stainless steel, carbon steel, titanium and other special alloys of nickel, magnesium, zirconium, tantalum, niobium, and silver are supplied to the Department of Atomic Energy, the Indian Navy, Hindustan Aeronautics Limited and other defence organisations, as well as chemical, fertiliser, and ball bearing industries. The compliance of quality requirements are carried out by an independent Quality Assurance department in order to ensure the quality at intermediate stages and at the final stage. The organisation has given special importance to safety and environment protectionby having a dedicated section for the purpose. NFC is also planning to establish two major fuel fabrication facilities to meet the expected jump in nuclear power production.

IREL (India) Limited
(Formerly Indian Rare Earths Ltd)
A Govt. of India Undertaking
A Miniratna–I Company

Unleashing Values

IREL (India) Limited, the erstwhile Indian Rare Earths Limited was incorporated on August 18,1950, with its first unit Rare Earths Division (RED), Aluva, in Kerala. It became a full-fledged Government of India Undertaking under the administrative control of Department of Atomic Energy (DAE) in year 1963 and took over companies engaged in mining and separation of Atomic Minerals in southern part of the country at Chavara, Kerala and the other at Manavalakurichi (MK), Tamilnadu. IREL commissioned its largest flagship Mining & Mineral separation unit Orissa Sands Complex (OSCOM) at Chatrapur, Odisha in 1986. Presently IREL has established plant capacity of about 6 lakhs tons per annum of minerals processing to produce processed minerals i.e. Ilmenite, Rutile, Zircon, Sillimanite and Garnet. IREL has also set up a Rare Earths Extraction Plant at Odisha to produce about 11,000 tonnes Rare Earth Concentrate in terms of RE Chloride and associated products. A RE refining plant at RED, Aluva is operational to produce High Pure Rare Earths Oxide/Carbonates. IREL is profit-making since 1997-98 with its sales turnover reaching a peak exceeding Rs.14625 million in 2021-22, with an export component of about Rs.7000 million. IREL is also in the process of facilitating setting up of industries in the value chain of minerals and rare earths, besides expanding its existing mineral producing capacities. IREL has in house R&D division at Kollam, Kerala to support mineral and chemical operation and Corporate Office at Mumbai, Maharashtra.

The main mission of IREL is:

- To maintain a global reputation and sustainably grow the core business of heavy minerals and rare earths by expanding our mining, mineral processing, and rare earth refining asset base domestically and globally.
- To adopt best-in-class sustainable and technologically advanced business processes and practices across the value chain.
- To foster long-term and credible relationships with our customers by pursuing a customer-first focus.
- To cultivate a conducive environment for continuous improvement, growth, and empowerment of current and prospective employees.
- To abide by and promote the highest standards of ethics, governance, and integrity in executing responsibilities and managing relationships.

INDIAN ASSOCIATION FOR RADIATION PROTECTION (IARP)

In 1968, a group of scientists at Bhabha Atomic Research Centre concerned with radiation safety initiated a proposal to setup a professional association to promote safety in the manifold uses of ionizing radiation in the country. The Indian Association for Radiation Protection (IARP) was registered under the Public Trust Act, 1950. The association has a large membership of specialists and users of natural and man-made radiation sources from different parts of the country. The association has been guided by eminent scientists in the field. Late Dr. A.R. Gopal Ayengar an internationally renowned radiation biologist was its first President. The Association was admitted in May 1970 as an Associate Society of the International Radiation Protection Association (IRPA). To strengthen the countrywide spread of knowledge in the field of radiation protection, Association has started many new chapters. The objectives of IARP are:

- To bring about proper awareness of the hazards from ionizing radiations amongst their users in particular and the public in general
- To encourage adoption of appropriate means for avoiding or reducing radiation exposure in the applications or ionizing radiations and nuclear technology in the country, such as power generation, industry, medicine, agriculture, scientific research etc., thereby maximizing the benefits which are derived out of these applications while minimizing the risks.
- To facilitate contacts and exchange of information amongst specialists in radiation protection and related disciplines in the country and with their counterparts in other countries.
- Take appropriate steps to carry out, support and encourage research and development as well as teaching in the various fields relevant to radiation protection.

To fulfil the above aims, the association conducts every year one annual conference. In addition to this it also holds topical meetings and workshops on subjects of current interest related to safety aspects in the applications of ionizing radiations and radioisotopes in various field. It also published the journal “Radiation Protection and environment” and conducts public awareness programmes.

SCHEDULE

23rd February 2023

INAUGURAL SESSION (9.30 AM -11.00 AM)	
Prayer	
Welcome	Dr. M Anilkumar, Convenor
Presidential Address	Dr. M.I Punnoose, Principal, Union Christian College, Aluva
Inaugural Address	Dr. K.N Madhusoodanan, Vice Chancellor, CUSAT
Keynote address	Shri. M.Venkatachalam, Distinguished Scientist & Executive Director, NPCIL
Felicitations	Rev. Thomas John, Manager, Union Christian College, Aluva
	Shri. G.D Mittal, Secretary, Indian Nuclear Society
	Shri. K.R Viswambaran, President, AERAK
	Dr.T.R Govindankutty, Joint Convenor
Vote of Thanks	Dr. Sareen Sarah John, Organising Secretary
TEA BREAK	
SESSION 1 (11.30 AM -01.00 PM) ***Advantages and Challenges of Nuclear Power Generation*** Session Chairman: Shri.Umed Yadav, Additional Chief Engineer, NPCIL Co Chairman : Shri. R.G Panicker, Rtd. Scientist	
Keynote address 1	**Dr. Arun Nayak,** Head, Nuclear Control & Planning Wing, DAE ***"Climate Change, Clean energy transition, role of nuclear power & fear of radiation"***
Keynote address 2	**Shri. Martin Mascarenhas,** Head, Laser & Plasma Technology Division, BARC ***"Development & Deployment of Indigenous Technologies for Industrial Applications in BARC"***
LUNCH BREAK	
SESSION 2 (2.00 PM -03.30 PM) ***Nuclear fission, fusion and hydrogen generation using nuclear power*** Session Chairman: Dr. Arun Nayak, Head, Nuclear Control & Planning Wing, DAE Co Chairman : Dr M.P Rajan, Retd Scientist, DAE	

