Precise measurements on very heavy nuclei separated by HYRA using an Ion trap and the facilitation of low energy nuclear astrophysics experiments

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Inter-University Accelerator Centre (IUAC), at present, provides energetic ions accelerated by 15UD 16 MV Pelletron accelerator and boosted by superconducting linear accelerator (SC-LINAC). A High Current Injector (HCI) is being commissioned to increase the beam intensity by nearly two orders of magnitude and will inject beams directly into SC-LINAC. The nuclear physics experimental facilities Heavy Ion reaction Analyzer (HIRA) and HYbrid Recoil mass Analyzer (HYRA) spectrometer/separator, Indian National Gamma Array (INGA) and National Array of Neutron detectors (NAND) cater to nuclear structure and reaction dynamics around the Coulomb barrier. Excellent background suppression (~ 10^{12}) of gas-filled mode of HYRA in selecting fusion evaporation residues (ERs) in the direction of primary beam opens up immense possibilities. HYRA-TIFR 4π spin spectrometer has been providing angular momentum distributions of selected ERs which, in addition to ER cross sections, help in understanding fusion-fission dynamics better. Coupling of HYRA and INGA is on the anvil which will open up the study of high spin spectroscopy of heavy unstable nuclei produced sparsely in fusion reactions and surviving fission. An array of gamma detectors is planned at the focal plane to search for microsecond isomers in heavy nuclei, buoyed by the initial success in finding a new isomeric state in ^{195}Bi in the very first attempt using HYRA. HYRA operated in vacuum mode, can produce secondary light radioactive ion beams from direct reactions using inverse kinematics. While all these studies are possible by pooling existing equipments or with nominal additional investment, a new field of research can be opened up in the country by coupling HYRA to an ion trap.

The heavy ERs, of energies 0.05 to 0.25 MeV/u (depending on the projectile-target system chosen), separated by the first dipole magnet (MD1) of HYRA operated in gas-filled mode can be extracted through the straight-through port of the second dipole magnet (MD2). The ERs can then be decelerated in a gas cell provided with focusing field to enhance the extraction. As the primary beam from SC-LINAC will already be pulsed and time-focused, the ERs will need modest effort to bunch again before injecting them into an ion trap. The choice of the ion trap (usually a two-stage Penning Ion Trap) and the associated add-ons can be tailor-made to carry out accurate mass measurements, laser spectroscopy and decay studies involving trapped heavy ions initially selected by HYRA. There is some expertise in ion traps in the country at BHU, VECC, IUAC (in collaboration with GSI), etc. which can be channelised to realise this facility.

In Geochronology project sanctioned by MoES, GoI and being executed at IUAC, a low energy accelerator of around 5 MV terminal potential is envisaged which can have an additional beamline for nuclear astrophysics experiments. As the accelerator will be installed in the basement, background reduction will be easier to achieve. There is interest in this field among researchers from TIFR, SINP, etc. In addition, the FRENA facility at SINP will greatly benefit if a mass spectrometer is added to it and the expertise at IUAC can be utilised to realise the same.

In this talk, the possibility and advantages of having an ion trap facility coupled to HYRA will be elaborated and the strengthening of the study of nuclear astrophysics at IUAC and/or SINP will be outlined. These will open up new areas of research which are, at present, lacking in the country and will pave way for nuclear physics research to grow further.

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