Global and systematic study of nuclear Structure of even-even nuclei of $A = 100 - 200$ mass region

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The nuclei in the mass region $A = 100-200$ are of significant attraction, because this region consist of spherical, transitional and highly deformed nuclei. The interesting characteristics of this mass region are the well known shell effects, the strong dependence of nuclear structure on the neutron and proton numbers likewise on the spin, energy of first 2^+ state $E(2_1^+)$, energy ratio $R_{4/2}$ [$= E(4_1^+)/E(2_1^+)$], chiral partner bands, shape coexistence, rotational band termination etc. In present thesis work, the nuclear structure have been studied using the Asymmetric Rotor Model, Modified Soft Rotor Formula (MSRF) and Interacting Boson Model (IBM) and then the results are compared with the latest available experimental data.

In the first problem, the Grodzins product ($E(2_1^+) * B(E2) \uparrow$) has been study for $A = 100 - 200$ mass region. The major shell space $Z = 50 - 82, N = 82 - 126$ is suggested to divide into four quadrants which correspond to the valence-particle, valence-hole subspace by Gupta *et al.* [1]. The quadrant-I has particle-particle nucleons with $N > 82$, quadrant-II contains hole-particle nucleons with $N < 104$, quadrant-III consists of hole-hole nucleons with $N > 104$ and quadrant-IV comprises of particle-hole nucleons. But there is no nuclei lie in quadrant-IV, therefore, we don't study this quadrant. We also study the light nuclei region $Te - Sm$ in detail. The experimental data is also studied with neutron number N and proton number Z. Gupta [2] pointed out the relation between the reduced excitation strength $B(E2; 0_1^+ \rightarrow 2_1^+)$ or $B(E2) \uparrow$ values and ground state energy $E(2_1^+)$, which was given by Grodzins [3] using the concept that with increase in the valence nucleons to closed shell, the energy $E(2_1^+)$ starts decreasing and the $B(E2) \uparrow$ values increases. The Grodzins product can be represented as:

$$(E(2_1^+) * B(E2) \uparrow) \sim constant(Z^2/A).$$

Gupta [2] studied the constancy of the Grodzins product ($E(2_1^+) * B(E2) \uparrow$) and concluded that the Grodzins product breaks down in the combined effect of the $Z = 64$ subshell effect and the shape phase transition at $N = 88 - 90$. Casten [4] proposed that whenever the nuclear data covering nuclear deformation plotted upon the product of valence proton and valence neutron numbers N_pN_n, a simple pattern is evident.

We study the Grodzins product ($E(2_1^+) * B(E2) \uparrow$) against N_pN_n product for $A = 100 - 200$ mass region [5]. In quadrant-I, $N > 82$, the Grodzins product decreases with increasing N_pN_n product, except at few N_pN_n values which may be possibly due to the $Z = 64$ subshell effect. In quadrant-II, $N \leq 104$, the Grodzins product decreases with increasing N_pN_n product. The Grodzins product shows more dependence on N_pN_n for deformed nuclei. For $Yb - Pt$ nuclei ($N > 104$), it shows a very different behaviour as compared to other quadrants. The different nature of Pt nuclei may be due to the presence of neutron shell gap at $N = 114$. The Grodzins product decreases with increasing N_pN_n product, but in case of transitional nuclei a variation is also seen.

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The systematic dependence of Grodzins product $(E(2_1^+) * B(E2) \uparrow)$ on the asymmetry parameter γ_0 of the asymmetric rotor model is studied in $Z = 50-82, N = 82-126$ major shell space [6]. All types of nuclear structure from spherical vibrator to deformed rotor are also explored. The Grodzins product provides a contribution of $E(2_1^+)$ and $B(E2) \uparrow$ simultaneously, which further reflects the shape phase transitions, sharp or gradual with asymmetry parameter γ_0. In the region of deformed nuclei, the Grodzins product $(E(2_1^+) * B(E2) \uparrow)$ shows direct dependence on the asymmetry parameter γ_0.

We present for the first time, the study of the product $((E(2_2^+)/E(2_1^+)) * B(E2) \uparrow)$ within the framework of asymmetric rotor model where the asymmetry parameter γ_0 reflects change in the nuclear structure [7]. The systematic study of the product $((E(2_2^+)/E(2_1^+)) * B(E2) \uparrow)$ with neutron number N is also discussed. The product $((E(2_2^+)/E(2_1^+)) * B(E2) \uparrow)$ provides a direct correlation with the asymmetry parameter γ_0. The effect of subshell is visible in $Ba-Gd$ nuclei with $N > 82$, but not in $Hf - Pt$ nuclei with $N > 104$.

When the vibration of one-phonon has no component of angular momentum along the symmetry axis, it is known as β-vibration (K=0). Similarly, the vibration of one phonon with a component of angular momentum along the symmetry axis (K=2) is known as γ-vibration. The two-phonon γ-vibration bands can be obtained by combination of parallel or antiparallel K=2 quanta, which lead to two bands, one with K=0 angular momentum and other with K=4 angular momentum. The two-phonon vibration bands i.e. $\beta\beta$ with K=0 and $\beta\gamma$ with K=2 are also observed in few nuclei. The excitation energies of ^{112}Ru, ^{104}Mo, ^{106}Mo and ^{108}Mo nuclei have been calculated with the MSRF formula for ground, γ- and $\gamma\gamma$-bands [8]. An excellent energy fits are obtained in all these nuclei. The MSRF formula yields a positive value for the moment of inertia θ and softness parameter σ for all the bands studied here of Ru, Mo nuclei. In these nuclei, the derived θ for the $\gamma\gamma$-band is almost equal to the derived θ for the γ-band and similar is the case for ground band, which is also true for the corresponding rotor model values. It has been studied that for the ground band, the softness parameter σ is less than 0.5 in most nuclei with $R_{4/2} > 2.5$ (see Ref. [9]). For γ-band, the same statement has been proved true by Gupta *et al.* [10]. Here, we deal with multiphonon $\gamma\gamma$-band and we obtain the softness parameter σ less than 0.2 by using MSRF formula for ^{112}Ru, ^{104}Mo, ^{106}Mo and ^{108}Mo nuclei. The multiphonon K=2 $\beta\gamma$-band and K=4 $\gamma\gamma$-band are also studied using MSRF formula for ^{154}Gd nucleus.

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