Keynote address 3	**Shri.Umed Yadav,** Additional Chief Engineer, NPCIL ***"Understanding Fear of Unknown – A nuclear energy Perspective"***
Keynote address 4	**Dr. Rhine Kumar A.K,** Asst. Professor, Department of Physics,CUSAT, Kochi ***"Overview of Nuclear Fusion reaction and its importance in nuclear power generation"***
Keynote address 5	**Dr. Drisya K,** Asst. Professor, Department of Physics, University of Calicut, Kozhikode ***"Nucleosynthesis in low-massstars: Understanding the cosmic origin of heavy elements"***
TEA BREAK	
SESSION 3 (3.45 PM -04.45 PM) ***Radiological safetyAspects & Environmental Issues*** Session Chairman: Dr. Rhine Kumar A.K, Asst. Professor, Department of Physics, CUSAT, Kochi Co Chairman : Dr Krishna prasad, Retd. Scientist, BARC	
Keynote address 6	**Shri. S.Bansal,** AERB, Mumbai ***"Nuclear Safety"***
Keynote address 7	**Dr. M.R Iyer,** Head RSSD, IAEA (Retd) ***"Development of science in early 20th century in India"***
Keynote address 8	**Shri. G.D Mittal,** Secretary, Indian Nuclear Society ***"Use of Radiation in Medicine, Agriculture and Industry"***

24th February 2023

SESSION 4 (09.30 AM - 11.30 AM) ***Accelerator Technologies & Nuclear Medicine*** Session Chairman : Shri. S.Bansal, AERB, Vice President, INS Co Chairman : Dr. A. Venugopalan, Retd. Scientist, BARC	
Keynote address 9	**Dr. G.S Shagos,** Consultant – Nuclear Medicine, Aster Medicity,Kochi ***"Introduction to nuclear medicine imaging - What, how and when?"***
Keynote address 10	**Dr. Vijay Harish,** Senior Consultant –Nuclear Medicine, Rajagiri Hospital, Aluva ***"Therapeutic Nuclear Medicine:the use of radioisotopes for targeting diseases"***
Keynote address 11	**Dr G Sugilal,** Head, FRD, BARC ***"Spinoff Technologies of Indian Nuclear Power Programme"***
Keynote address 12	**Dr. C.V Midhun,** Department of Physics,University of Calicut ***"Low Energy Nuclear Physics –Highlights, Hope and Challenges"***

TEA BREAK	
SESSION 5 (11.45 AM - 1.00 PM) **Application of Nuclear Applications in Biology & Agriculture** Session Chairman: Sri. G.D Mittal, Secretary, INS Co Chairman : Dr. K. K Surendranathan, Retd Scientist, BARC	
Keynote address 13	**Dr. Susan Eapen,** Former Senior Scientist, BARC ***“Nuclear Technologies for feeding the world”***
Keynote address 14	**Dr. M. Anil Kumar,** Head, Dept of Botany &Academic Dean, Union Christian College, Aluva ***“Applications of Radiations in Biological Research”***
Keynote address 15	**Shri. Amritesh Srivastava,** DGM, NPCIL, Mumbai ***“Nuclear Power: An inevitable option for clean, green & safe generation of electricity”***
LUNCH BREAK	
SESSION 6 (2.00 PM - 04.00 PM) ***Students Session*** Session Chairman: Dr. Martin Mascarenhas, Head, L&PTD, BARC Co Chairman : Dr. Susan Eapen, Former Senior Scientist, BARC Dr. M.R Iyer, Head RSSD, IAEA (Retd) Dr. T.R Govindan Kutty, Former Scientist, BARC	
1	Dani Rose J. Marattukalam, A.K.Rhine Kumar ***“Nuclear structure studies withHFB theory”***
2	Vafiya Thaslim T.T , M.M Musthafa , Midhun C.V , S. Ghugre, R. Rout, Gokul Das. H , Swapna. B, Najmunnisa.T, F.S Shana, Rijin N.T, J Datta, S.Dasgupta ***“Estimation of total neutron production from alpha induced reaction on ^{nat}Zr”***
3	Gokul.A, Arya E. R, Anagha C.R, A.K. Rhine Kumar ***“Theoretical Approaches in Nuclear Clustering”***
4	K. Jyothish, V. Parvathi, A. K. Rhine Kumar ***“Fission Barrier Calculation of 230Th Nucleus using BARRIER Code”***
5	T. Najumunnisa, M.M. Musthafa, P.Mohammed Aslam, K.K. Rajesh, A.Shanbhag ***“Production of 135Xe through proton induced fission of U-238”***

6	Nabeel Salim, V. Parvathi, A.K.Rhine Kumar ***"Thermal behavior of pairing correlation in nuclei: a study of 162Dy"***
7	V. Parvathi, A.K. Rhine Kumar ***"Study of Collective Enhancement in Nuclear Level Density"***
8	Farhana Thesni M.P ***"Impact of Nuclear Reactions on Proton Therapy Dose distribution"***
9	Anjana A.V, Nicemon Thomas, Antony Joseph ***"Rhenium And Platinum Nuclei Using the HFB Theory"***
10	Nicemon Thomas, Antony Joseph ***"A Hartree-Fock-Bogoliubov approach to the ground state properties of the isotopes of Krypton"***
11	Ummukulsu. E, Antony Joseph ***"Chemical Potential of Thorium Isotopes Lying Between the Drip Lines"***
TEA BREAK	
VALEDICTORY CEREMONY & CONCLUDING SESSION (4.30 PM - 6.00 PM)	
Chief Guest	Dr. Sreejith C.M, Controller of Examinations, Mahatma Gandhi University, Kottayam

