Shell structure and evolution of collectivity on and away from the stability line

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The present thesis is based on studies of an interesting aspect of nuclear structure - shell structure and evolution of collectivity on and away from the stability line. Both experimental and theoretical investigations have been performed in two regions of the nuclear chart: stable nuclei with N $\approx$ Z near ^{40}Ca and highly neutron-rich ones above ^{132}Sn. The experimental investigations have been performed using the Compton suppressed Clover detectors. The thesis comprises of three parts.

The first part deals with the high energy characterisation of the Compton suppressed Clover detector. Gamma-ray cascades from the resonant states following proton capture resonance reactions have been used for providing the high energy gamma-rays upto $\approx$ 11 MeV. Typical characteristics of a Clover detector like addback factor, hit pattern distribution have been determined [1]. Efficiency of Clover in addback mode has been compared with those of a standard HPGe detector. Our results have provided crucial information on the efficiency of such detectors at high energies and have shown the advantage of using composite detectors over normal HPGe detectors for high energy discrete gamma-ray spectroscopy. This work has been done as a prelude to our experimental study of mass 40 region using a Clover array.

In-beam gamma-ray spectroscopic study of high spin states of ^{35}Cl is the second topic. Using heavy ion fusion-evaporation reaction and efficient Clover detector array, new structure information on high spin states have been obtained [2]. Both polarisation and lifetime measurements have been performed. It has been shown that for reliable reproduction of high spin states in ^{35}Cl, shell model calculation including fp orbitals in the valence space as well as reduction of the $sd - fp$ shell gap may be essential. It is known that the shell structure changes for neutron-rich nuclei, but in the present case we have observed reduced shell gap for a stable nucleus which apparently lies away from the "Island of inversion". This observation indicates the importance of the issue of reduction in shell gap for both stable and neutron-rich nuclei.

The third part of the thesis deals with the spectroscopic studies of neutron-rich nuclei in ^{132}Sn region. Experimental studies have been performed with ^{252}Cf fission source using simple two detector set-ups for checking the feasibility of performing such experiment with a larger array in future [3]. Motivated by the observed regularity in the energy spectra and the structure of the shell model wave functions for the levels of ^{137}Te and ^{137}I, a few weakly and moderately deformed neutron-rich odd-A nuclei have been studied using the simple phenomenological Particle Rotor Model [4]. In a few cases ambiguity in level ordering has been resolved and spin-parities have been assigned to the levels. Results indicate that the appearance of collectivity depends delicately on the valence neutron and proton numbers.

Our work emphasizes that the issues thought to be relevant for nuclei away from stability, should also be studied over a broader region of nuclear territory. With the latest developments in the experimental facilities, the nuclei near the stability line should be re-investigated for finding possible correlations with those away from stability. The importance of the composite detector has also been highlighted. Regarding theoretical

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models, our work indicates the importance of the phenomenological models for their simplicity and predictability in regions with insufficient data. If computational facilities permit, the shell model calculations are always important for getting a microscopic view of nuclear structure.

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