Inter-University Accelerator Centre
New Delhi – 110067

Advertisement No: - 05/2022

Ph. D Admission 2022

IUAC Offers Ph. D. programme in ion-beam/accelerator based **experimental research** in following areas: -

Nuclear Physics
Materials Science
Accelerator Physics
Radiation Biology

Total Junior Research Fellow (JRF) seats for 2022-23 are eight [UR- 04 OBC - 02, EWS-01, SC-01]

Applicants must satisfy the following eligibility criteria:

- **(a)** The candidate must have Master's Degree (Five years degree after + 2 level) in Physics / Applied Physics / Biological Sciences.
- **(b)** The applicants must have scored a minimum of 55% aggregate marks (or equivalent grade) in Master's Degree.
- **(c)** Master's degree should be on or after 2020. Those students awaiting results of Master's degree are also eligible to apply. However, their results should be available at the time of interview.
- **(d)** The applicants must have studied physics and mathematics in their Bachelor's degree (applicable for candidates applying for areas other than Radiation Biology).
- **(e)** **The applicants must have qualified CSIR-UGC/NET-JRF [December 2020 onwards] in Physical Sciences/Biological Sciences.**

Selection Procedure

Shortlisted candidates will be called for interview. Date and time will be communicated to the shortlisted candidates.

Important points

1. Normal relaxation to the eligibility criteria will be applicable as per UGC guidelines.
2. The Selected students will be required to join the Ph.D. programme within one week of announcement of result. They will be registered for Ph.D. with Jawaharlal Nehru University (JNU), New Delhi.
3. All students will be required to undergo the course work for two semesters upon joining as per UGC regulation.
4. The selected students will be provided with hostel accommodation.
5. The number of positions may increase or decrease. The decision of the Centre shall be final in this regard.

How to Apply

Candidates fulfilling the eligibility criteria may fill the online application available at https://*www.iuac.res.in*/*vacancies*

Merely fulfilling the minimum eligibility criteria does not entitle a candidate to be called for the interview.

IUAC will not be responsible for any consequences arising due to furnishing incorrect/incomplete details or delay in submission, beyond 20th August, 2022, 23:59 hrs.

"The Centre strives to have a workforce which reflects gender balance and women candidates are encouraged to apply."

For details of the available research projects given below.

Inter-University Accelerator Centre

Aruna Asaf Ali Marg

New Delhi 110067

Research topics offered by IUAC for admission of JRFs

(Session starting in August 2022)

A. Nuclear Physics (2 JRFs)

1. Supervisor: Dr. R. P. Singh Co-supervisor: Dr. S. Nath

Exploring higher modes of excitations in nuclei

Nuclei with nucleon numbers 8, 20, 28, 50, 82 and 126, the so-called magic numbers, are found to have spherical shape at low excitation energies. However, there are many nuclei with nucleon numbers that lie between the magic numbers. These nuclei deviate from the spherical shape and are deformed. The change of shape in nuclei signals quantum phase transition. This transition can come about due to changes in isospin (proportional to difference in number of neutrons and protons), spin (angular momentum) and/or due to change in excitation energy. When such a transition happens the underlying configurations of nucleons change in a big way. These changes have strong bearing on the various properties of the nucleus. Nuclei of the shape of a rugby ball or a disc are quite common. However, in special cases quantum correlations between nucleons are predicted to favour other exotic shapes, such as pears, tetrahedral (pyramid-like) or like a banana. Intensive research activities are focused internationally to identify and study nuclei and their properties with such exotic shapes.

The thesis research would involve study of nuclei predicted to be pear-shaped or octupole-deformed as a function of spin. Pear-shaped nuclei are expected to be favoured due to strong correlation between nucleons in states for which the difference in orbital angular momentum and total spin quantum number is 3. This happens in special cases when such states come close in energy. The research work would involve use of Clover Ge detectors in Indian National Gamma array (INGA), mass spectrometers (HIRA / HYRA) and other ancillary devices along with particle accelerators to produce and study such nuclei using techniques of high-resolution gamma-ray spectroscopy.

2. Supervisor: Dr. S. Nath

Study of multi-nucleon transfer reactions

Our knowledge about atomic nuclei dates back to 1896 when Becquerel discovered natural radioactivity. Since then, a total of 3326 nuclides have been discovered until the end of 2021. According to the latest estimate, based on nuclear density functional theory, about 7000 nuclides are bound with respect to neutron or proton emission. Out of about 3700 unexplored nuclides, experts believe that about 1200 could be synthesized in laboratories in the coming decades. In this context, renewed interest in multi-nucleon transfer reactions has been observed in recent years. Several nuclei in the “north-east” corner of the nuclear landscape, in the vicinity of N = 126 shell closure, are predicted to be synthesized in multi-nucleon transfer reactions. No other reaction channel, known till date, can lead us to these nuclei, knowledge of which is crucial for understanding production of heavy elements in stellar nucleosynthesis via r-process.