ABSTRACTS - TECHNICAL SESSION

Sl. No	Title & Author	Page No.
1	Climate change, clean energy transition, role of nuclear power & fear of radiation. ***Dr. Arun Nayak***	1
2	Development and Deployment of indigenous technology for industrial applications in BARC. ***Shri. Martin Mascarenhas***	2
3	Understanding Fear of Unknowns - A Nuclear Energy Perspective. ***Mr. Umed Yadav***	3
4	Overview of Nuclear Fusion Reactions and its importance in nuclear power generation. ***Dr. A. K Rhine Kumar***	4
5	Nucleosynthesis in low-mass stars: understanding the cosmic origin of heavy elements. ***Dr. K. Drisya***	4
6	Nuclear Safety. ***Mr. Satyawan Bansal***	5
7	Development of Science in early 20th Century in India. ***Dr. M.R Iyer***	6
8	Use of Radiation in Medicine, Agriculture and Industry. ***Mr. G.D Mittal***	7
9	Introduction to nuclear medicine imaging - What, how and when? ***Dr. G.S. Shagos***	8
10	Therapeutic Nuclear Medicine: the use of radioisotopes for targeting diseases. ***Dr. Vijay Harish Somasundaram***	9
11	Spinoff Technologies of India Nuclear Power Programme. ***Dr. G. Sugilal***	10
12	Low Energy Nuclear Physics – Highlights, Hope and Challenges. ***Dr. Midhun C.V***	11
13	Nuclear Technology for Feeding the world. ***Dr. Susan Eapen***	12
14	Applications of Radiations in Biological Research. ***Dr. M. Anilkumar***	13
15	Nuclear Power: An Inevitable Option for Clean, Green and Safe Generation of Electricity. ***Mr. Amritesh Srivastava***	14

ABSTRACTS - STUDENTS SESSION

Sl. No	Title & Author	Page No.
1	Nuclear structure studies with HFB theory. ***Dani Rose J Marattukalam, A. K. Rhine Kumar***	15
2	Estimation of total neutron production from alpha induced reaction on ^{nat}Zr. ***Vafiya Thaslim T.T, M.M Musthafa, Midhun C.V, S. Ghugre, R. Rout, Gokul Das. H, Swapna. B, Najmunnisa T, F. S Shana, Rijin N.T, J. Datta, S. Dasgupta***	16
3	Theoretical Approaches in Nuclear Clustering. ***Gokul A, Arya E. R, Anagha C. R, A.K. Rhine Kumar***	17
4	Fission Barrier Calculation of 230^{th} Nucleus using BARRIER Code. ***K. Jyothish, V. Parvathi, A.K. Rhine Kumar***	18
5	Production of 135Xe through proton induced fission of U-23. ***T. Najumunnisa T, M.M. Musthafa, P. Mohammed Aslam, K.K. Rajesh, A. Shanbhag***	19 - 20
6	Thermal behavior of pairing correlation in nuclei: a study of 162Dy. ***Nabeel Salim, V. Parvathi, A. K.Rhine Kumar***	21
7	Study of Collective Enhancement in Nuclear Level Density. ***V. Parvathi, A.K. Rhine Kumar***	22
8	Impact of Nuclear Reactions on Proton Therapy Dose distribution. ***Farhana Thesni M.P***	23
9	A Systematic Study of Pairing Correlations in Neutron-Rich Rhenium and Platinum Nuclei Using The HFB Theory. ***Anjana A.V, Nicemon Thomas, Antony Joseph***	24
10	A Hartree-Fock-Bogoliubov approach to the ground state properties of the isotopes of Krypton. ***Nicemon Thomas, Antony Joseph***	25
11	Chemical Potential of Thorium Isotopes Lying Between the Drip Lines. ***Ummukulsu. E, Antony Joseph***	26

Climate change, clean energy transition, role of nuclear power & fear of radiation

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Energy is one of the most critical requirements for the development of a nation. Of course, India, at present is one amongst the top producers and consumers of energy globally, however, our per capita energy consumption is still very low. We are a developing nation, with an ambitious GDP growth rate which would require significant demand in energy in domestic, transport, industries, infrastructure, etc for a growing population. Today, the country's energy supply is primarily driven by carbon based sources. The international pledge to reduce the global warming due to emission of carbon dioxide gases, would require replacement of carbon based energy sources with clean and green energy sources very soon.

This talk would focus on possible energy demand of India by 2050, contributions from renewable and requirements of nuclear power to meet the low carbon energy budget of India. Apart from large reactors, small modular reactors (SMRs) are being developed globally as new frontiers in nuclear reactor technology. For expansion of nuclear power, the public has a fear of radiation. This talk would provide a historic review on radiation, radiation caused effects due to atomic bomb explosions and nuclear reactor accidents, radiation effects on health of human beings, the biological changes due to radiation, radiation hormesis, ambiguous scientific explanation of linear no threshold theory, industrial conspiracy, fabrication of phobia against radiation, and some insights and thoughts for future.

Development and Deployment of indigenous technology for Industrial Applications in BARC

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The climate change crisis can be resolved by working on solutions involving strategies based on zero carbon emission in two-fold manner, viz. i) by adhering to suitable energy technologies and ii) by adopting suitable waste management technologies, that support zero or low CO_2 emission.

Nuclear technology for energy is a sustainable, climate friendly technology for generation of low carbon electricity. R & D in nuclear technology has not only resulted in clean energy but also has provided valuable contributions in other areas like radioisotopes, their applications in industry and nuclear medicine. This talk unfolds contributions of Beam Technology Development Group of BARC from R & D efforts to mature technology demonstration, in two important societal applications, namely, medical isotope separation for production of radioisotopes having important applications in radiopharmaceutical industry and environment friendly waste management solutions based on plasma gasification/incineration techniques and accelerator based technologies.

The widely used medical isotopes Lu-177 and Sm-153 can be produced in nuclear reactors by neutron activation of their precursors (Yb-176/Lu-176 and Sm-152 respectively). High specific activity production of the medical isotopes demands use of high isotopic purity of the precursor and necessitates its enrichment to high degree before neutron irradiation. We have realized requisite enrichment of Lu-176, Yb-176 and Sm-152 and the medical isotopes produced with our enriched isotopes have been successfully administered to patients leading to self-reliant solutions towards production of these isotopes. We also have a program on development of X-band Medical lianc for production of certain medical isotopes and development of linac based neutron source for n-radiography purpose.

