Hybrid Recoil mass Analyzer (HYRA) at IUAC, New Delhi: the path traveled so far and the way ahead

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The kinematic focusing effect of heavy ion induced fusion reactions result in the evaporation residues (ERs) to be forward focused and to move within a cone axial with the direction of primary beam. The selection of ERs amidst the large beam background requires carefully designed, large electromagnetic separators. While a vacuum mode mass spectrometer helps in mass (or mass/charge) dispersion of selected ions and an excellent primary beam rejection at the focal plane, it suffers reduction in transmission efficiency due to the selection of one to few charge states at a time. However, a gas-filled magnetic separator offers increased transmission efficiency due to velocity and charge state focusing effects and an excellent primary beam rejection, both at the cost of mass (or mass/charge) dispersion. Most of the current search for Super Heavy Nuclei in various laboratories use 'hot fusion' reactions and gas-filled separators. Hybrid Recoil mass Analyzer (HYRA) is a unique combination of both these virtues with the first stage capable of operation in gas-filled mode and both the stages together operable in vacuum mode to obtain mass resolution, along with excellent primary beam rejection in both modes of operation.

HYRA, in gas-filled mode, has been used successfully to measure ER cross-sections, from well above barrier to near and/or sub-barrier region, in several heavy systems to understand the role of entrance channel mass asymmetry, nuclear viscosity and dynamical effects, shell closure in target or compound nucleus (CN) and deformation of colliding nuclei on the survival of ER. Experimental ER cross-sections have led to additional information on possible non compound nuclear reaction processes, nuclear viscosity and effective fission barrier. The coupling of TIFR 4π spin spectrometer to HYRA has helped in extracting angular momentum distributions of surviving ERs which is an effective additional parameter in constraining theoretical statistical (or dynamical) model parameters. In addition, a new microsecond isomer has been identified in neutron-deficient bismuth nucleus using a single clover germanium detector at the focal plane and the selectivitiy of HYRA along with the time correlation it preserves from the instant of reaction. A modified focal plane setup is planned to accommodate up to seven clover germanium detectors to carry out more such measurements. Nuclear spectroscopy studies following alpha or beta decay at the focal plane of HYRA are some of the experiments which are being pursued. There is a plan to combine Indian National Gamma Array (INGA) with HYRA to study sparsely produced heavy nuclei selected from the huge fission background. In vacuum mode, an experiment to look for pairing vs. clustering effects in ^{18}O has been successfully carried out.

In this talk, some experimental results obtained using HYRA and ancillary detectors will be presented along with plans for the future.

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On behalf of HYRA group/collaboration, HYRA-TIFR 4π Spin Spectrometer and HYRA-INGA collaboration