Historically, transfer reactions have been instrumental in the study of nuclear structure. Spins and parities of nuclear states could be obtained from the angular distribution of single-particle transfer reactions. The strong specificity of one-nucleon transfer reactions had been used extensively to validate nuclear shell-model by identifying the single particle states in many nuclei. Furthermore, two-nucleon transfer had been used as a direct probe to study pairing-correlations among two nucleons which led to configuration mixing and superfluidity. It is now possible to decipher, within the framework of coupled-channels theories, whether nucleons are transferred sequentially, in pair(s) or as a cluster. However, there are several open questions about the probable role of multi-nucleon transfer channels in influencing fusion between two heavy nuclei in the vicinity of the Coulomb barrier.

The proposed thesis work would focus on the understanding of heavy ion-induced nuclear reaction dynamics, in general, and investigation of some of the open problems in transfer reactions, in particular. A few large-acceptance magnetic spectrometers have been built in Europe in the last two decades with the specific goal to study multi-nucleon transfer reactions. The Inter-University Accelerator Centre (IUAC) has two state-of-the-art recoil separators for investigation of heavy ion reaction dynamics. Our research group, at IUAC, has recently devised a methodology to measure transfer cross sections using a conventional recoil separator. In this method, forward-moving target-like ions are identified in the focal plane of the recoil separator and cross sections are extracted from measured yields. The proposed work will necessitate numerical simulation, fabrication of gas detector(s), carrying out accelerator-based nuclear experiment(s) and theoretical calculations.

B. Materials Science (4 JRFs)

1. Supervisor: Dr. D. Kabiraj   Co-supervisor: Dr. Fouran Singh

Controlled modification in wide bandgap (WBG) and ultra-wide bandgap (UWBG) semiconducting materials under energetic ion interaction

Compared to the development of traditional semiconductors such as Si and the III–Vs, wide bandgap (WBG), especially ultra-wide bandgap (UWBG) materials are relatively immature and still attract research interest. UWBG (e.g., Ga_2O_3) semiconductors, with energy bandgaps (>4 eV), much wider than the conventional WBG of GaN (3.4 eV) and SiC (3.2 eV), represent an emerging new area of research covering a wide spectrum from materials, physics, devices, and applications. This new class of semiconductors has promising applications for future generations of RF and high-power electronics, as well as deep-UV optoelectronics, quantum electronics, and harsh-environment applications. The response of oxide and nitride WBG and UWBG semiconducting materials to energetic ions will be studied in this work. The research outcome will be useful to predict the useable life of the devices used in harsh radiation environments. And to understand the damage recovery mechanism after ion implantation which is an important step in device fabrication. Energetic ion irradiation will be used to engineer electrical, optical, and structural properties by controlled defect formation. By judiciously selecting ion beam parameters simple defects to extended defects will be introduced in the materials. Which will be further used to study thermal and ion beam-assisted defect recovery. The electrical properties will be studied by electrical transport studies like temperature-dependent resistivity and Hall effect measurement. Thermally stimulated current spectroscopy (TSC) and Hall-TSCS will be developed to study electrically active defects in high resistive samples. Temperature-dependent photoluminescence spectroscopy will be used to investigate modification in the optical properties. The structural modifications will be studied by techniques like Rutherford Back Scattering in channel condition (c-RBS), X-ray diffraction (XRD), Raman spectroscopy, and transmission electron microscopy (TEM).

2. Supervisor: Dr. Fouran Singh

Bi-based nanomaterials / nanocomposites and their modifications by ion irradiation for advanced applications

This study will be focused on Bi-based nanomaterials and nanocomposites in view of their salient properties such as large surface area, high stability, and capability to tune the shape and size for the potential applications in optical, chemical, electronic, and engineering fields. These materials also exhibit near-infrared absorbance, excellent light-to-heat conversion efficiency, and a long circulation half-life. The properties of these materials will be further modified by ion irradiations. Detailed spectroscopic and transport studies will be carried for in-depth understanding of fundamental interactions along with possible applications.

3. Supervisor: Dr. Fouran Singh

Transport and spectroscopy studies of nanohybrids

This study will be focused on the nanohybrid materials and detailed transport and spectroscopy studies will be carried out. The hybrid films will be grown on the modified silicon surfaces and the properties will be tuned further by ion irradiation. The applications such as diodes will be demonstrated with very superior parameters and their functionality / stability will be studied as function of ion irradiation parameters. The involved ion and nanohybrid interactions will be understood in-depth to further enhance the functionality of such materials.

4. Supervisor: Dr. Saif Ahmad Khan

Studies of energetic ion induced near-interface atomic transport

The energetic ions while passing through a material can cause atomic displacements. The atomic transport near the interfaces can induce phenomena such as mixing, sputtering, manipulation of size and shape of nanostructures. These phenomena have been of interest both from the fundamental and application point of view. They have been found to depend on materials properties as well as on the dimensions of the structures. Atomistic simulations provide an opportunity to reveal the finer details of these phenomena. In this research work, atomistic simulations will be utilized to investigate the energetic ion induced near-interface atomic transport to understand some of these phenomena. Also, these studies will be complimented by experimental investigations whenever required.