Conventional solid waste treatment and management techniques are potential source of atmospheric pollution as they release harmful compounds like dioxin, furan, ash, NO_x and carbon monoxide into the environment. Air plasma gasifier/incinerator technology developed by BTDG employs both high temperature gasification and controlled burning of syn-gas for incineration to effectively reduce the release of pollutants.

Further, Accelerator technology has been successfully employed for efficient waste water treatment.

Understanding Fear of Unknowns - A Nuclear Energy Perspective

Mr. Umed Yadav
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Any new technology in the process of percolating down to the real end user, goes through a phase of uncertainty, questioning, fear, understanding and acceptability. Nuclear Power is no different. The potential of Nuclear Energy alias Atomic Energy was known to the common man through its destructive capabilities in the past. The devastation caused, guzzled in the minds through generations. The scenario persisted for so long on mainly two accounts – fear sells & consumed faster and lack of proper addressal by the authorities worldwide. In today's world when information is a key driver in deciding fate of the technologies/projects, it is imperative to ensure that a factual information be shared with all stakeholders in time. The apprehensions and fear need to be understood, attended and addressed appropriately using all means of communication in a credential manner. The main areas of concern of general public spans over Safety, Radiation and Livelihood attributes when it comes to Nuclear Energy. This presentation will help in understanding the basics of the technology, its safety aspects besides addressing the associated topics on fear of radiation and loss of livelihood.

Overview of Nuclear Fusion reaction and its importance in nuclear power generation

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The applications of nuclear science are spread over different fields such as energy generation, industrial applications, health care systems etc. I would like to concentrate on nuclear energy generation and its different methods. The nuclear fission and fusion processes are the main reactions which produce nuclear energy in large amounts. The physics of these nuclear processes and the recent developments in the field of nuclear energy generation will be discussed.

Nucleosynthesis in low-mass stars: understanding the cosmic origin of heavy elements

Dr. K. Drisya
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Nucleosynthesis of elements started soon after the Big Bang producing elements, mainly H, He, and traces of Li. The First Stars and the subsequent generations of stars are responsible for the elements beyond Li. Hence, they contribute significantly to the chemical enrichment of their host galaxies. A quantitative understanding of the production mechanisms of these elements and their distribution in space over time, the so-called galactic chemical evolution (GCE), is an important challenge of modern astronomy. One key aspect in understanding the GCE is to obtain accurate abundances of chemical elements in stars and compare them with yield predictions from nucleosynthesis models. In my talk I will briefly discuss our attempts to understand the GCE through the nucleosynthetic models in low-mass stars.

Nuclear Safety

Mr. Satyawan Bansal
AERB, Mumbai

Nuclear Safety intends to ensure the highest level of safety that can reasonably be achieved for the protection of workers, the public and the environment from harmful effects of ionizing radiation arising from nuclear facilities. Nuclear Safety as defined by the International Atomic Energy Agency (IAEA) is the achievement of proper operating conditions, prevention of accidents or mitigation of accident consequences, resulting in protection of workers, the public and the environment from undue radiation hazards. Nuclear power plants (NPP) are designed to prevent abnormal incidents from occurring. Even if abnormal incidents occur, nuclear plants are also designed to prevent the potential spreading of abnormal incidents and leakage of radioactive materials around plants, which may cause adverse impacts on the surrounding environment. In a way NPPs are among the safest and most secure facilities in the world. Notwithstanding the few major accidents that have occurred, nuclear power has a safety record that is good compared with those of the viable competing options for producing electricity. The technology of nuclear power is unfamiliar to most people and is more complex than that of other currently viable means of generating electricity. Involvement of the public is seen as a vital enhancement of the nuclear safety system; the obligation to explain in public how high standards of nuclear safety are being achieved. It has impact on the behaviour and decisions of the nuclear industry and regulator, and provides a vital feedback mechanism to arrive at a win-win situation for all.

Development of Science in early 20th Century in India

M R Iyer
Head RSSD, IAEA (Retd)

The presentation enumerates the progress of education and science in India during the last two centuries. It is pointed out that some of the basic discoveries in Physics originated in India in the earlier part of this century and even produced a couple of Nobel Laureates. Some of the earlier experimental work basic to nuclear energy is recalled, sprinkled with a few personal nostalgia of those periods. It is stressed that the strong foundation laid in Travancore State on education enabled Kerala to be the highest literary state in India today. The strong vernacular education base that was prevalent in the past was responsible for the high rate of literacy. The smooth transition to English medium in University level led to strong University education. The early institution of Universities in turn has led to some of the path breaking scientific investigations such as on equatorial magnetism subsequent to finding that the magnetic equator passes though the state. This offered a unique location in the world to carry out such investigations. Due to this, later in the post-independence period the Department of Space Research Centre of GOI was located in the State.

The thorium reserves in the West Coast of Kerala which provides an eminent positon for India to make use of it to harness nuclear power in a big way was first discovered in early as 1908 in Travancore. The State followed up with setting up monazite separation plants soon afterwards with international collaborations.

Following this discovery, work on environmental radioactivity was started in forties in the University College Trivandrum with homemade radiation detectors. This becomes the first of such studies in India. The strong footing on science and technology in the University education initiated those days is responsible for our having moderate industrial infra structure today.

Use of Radiation in Medicine, Agriculture and Industry

G D Mittal
Secretary, Indian Nuclear Society

Radioactive materials can be helpful to diagnose and treat illnesses or in medical research. The Nuclear Regulatory Board regulates these uses. These rules aim to ensure radioactive materials are used properly and in a way that protects patients, medical workers, the public and the environment. Radioactive materials are also used to inspect metal parts and the integrity of welds across a range of industries. Industrial gamma radiography exploits the ability of various types of radiation to penetrate materials to different extents. Gamma radiography works in much the same way as X-rays screen luggage at airports. About one-third of all patients admitted to hospitals are diagnosed or treated using radiation or radioactive materials. This branch of medicine is called nuclear medicine and radioactive materials used are called radiopharmaceuticals. Further, nuclear technology finds it's applications in agriculture. And Some of the most innovative ways of improving agricultural practices involve this technology. Using isotopes or radiation techniques in agriculture can control pests and diseases, increase crop production, protect land and water resources and ensure food safety.

