Investigation of interplay of single particle and collective modes of excitation in *sd* shell nuclei

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Nuclei in the neighborhood of doubly closed ^{40}Ca usually exhibit characteristics of single particle excitations at low energies [1]. However, several nuclei *viz.*, ^{40}Ca and ^{36}Ar [2] in this mass region have also revealed deformed states (even superdeformation) at relatively higher excitation energies. The observed Superdeformed (SD) bands in these α-conjugate nuclei have been explained using complementary descriptions in terms of particle-hole excitations in the shell model [3], and α-clustering configurations within various cluster models [4]. In ^{36}Ar, ^{40}Ca, the average deformation (β_2) of the SD bands generated with (4p-4h) and (8p-8h) excitations in the *pf* (N=3) shell, are 0.45 and 0.59, respectively. This is similar to the observation in heavier nuclei where the occupation numbers of high-N orbital have been found to characterise SD bands. So far no similar clustering manifested through superdeformation, have been observed in odd A ($N \neq Z$) nuclei in A $\approx$ 40 region. Although α-cluster structure of ($N \neq Z$) nuclei is a subject of theoretical discussion, not enough experimental data are available.

So the primary motivation of this work is to study odd - A ^{33}S [5], ^{35}Cl [6] and odd-odd ^{34}Cl [7] nuclei for investigating the evolution of collectivity from nearly spherical to super-deformation with increasing spin as well as with number of particle-hole excitations in the *pf* shell. These nuclei also provide us new insight on the relation between the strong deformation and α-clustering in non α-conjugate nuclei through large basis shell model (LBSM) calculation.

These nuclei have been populated by fusion-evaporation reactions using energetic beams at Indian accelerator centers. In-beam gamma spectroscopic techniques using the various implementations of the Indian National Gamma Array (INGA) comprising of Compton-suppressed clover detectors have been utilised to study them experimentally. The level schemes of these nuclei have been extended by adding few new levels and transitions. The spin and parity of the levels has been assigned or reconfirmed from DCO and polarisation measurements. Level lifetimes of few levels were estimated from lineshape analysis. Apart from single particle excitations, collective excitations (deformed and superdeformed states) have been observed in these nuclei. α-cluster structure in non α-conjugate ^{35}Cl nucleus has been identified. Energies, transition probabilities as well as spectroscopic factors from LBSM calculations have been utilised to interpret the data.

References

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