C. Accelerator Physics (2 JRFs)

1. Supervisor: Dr. Pravin Kumar Co-supervisor: Dr. G. O. Rodrigues

Understanding the behaviour of two-component Electron Cyclotron Resonance (ECR) plasma in correlation with high intensity of highly charged ions

The capability of producing multiply charged positive ions via electron-impact ionization without using any cathodes/filaments made the Electron Cyclotron Resonance Ion Sources (ECRIS) very popular among Accelerator Physicists. The ion intensities in ECRIS are mainly governed by the ion-confinement, using sophisticated magnetic fields. In a typical ion source with operating frequncies up to 18 GHz, multipole permanent magnets are used for the radial confinement, whereas, the axial confinement is achieved either by using permanent magnets or the electromagnets. The fourth-generation high frequency ECRIS utilizes superconducting magnetic coils for the radial and axial confinement. The resonant electrons, which have a gyration frequency equal to the frequency of the input electromagnetic wave, gain enough kinetic energy to ionize the gaseous atoms / molecules step-by-step and yield the intense plasma.

In an ECR plasma mixed with a gas of lower atomic mass (mixing gas), the intensities of highly charged ions of the beam are significantly improved. Further, the plasma produced with isotopic mixtures shows an anomalous effect i.e., the intensity ratio of heavier to lighter isotope varies exponentially with the charge state. With the experiments performed so far, we have limited understanding of these physical process and their subsequent effects. Furthermore, the experimental results performed with several plasmas are not consistent i.e., these vary from case to case. Therefore, we would like to explore the possibility of finding the exact mechanism leading to such behaviour of a “two-component” ECR plasma and also establish a generalized model for the same. For this purpose, two existing, operating ECR ion sources (10 GHz all-permanent-magnet, Nanogan ECR ion source and 18 GHz High Temperature Superconducting ECR ion source, PKDELIS) at IUAC will be utilized. Various plasmas at several operational conditions will be developed and the intensities of ions will be recorded after analyzing them in mass and energy.

Development of subsystems of RF photocathode based Free Electron Laser facility of IUAC

An accelerator-based project to produce intense short THz pulses based on the principle of Free Electron Laser (FEL) is currently being commissioned at IUAC. The electron beam has

2. Supervisor: Dr. C. P. Safvan Co-supervisor: Dr. Subhendu Ghosh

been already produced and accelerated. It is expected that the first signature of THz radiation will be demonstrated shortly. The different sub-systems of FEL where the JRF can contribute are given below:

- Radiation simulation Calculation: An in-house code developed to calculate the frequency and power of the electromagnetic radiation (Synchrotron radiation) emitted from the electrons when injected in to the compact Undulator needs to be extended further and it is to be matched with the experimental observation when the facility will be fully operational.
- Electron gun: The electron beam produced from the RF photocathode-based electron gun has reached up to the undulator. Various beam diagnostic and beam measuring devices are being installed and operated. Design, development, installation and operation of the various other beam line components will be going on in future.
- Photocathode system: An advanced deposition system to deposit semiconductor thin film is being commissioned in the beam line of FEL. The advanced photocathode materials like CsKSb, GaAs, etc. will

be deposited by using this deposition system and will be subsequently used in the electron gun to produce electron beam.

- Fibre Laser system: An advanced fibre laser system with peak power of a few μJ and pulse width ~ 250 fs with the provision to split a single laser pulse into many micro-pulses (maximum 16) will be commissioned shortly.
- Transportation, Detection and measurement of THz and setting up the experimental facilities with THz: After producing the THz radiation inside the undulator, it is to be transported, detected and to be measured for its frequency / power before delivering it to the experimental stations.

D. Radiation Biology (1 JRF)

1. Supervisor: Dr. Saif Ahmad Khan Co-supervisor: Dr. Damodar Gupta (INMAS, New Delhi)

Study of the effects of ionizing radiation on living cells

High energy of Ionizing radiation is able to affect the atoms in living cells and release electrons from atoms and molecules. It can generate ions or break chemical bonds. Ionizing radiation can directly affect DNA structure by inducing DNA breaks (complex clutter DNA damage in case of high LET radiation), or indirectly by generation of reactive oxygen species (ROS). ROS can also oxidize critical biomolecules including, proteins and lipid. This can disrupt physiological processes including gene expression and protein modification. Therefore, potential identified area to contribute in field of radiation biology is need of hour globally. This will be helpful in understanding radiation effects on living beings along with improvement of health and wellbeing.

- Development of various tools and technologies to assess absorbed radiation dose at cellular and subcellular level
- Assessment of radiation effects in different scenarios (oxygen tension, altitude changes, microgravity)
- Modification of biological effects of radiation in both pre and post radiation exposure scenarios using pharmacological approaches.
- Assessment of different type of cell deaths (apoptosis, necrosis, necroptosis, ferroptosis, autophagy, entosis etc) using genomic, proteomic approaches, other cell biology and imaging approaches.