Introduction to nuclear medicine imaging - What, how and when?

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Nuclear medicine is a specialized branch of modern medicine that uses radioactive tracers for diagnostic imaging in a wide variety of disease conditions and also radionuclide therapy of certain types of cancers. It is one of the most important peaceful use of radioactive substances for the general good of humankind.Nuclear medicine imaging is typically referred as functional imaging. The main difference that sets apart nuclear medicine scans from other diagnostic scans like CT , Ultrasound,MRI etc is the fact that if other scans mainly give us information related to the structural integrity or abnormalities of a particular organ in our body, nuclear medicine scans gives us details about the functional status of an organ .These scans can be done in any age group from new borns to old age as the very small quantity of radioactive tracers that are used in this does not cause any significant radiation hazard to the patient and is generally excreted through urine in a few hours .In the past decade this branch of medicine has progressed significantly and now a wide variety of radioactive tracers and newer imaging machines are available that helps us understand the functioning of organs better, diagnosing neurological conditions like Alzheimer's disease, Parkinsonism, non invasive imaging of blood flow to heart muscles etc apart from the extensive use of these scans in the management of cancer.

Therapeutic Nuclear Medicine: the use of radioisotopes for targeting diseases

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Nuclear Medicine is traditionally defined as a field of medicine, where clinically approved radionuclides / radioisotopes tagged with specific biological molecules are used, for the diagnosis and treatment of clinical conditions. The history of radionuclide in therapy can be tracer back to the early 1900s. Radioisotope emissions with high Linear Energy Transfer (LET) such as α- and β- particles are used for therapy. This is primarily to achieve maximum energy deposition within a small range of tissue; it ensures better treatment outcomes and also reduces the need for radiation protection to the personnel / public as the radiation will not penetrate out of the patient's body. Further, the radio-isotope selected should have a balanced biological versus physical half-life for efficient radiation delivery at the site of the disease. The most commonly used radionuclide today for therapy is iodine-131 as sodium iodide solution (^{131}I-NaI). Widely known as radioactive iodine (RAI) therapy, it is extensively used for the treatment of thyroid related disorders, both malignant and benign. The recent advent of lutetium-177 (^{177}Lu) labelled ligands for targeted treatment of metastatic cancer of prostate and neuroendocrine tumors, has re-established the role of nuclear medicine in precision oncology. Inspired by the success so far, newer radionuclide-labeled antibodies and small molecule compounds are being investigated to precisely target the molecular characteristics of tumors.

Spinoff Technologies of India Nuclear Power Programme

G. Sugilal
Head, FRD, BARC

Indian nuclear power program has led to the development of several spinoff technologies. The production of medical isotopes, used for the diagnosis and treatment of various diseases, has been a major spinoff of India's nuclear power program. Radiation technology has been used in a variety of industrial applications, including sterilization of medical equipment, food preservation, and the treatment of waste. India has developed nuclear desalination technology, which uses the waste heat generated by nuclear power plants to produce fresh water from seawater. The high temperatures and intense radiation environment of nuclear reactors has led to the development of new materials and advanced manufacturing processes, which have applications in various industries. Nuclear techniques, such as radiation-induced mutation, have been used to develop new crop varieties with improved yield, disease resistance, and other desirable traits. The management of nuclear waste has led to the development of new technologies for the safe and effective disposal of radioactive waste. These spinoff technologies demonstrate the versatility and potential of nuclear technology, and highlight the many ways in which it can be used for the benefit of society.

Low Energy Nuclear Physics – Highlights, Hope and Challenges

Dr. Midhun C.V
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Nuclear Physics is crossing a milestone of 125 years of its journey since the Gieger-Marsdon Experiment and Rutherfords' interpretation of the nucleus. Since now thousands of nuclei are which are stable and artificially synthesized are studied to explore the physics of nuclei. The knowledge of the nucleus and the technology developed for studying the nucleus is then utilized in interdisciplinary areas, for benefitting the public.

The low-energy nuclear reactions are the most highlighted academic subject in nuclear physics as they reveal the true nature of nuclear force. Further, these low-energy reactions are responsible for the synthesis of elements in the Big Bang and Stellar Nucleosynthesis. Since the low energy reactions are considered, there are several resonances, dips corresponding to the structure effect of the nuclei, and competition between Columb and nuclear potential are existing. However, the exploration of these is an existing challenge due to the low energy particles emitted and lower cross-section. This demands low energy high current particle accelerators and special detectors in this respect. For this, globally low-energy particle accelerators and dedicated instrumentation has been established.

In the Indian scenario, the FRENA accelerator setup has been established at SINP to measure nuclear astrophysics reactions. Further, we rely on indirect methods for the measurements. In this respect, a low-energy particle accelerator based on the Electron Cyclotron Resonance method has been developed at University of Calicut. A novel Hybrid LiF-Si Hybrid detectors were developed indigenously for the measurement of low-energy charged particles to address the requirement of nuclear astrophysics, by scintillator- silicon based readout system.

Nuclear Technology for Feeding the world

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The potential of nuclear energy concealed in the atoms has several applications in agriculture for improvement of food crops and increasing the shelf life of agricultural produce. In nature although spontaneous mutations are induced in plants, the frequency is very low for effective utilization. Mutation frequency can be enhanced using gamma rays, x-rays and electron beamand suitable plants with desirable characters selected, evaluated for several generations and finally released as varieties. Using radiations followed by selection and recombination breeding, BARC has released 55 varieties in oil seed crops (groundnut, mustard, linseed, soybean and sunflower), pulse crops (cowpea, mung bean, pigeon pea and urad bean), rice and jute which are grown throughout India.

Radiation can also be used to enhance shelf life in food produce (chicken, meat, fish), sprout inhibition (onion, potato, garlic and ginger), hygenization (spices) and for quarantine (mango for export). Wholesomeness studies – absence of radioactivity, microbiological safety, nutritional assessment, multigeneration feeding studies and volunteer studies have been extensively carried out. Different organizations like WHO, FAO etc. have approved irradiated food and is available in more than 70 countries. Nuclear technology can thus play a crucial role in feeding the world by releasing new climate resilient varieties and in preserving agricultural produce.

