Efficacy of Cranking Technique in the Study of Some Neutron-Deficient Neodymium Isotopes

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The nuclei in the light rare-earth region have attracted much attention recently as a sundry of highly deformed bands have been observed. These structures typically have a quadrupole deformation parameter of β_2= 0.3 - 0.4 [1, 2] for example, while bands of normal deformation in the same nuclei are found to have β_2= 0.20 - 0.25. Occupation of at least one neutron in the intruder $I_{13/2}$ orbital, the presence of highly deformed shell gaps at N=72, 74, and or holes in the proton $g_{9/2}$ orbital are often cited as the primary causes of these sequences. The family of even–even, neutron deficient, neodymium isotopes has received special attention during the past years [3–5], because they are characterized by a fast transition from spherical to axially deformed shapes and provide a sensitive testing grounds for nuclear models. So, they represent an ideal case for studying the influence of the shape transition from spherical to deformed nuclei.

In the present work, the results of calculations on various nuclear structure quantities in even-even neuton-deficient $^{130\text{-}136}$Nd using Cranked Hatree-Fock Bogoliubov (CHFB) technique have been presented. The various nuclear structure quantities that have been calculated in $^{130\text{-}136}$Nd isotopes are the yrast spectra, subshell occupation probabilities of various valence orbits and intrinsic quadrupole moments. Besides this, a comparative study of the calculated yrast spectra with the available experimental data as well as with the results of calculations obtained by R.K Bhat et al. [6] using Variation After Projection (VAP) technique on the same neutron – deficient $^{130\text{-}136}$Nd isotopes has also been presented

The many body Hamiltonian taken is

$$H = \sum_i \langle i|\varepsilon|i\rangle\, a_i^\dagger a_i + \frac{1}{4}\sum_{ijkl} \langle ij|V_a|kl\rangle a_i^\dagger a_j^\dagger a_l a_k$$

the indices 'ijkl' span the active valence single-particle states contained in the model space, and $a_i^\dagger$ and a_i are the particle creation and annihilation operators, respectively. The effective nucleon-nucleon interaction V appropriate for the model space is antisymmetrized, so that

$$\langle ij|V_a|kl\rangle = \langle ij|V|kl\rangle - \langle ij|V|lk\rangle$$

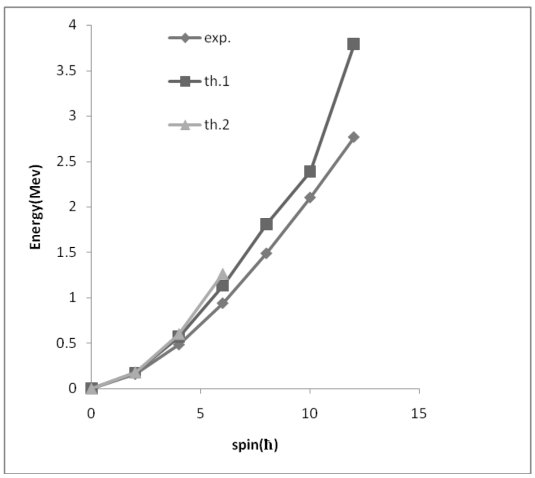
The magic nucleus $_{50}Sn^{100}$ has been taken as inert core. The valence space spanned by $3s_{1/2}$, $2d_{3/2}$, $2d_{5/2}$, $2f_{7/2}$, $1g_{7/2}$, $1h_{9/2}$ and $1h_{11/2}$, orbits for protons and neutrons has been selected. The spherical single particle energies (S.P.E.'s) that we have employed are (in MeV): ($2d_{5/2}$) = 0.0, ($3s_{1/2}$) = 1.4, ($2d_{3/2}$) = 2.0, ($1g_{7/2}$) = 4.0, ($1h_{11/2}$) = 6.5, ($2f_{7/2}$) = 12.0 and ($1h_{9/2}$) = 12.5 for $^{130\text{-}136}$Nd isotopes. This set of input SPE's is exactly the same as that employed Vergados and Kuo[7] as well as Federman and Pittel [8].

The two body effective interaction that we have employed is of the "pairing – plus – quadrupole - quadrupole" type [9]. The strength for the like particle (n-n) as well as neutron-proton (n-p) components of the quadrupole - quadrupole (q-q) interaction were taken as: $\chi_{nn}(=\chi_{pp})$ = -0.0116 MeVb^{-4}, χ_{np} = -0.0225 MeVb^{-4} for ^{130}Nd and $\chi_{nn}(=\chi_{pp})$ = -0.0112 MeVb^{-4}, χ_{np} = -0.0216MeVb^{-4} for $^{132\text{-}136}$Nd. Here, $b = \sqrt{\frac{\hbar}{m\omega}}$ is the oscillator Parameter. The strength for the pairing interaction was fixed through the approximate relation G = (18-21)/A.

From the results of calculation, it has been found that:

- CHFB calculations carried out with quadrupole-quadrupole–plus pairing model of the residual interaction operating in a reasonably large valence space gives a very good description of the ground state yrast states in these nuclei. In Fig.1, comparison of the theoretical (th.1) results obtained by CHFB calculations with the experimental results and theoretical (th.2) results obtained by R.k Bhat et al.[6] for ^{130}Nd are presented.

- The CHFB calculations for E_2^+, E_4^+/E_2^+ and intrinsic quadrupole moments leads to the conclusion that deformation decreases as one moves from ^{130}Nd to ^{136}Nd .
- In addition to the CHFB calculations for E_2^+, E_4^+/E_2^+ and intrinsic quadrupole moments, theoretical calculations have also been performed to obtain sub-shell occupation numbers, charge radii for protons and neutrons. And all these theoretical results obtained by CHFB calculations for even-even neutron deficient $^{130-136}$Nd nuclei will be presented in the symposium.



. **Fig.1** Comparison of the observed (exp.) and theoretical (th.1 & th.2) low lying yrast spectra for ^{130}Nd.

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