STUDY OF NUCLEAR STRUCTURE OF SOME NUCLEI IN MEDIUM MASS REGION

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ABSTRACT

This research work is limited to the medium mass region (A=150-200). In this work, the collective nuclear structures of some medium mass nuclei have been analyzed, using empirical studies, phenomenological, geometrical, group theoretical models. The research work is divided into five Chapters. The Introduction is given in the Chapter I and Nuclear Models are discussed in Chapter II. In Chapter III, the values of asymmetry parameter (γ_0) of Davydov and Filippov model are calculated using the experimental energies of $E2_2^+$ and $E2_1^+$ states for $50 \leq Z \leq 82$ and $82 \leq N \leq 126$ region. The whole calculated data is divided into four quadrants. The Quadrant I (Q-I) is for $50 \leq Z \leq 66$ and $82 \leq N \leq 104$ shell space with particle like proton-bosons and neutron-bosons and it is forming the p-p space. The Quadrant II (Q-II) is for $66 \leq Z \leq 82$ and $82 \leq N \leq 104$ shell space, with hole like proton-bosons space and particle like neutron-bosons space and it is forming the h-p space. The Quadrant III (Q-III) is for $66 \leq Z \leq 82$ and $104 \leq N \leq 126$ region shell space, with hole like proton-bosons and neutron-bosons and it is forming h-h space. The quadrant IV (Q-IV) is for $50 \leq Z \leq 66$ and $104 \leq N \leq 126$ shell space with particle like proton-bosons and hole like neutron-bosons and it is forming the p-h space. The study of systematic dependence of γ_0 on N, N_B and NpNn has been carried out on *quadrant wise basis* to find out the role of valence nucleons and holes on the nuclear structure. The role of Z=64 subshell effect for $N \leq 90$ region is also discussed. The NpNn product is a good measure of its effect in producing the deformation in atomic nuclei. This product is also an indicator of the n-p interaction among the valance proton and/or neutron nucleons causing the deformation of nuclear core. In quadrant-I and quadrant-II, the asymmetry parameter decreases; from 30^0 in Q-I and from 22^0 in Q-II to 9^0- 10^0; with increasing N from 82 to 104 (i.e. the mid of N=82 to 126 neutron shell), signifying that the nuclear deformation (β) is increasing, while the energy ratio R_4 increases from 2 (for harmonic vibrators or SU(5) type nuclei) to 10/3 (for good rotors or SU(3) type nuclei). This indicates that in this region the nuclear structure depends

much more on Z. In quadrant-I, the asymmetry parameter is having more correlated dependence on N, rather than on NpNn. Also in quadrant- I, the Z=64 sub-shell effect for N≤90 nuclei affect the variation of asymmetry parameter with N and NpNn product. The existence of X(5) symmetry in N=90 isotones established in recent works supports the formation of isotonic multiplets in this work. The systematic dependence of asymmetric parameter on NpNn has strong dependence in quadrant-II. In Q-II, the line of β- stability runs nearly diagonally, i.e. parallel to N_B and leading to the formation of F-spin multiplets. The same feature had been observed earlier for the energy of first excited state i.e. E2g. In quadrant-III, the variation of asymmetry parameter is different from quadrant I and II because the asymmetry parameter increases sharply from 9^0 - 10^0 to 30^0 with increasing N from 104 to 126. This is signifying that the nuclear deformation (β) is decreasing and the nuclear structure changes from pure rotor SU(3) type to vibrational SU(5) or γ-unstable O(6) type. Further, the asymmetry parameter for different elements has smooth curve with NpNn with almost same slopes except for Hg isotopes. In Chapter IV, the predictions of asymmetric rotor model of Davydov and Filippov for B(E2;4g→2g)/B(E2;2g→0g) branching ratio are compared with the experimental data in medium mass region. It is found that the observed data point of this ratio for N=88 isotones (Nd, Sm, Gd, Er) are indicating the shape phase transition from an ideal spherical harmonic vibrator or SU(5) to an axially symmetric deformed rotor or SU(3). It is also noted that this B(E2) ratio is anomalously small in case of two non- magic nuclei i.e., $^{198}_{80}Hg_{118}$ [=0.375(18)] and $^{144}_{60}Nd_{84}$ [=0.73(9)] with only two vacancy of protons for Z =82 and two valence neutrons outside N=82, respectively. The data points for other nuclei are lying between SU(5) and SU(3) limits. The calculated B(E2) ratios of ARM are very close to the SU(3) limit of IBM indicating that it can explain the structure of only well deformed nuclei. Therefore the ARM is partially successful in explaining this branching ratio. The variation of experimental B(E2; 4g→2g)/ B(E2;2g→0g) branching ratio with N and Z is carried out for Nd–Hg nuclei. It is found that the there is shape phase transition for N=88 and 90 isotones (Nd, Sm, Gd, Er) from an ideal spherical harmonic vibrator or SU(5) to an axially symmetric deformed rotor or SU(3). The present study supports the sub shell closer effect around Z=64, for N≤ 90 and the constant nuclear structure of N=90 isotones. Finally, in

Chapter V, the interacting Boson Model-1is used to study the nuclear structure of ^{152,154}Sm nuclei. The ^{152}Sm is chosen for study, because it is a best example of recently discovered X(5) symmetry of IBM and ^{154}Sm is a rotor type i.e. SU(3) symmetry. The bunching of various levels in ^{152,154}Sm is reproduced well in present calculation and is in agreement with the observed energy level diagram of experimental data. In ^{152,154}Sm, the B(E2) branching values and B(E2) branching ratios are calculated for inter-band and intra-band transitions for g-, β-, γ- and β_2- bands and the calculated results are in good agreement with experimental data. In ^{152,154}Sm nuclei, the IBM-1 Hamiltonian reproduce the energy spectrum, B(E2) values and B(E2) ratios for g-, β- and γ– bands. Present calculation supports that ^{152}Sm is as a best example of X(5) symmetry and ^{154}Sm is a SU(3) type in nature.