Applications of Radiations in Biological Research

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Radiation is used in medicine, academics and industry as well as for generating electricity. It has powerful applications in areas such as agriculture, archaeology (carbon dating), space exploration, geology (mining), and many others for the benefit of humanity. Among the different types of radiations, X-rays and gamma rays are the most preferred. Gamma irradiations have immense use in bioresearch and falls under four categories such as encapsulated chambers containing source material in solid materials, panoramic gamma irradiators, irradiation chambers in submerged pool of water and panoramic irradiators in submerged pool of water. Biological irradiators usually use Cesium -137 as the source of gamma radiations due to its 30 years of long half -life. In medical research apart from X - rays and gamma rays, densely ionizing particles such as neutrons, protons, mesons, alpha rays and heavy ions have been increasingly used in cancer treatment. The advent of new imaging techniques like Computerised Axial Tomography (CAT or CT) scanning, Positron Emission Tomography (PET), Nuclear Magnetic Resonance (NMR) imaging and use of various radionuclides made disease diagnosis and treatment faster. In agriculture gamma rays (Cobalt -60), X-rays and electron beams are routinely used. The major applications in agriculture includes 1. Improve food crops, preserve food, determine ground water resources and to study environmental pollution; 2. produce high yielding, high protein-containing varieties of food crops; 3. Produce disease- and weather-resisting varieties; 4. Locate and make efficient use of water resources; 5. Determine fertilizer uptake and the role of trace elements; 6. Control or eliminate pests; 7. Prevent losses of crops during storage; 8. Improve productivity and health in domestic animals. Mutation breeding is one of the most widely used and successful method of crop improvement. Many varieties of agriculturally important crops such as rice, wheat, barley, pears, peas, cotton, peppermint, sunflowers, peanuts, grapefruit, sesame, bananas, cassava and sorghum have been raised by mutation breeding. Improved White Ponni - a semi dwarf, early maturing and high yielding rice cultivar in South India, 'Sharbati Sonora'- a semi dwarf and lodging resistant wheat variety, 'Golden Promis' a gamma-ray induced semi-dwarf mutant of barley that revolutionized brewing industry in Europe etc are some of the promising contributions of mutation breeding.

Nuclear Power: An Inevitable Option for Clean, Green and Safe Generation of Electricity

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During the last couple of years, with systematic and multi-pronged approach, we have been working with full determination and endurance to strengthen our country for meeting the long-term energy demand through Nuclear Power. To achieve this, it's very much prudent to gain public confidence by educating and imparting factual knowhow about the various nuances of nuclear energy along with the splendid and impeccable performance of all the operating stations of NPCIL. The objective is to make people aware about the consistent, safe, reliable and immaculate operation of all the nuclear power stations for long periods, which has not only demonstrated the strong work culture but reflected the robustness in nuclear power technology also. Therefore, it's very important to communicate the society about our strong commitment for generating electricity with utmost safety and in an economically viable and sustainable way.

The objective of this presentation is to make general people aware that being a clean, green and safe source, nuclear power can play significant role to achieve carbon neutrality / net zero in a time to come, our efforts should be to establish it as one of the most reliable and clean sources of electricity generation.

Apart from, the presentation would also like to emphasis about various ongoing and proposed innovative public awareness campaigns and media facilitation activities, through which we can build positive and constructive opinion about nuclear power. With a methodical and rational approach, it will definitely pave the way for winning public trust and confidence in support of nuclear power as well as will help also to dispel lots of apprehensions related to it.

Nuclear structure studies with HFB theory

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The Self-Consistent Mean Field (SCMF) models [1] and Energy Density Functionals (EDF) have been effective in reproducing the characteristics of nuclei, such as binding energies, radii, and deformations. These techniques are also used to investigate exotic nuclei and the structure of neutron stars. The Hartree-Fock-Bogoliubov (HFB) method is particularly well suited for these calculations because it considers both the mean field and the pairing correlations, which play an essential role in determining the properties of nuclei in the neutron-rich regions.

We examine the ground-state properties of the nuclei, such as the binding energy per nucleon, two-neutron separation energy, quadrupole deformation, proton, neutron, and charge radii, as well as the neutron skin thickness. Shape co-existence refers to the presence of multiple stable shapes for a single nucleus [2, 3]. This can be visualized by plotting potential energy curves, which show the energy variation with quadrupole deformation ($\beta 2$). The nucleus naturally settles into the configuration with the lowest potential energy curve energy. The goal of our studies is to provide a comprehensive analysis of the structural properties of isotopes with shape co-existence, including quadrupole deformation.

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Estimation of total neutron production from alpha induced reactionon ^{nat}Zr

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The studies on total neutron production cross-section in the reactor environment have an essential role since the presence of excess neutrons affects the reactor's criticality. The spontaneous decay and the ternary fission of the elements such as U, Th and Pu nuclei lead tothe production of alpha particles. The energy distributions of alpha particles, that are emitted in the process of neutron induced ternary fission of ^{235}U, were found to be in the energy up to35 MeV. These alpha particles have a greater possibility to interact with the structural materials used within the reactor and thereby production of various residual nuclei through the emissionof neutrons and different charged particles.

In the present work, the production cross sections of the alpha induced reaction on natural zirconium are studied by the stacked foil activation technique. Natural zirconium targethas been selected for the study, since it is used as the reactor structural materials. The alpha beam with energy of 30 MeV and 40 MeV is chosen for the measurements since ternary fissionand spontaneous fission results in these energies. The experiment has been carried out at VECC Kolkata, India, using the Cyclotron facility. The theoretical calculations have been carried outusing TALYS 1.96 code. The total neutron production cross section are estimated in such a way that the theoretical calculation gives best fit with measured excitation functions.

Theoretical Approaches in Nuclear Clustering

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Nuclear clustering is an exciting phenomenon that helps us better understand the nuclear structure. The tendency to form clusters is observed throughout the nucleus, from quarks to galaxies. Nuclear clustering was predicted theoretically in the 1960s when Kiomi Ikeda discussed the possibility of molecular-like states in atomic nuclei near a specific threshold limit. In heavier nuclei, cluster states are less likely to occur.

Many-body issues in nuclei have been studied to learn about clustering effects using Hartree- Bogoliubov methods [1, 2] and relativistic mean field theory [3, 4] and Density calculation and Nucleon localization functions are used as a parameter to learn the localization of nucleons in the nucleus and can be used to identify the clustering in the nucleus. The changes in the extent of localization with the change in parameters like quadrupole deformation are studied, and the resulting values are compared with other experimental and theoretical models.

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Fission Barrier Calculation of ^{230}Th Nucleus using BARRIER Code

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Fission is a peculiar nuclear phenomenon of disintegrating an unstable heavy nucleus into two or more fragments and a few neutrons with huge energy release. The fission barrier is among the most reliable and efficient quantities used to obtain fission rates in nuclei [1]. In this work, he fission barrier of Th has been calculated using the BARRIER code developed by Garcia [2]. It includes the Potential Energy Surface (PES) calculation using Strutinsky's [3] semi-microscopical approach and Cassini ovaloid shape parameterization. Cassini ovals are the family of quadratic curves, which can be defined as the product of the distances to two fixed points being constant. V. Pashkevich [4] considered the shape of the nucleus at the fission limit in the zeroth-order approximation as Cassini ovals. Myers and Swiatecki [5] modified the Liquid Drop Model(LDM) concept to explain the essential properties of fission reactions by incorporating shell corrections. The potential energy described in terms of a liquid-drop model is the sum of shape- dependent surface and Coulomb energy terms. The Woods-Saxon potential has been used for the calculation of shell correction. Elongation (quadrupole deformation) and asymmetry (hexadecapolar coordinate) are the parameters used for PES calculation since they highly influence the shape and deformation of the nucleus. The results of our calculations will be presented in the seminar.

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Production of ^{135}Xe through proton induced fission of U-238

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The requirement of nuclear data have significant importance in design, operation, safety performance predictions of nuclear reactors and transmutation of nuclear waste. The development of Accelerator Driven Sub-critical Systems (ADS) require significant amount of new nuclear data in extended energy regions [1].In ADS using light water as moderator, the high energy spallation neutrons will scatter the hydrogen in water elastically [2]. These secondary protons will interact with the moderator, fuel, fission fragments and structural materials inducing radioactivity. Hence it is important to estimate the activity induced by proton quantitatively. These secondary protons can induce fission on ^{238}U inside the reactor. The newly formed fission fragments may interact with the neutron flux in the reactor core and it will affect the reactor criticality [3]. The fission product ^{135}Xe is such a candidate which act as a reactor poison due to its large neutron capture cross-section. Neutron absorption of ^{135}Xe causes the formation of a stable isotope, ^{136}Xe and decreases the neutron population and the chain reaction stops. The reactor gets slow down due to the xenon accumulation. In nuclear reactor, along with neutron induced fission, proton induced fission also populate ^{135}Xe especially in the case of high flux reactors. Hence, the quantitative measurement of the yield of ^{135}Xe has significant importance in the operation of reactor. In this perspective, the yield of ^{135}Xe produced during the proton induced fission of ^{238}U has been measured and analyzed with theoretical model. The experiment has been carried out at TIFR, Mumbai, India using BARC – TIFR pelletron linac facility. Stacked foil activation technique has been employed for the experiment. Natural uranium samples of thickness 8.6 mg/cm^2 were prepared by rolling. A stack of four uranium foils with appropriate energy degraders were exposed to the proton beam of 22 MeV energy. After irradiation, the γ spectroscopy was performed with low background counting facility based on 100 cc HPGe detector. The yield of the fission fragment ^{135}Xe is calculated from the counts of the characteristic gamma rays of ^{135}Xe. The results are compared with theoretical model calculation using TALYS 1.95.

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Thermal behavior of pairing correlation in nuclei: a study of ^{162}Dy

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Pairing correlation is a central aspect in studying superconducting properties in many-body systems. In atomic nuclei, it plays a crucial role in shaping various nuclear structure properties, such as the binding energy, excitation spectra, and thermal properties. In this study, we focus on understanding the thermal effect of pairing gaps in the nucleus ^{162}Dy. To do this, we numerically solved the non- linear Finite Temperature Bardeen-Cooper-Schrieffer (FTBCS) equations. The single particle energies and spin states of the nucleus were computed using the WSBETA code [1]. The deformation parameters are taken from FRDM 2012 [2]. The study was further expanded to examine the impact of angular momentum on the pairing field, which enabled the examination of hot and rotating nuclei. Additionally, we calculated various statistical properties such as entropy, heat capacity, and level density, which provide important insights into the thermal properties of the system. The calculated level density was compared to experimental values obtained from the Oslo data [3]. This study provides a comprehensive understanding of the thermal effect of pairing in nuclei and its impact on various properties of the system.

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Study of Collective Enhancement in Nuclear Level Density

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In nuclear structure studies, Nuclear Level Density (NLD) has been an exciting topic for researchers due to its importance in many aspects of nuclear physics, such as energy distribution of excited nuclei, entropy, reaction cross-sections, specific heat etc. NLD, defined as the number of energy levels per unit of excitation energy [1], is a function of excitation energy, particle number, angular momentum and parity. Several phenomenological models, such as Fermi Gas Model, the Constant Temperature model and several microscopical models have been used to explain NLD. Level Density shows a rapid increase with increasing excitation energy which could be attributed to the increase in the number of degrees of freedom.

The inter-relationship between the collective excitations of nuclei and NLD was inevitable in these studies. Several experimental studies reported evidence of Collective Enhancement of Level Density (CELD) [2]. Apart from single particle excitations, nuclei display collective rotational and vibrational motion, introducing new energy levels to the bin. This results in the enhancement of NLD represented by a collective enhancement factor, K_{coll}. This enhancement was observed to fade out at higher excitations [3,4]. The magnitude and exact form of this K_{coll} remains unresolved. So far, not many theoretical studies have been carried out to understand the collective enhancement, which is fading out at more considerable excitation energies. In this work, we study the reasons for CELD and try to correlate it to nuclear shape transitions.

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Impact of Nuclear Reactions on Proton Therapy Dose distribution

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Proton therapy for cancer treatment gained significant attention due to its high conformity, by the benefit of Bragg peak in dose deposition. This utilizes a high energy protonbeam around 250 MeV for the treatment purpose. The dosimetry of the proton beam is performed based on the Bethe-Bloch formlism, limited to the atomic level. However in the pratical scenrio, along with atomic, several nuclear reations also initiated, but not well accounted as per the current dosimetry. The major limitation for the unaccountability is due to the nonavailability of nuclear data such as reaction cross sections, angular and energy distributions of the ejectile particles. This problem has been attempted in the present study by utilizing the optical models followed by statistical calculations for estimating the cross sections. Also direct and pre equilibrium components are accounted along with compound nuclear reactions.

A new set ov evaluated nulear data has been generated for the energy range upto 250 MeV, by optimizing the statistical nuclear reaction model code to the existingresidual cross sections innitiated by proton on the tissue (ICRU-A150), based on level density models, optical potentials, preequilibrium and direct reaction models. The enegy spectrum of ejectiles has been calculated using optimized parameters. This ejetile spectum and angular distribution has been loaded to Geant4 for calculation of dose produced by the nuclear reaction components.

This shows the dose deposition is at the off beam direction which having a Gaussian type of dose profile. The estimated dose is about 50% of total dose ie., sum of dose due to nuclear reaction and electronic losses. Further, it is observed that pre equilibrium and direct components of nuclear reaction enhances the secondary particle cross sections. It is alsoshown that default parametrization of simulations are not accurate to reproduce spectrum or ejectiles.

A systematic study of pairing correlations in neutron-rich Rhenium and Platinum Nuclei using the HFB theory

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Due to the availability of radioactive ion beam facilities, the nuclear structure studies has received considerable progress in recent years. Pairing correlations play an important role in the understanding of many nuclear properties. In this work, we have made an attempt to investigate the pairing correlations in Rhenium (Re) and Platinum (Pt) nuclei. The quantum mechanics of the pairing effect is provided by Hartree-Fock-Bogoliubov (HFB) approximation. The influence of pairing correlations are investigated using the self-consistent Skyrme-HFB calculations, with the density-dependent pairing interaction. In the mean field part, the zero range UNEDF0 Skyrme interaction is used. Here we have seen that, neutron pairing gap (Δ_n) of Re and Pt isotopes are greater than the proton pairing gap (Δ_p). The odd-even staggering in these isotopes can be easily identified. We have also observed that the values of Δ_n these isotopes first increases, reaches a maximum and then decreases with neutron number N. It is noticed that the values of Δ_p first decreases with increase in N, reaches a minimum value and then it start increasing. The decrease of the neutron pairing around magic numbers N=82 and N=126 may be due to a larger shell gap at these magic numbers.

Keywords: HFB theory, Skyrme functional, Pairing correlations, Magic numbers, Odd-Even Staggering.

A Hartree-Fock-Bogoliubov approach to the ground state properties of theisotopes of Krypton

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The concept of nuclear pairing correlation roots back to the well-known Bethe-Weizäcker formula for binding energy. Pairing correlations play a vital role in determining various properties of atomic nucleiand has been proved that it contributes additional binding and thereby increased stability and also influence the odd-even staggering, incompressibility, symmetry energy, moments of inertia, alignments, deformation etc. For nuclei with $N > Z$, neutron (nn) and proton (pp) pairs are known toexist with zero angular momentum $J = 0$ and isospin $T = 1$. For those nuclei with $N \approx Z$, nucleons nearthe Fermi surface tend to occupy identical orbitals, leading to neutron-proton (np) coupling, with either $J = 0$ and $T = 1$ (isovector) or $J = 1$ and $T = 0$ (isoscalar) pairs.

In the present study we have analysed the ground state properties of odd and even Krypton isotopes inthe light of Hartree-Fock-Bogoliubov (HFB) approach. For this, we performed the Skyrme Hartree- Fock-Bogoliubov calculations with transformed harmonic oscillator as the basis function, imposing noreflection symmetries for the purpose. In order to correct for the particle number non conservation inherent to the HFB approach, the Lipkin-Nogami prescription for an approximate particle number projection, followed by an exact particle number projection after the variation has been implemented. The pairing channel was parameterized by a density-dependent delta-pairing force with mixed featuresof volume and surface pairing (mixed pairing). The ground state properties such as binding energy per nucleon (BE/A), one- and two-neutron separation energies and pairing gaps using SLY4 functional areplotted and are compared with the available experimental results.

Chemical potential of Thorium isotopes lying between the drip lines

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The chemical potential has an important role for predicting the nuclear stability. It is the change in energy when a nucleon is added to the system. It is one of the important quantity for determining the nuclear structure properties related to shell closure. Different theoretical approaches are available for the study of nuclear structure, such as Hartree-Fock (HF), Hartree-Fock Bogoliubov, relativistic mean-field, shellmodel, shell correction approach etc. Nuclear structure property carried outhere is based on the self-consistent mean-field theory. The mean-field theory gives reliable results for nuclei distributed far from the line of β- stability. The self-consistent mean-field theory is also based on the energy density functional, which gives the information about the nuclear structure.Energy density functional is a functional of nucleon density matrices corresponding to the single particle states. The Meson Exchange (ME) andthe Point Coupling (PC) density functional are used for the calculations. Both models are based on interaction range: DD-ME has a finite interaction range, while DD-PC uses a zero-range interaction. Thorium nuclei are of special interest because of their various practical applications.They appear in thorium fueled nuclear reactors and at various stages in nucleosynthesis. In the present study, the neutron and proton chemical potential of thorium nuclei lying between the drip lines are estimated by using the relativistic mean-field theory. The neutron chemical potential increases on adding neutrons while the proton chemical potentialdecreases. Kinks are observed in the variation of neutron chemical potential at neutron number N=126, 138 and 184. The kink is due to the extra stability of nuclei and possible shell closure. Large kinks are observed around N=126 and 184 and hence these are neutron magic numbers. The small kink around N=138 may be due to its semi-magic nature.