Microscopic study of band structure of some actinide nuclei

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Recently, in beam measurements for the actinide region have been performed for gamma ray spectroscopy of even-even and odd mass nuclei. They reveal that these nuclei are well deformed at low spins near the ground state and exhibit very similar collective behavior with regular rotational level sequence. Some non-yrast and isomeric states have been observed in actinide nuclei. The yielded data contain useful information on excited levels and configurations of multi-quasi-particle states and they test strictly current nuclear models. Zhu et al [1] have studied the high spin states in some odd U and Pu nuclei. They have interpreted the experimental data in the framework of cranked shell model and observed that there is striking difference in behavior between the A=238, 240 even Pu isotopes and other actinide nuclei that require further theoretical investigation. In order to investigate the band structure of some even-even and odd actinide nuclei, the Projected Shell Model (PSM) approach has been employed. In the present piece of work we have obtained the yrast bands, band diagrams and electromagnetic quantities of some even-even and odd mass uranium (U) and protactinium (Pu) nuclei.

The PSM [2] is a kind of shell model approach. However, unlike the conventional shell model, the PSM begins with the deformed Nilsson type single particle basis. The Hamiltonian which has been used in the present work is described as follows.

$$\hat{H} = H_0 - \frac{1}{2}\chi\sum_{\mu}\hat{Q}^{\dagger}_{\mu}\hat{Q}_{\mu} - G_M\hat{P}^{\dagger}\hat{P} - G_Q\sum_{\mu}\hat{P}^{\dagger}_{\mu}\hat{P}_{\mu}$$

where H_0 is the spherical single particle Hamiltonian. The second term is the quadrupole-quadrupole interaction and the last two terms are the monopole and quadrupole pairing interactions, respectively. The quadrupole interaction strength χ is adjusted so that the known quadrupole deformation ε_2, from the HFB self consistent procedure is obtained. The single particle space consists of three major shells N=4, 5, 6 for protons and N=5, 6, 7 for neutrons.

The monopole pairing strength G_M is of the form

$$G_M = \left(G_1 \mp G_2\frac{N-Z}{A}\right)\frac{1}{A}(\mathrm{MeV})$$

with '−' for neutrons and '+' for protons. Here, G_1 and G_2 are taken as 19.12 and 13.13, respectively. Adjusting the parameters ε_2, G_2 and G_1 will change the energy gap for each shell and thus will affect the selection of the quasi-particle basis. The strength of the quadrupole-quadrupole pairing force G_Q, is assumed to be proportional to G_M. One may carefully adjust the ratio of G_Q/G_M during the calculation to get the best representation of experimental observation.

In the Fig. 1, the calculated yrast bands of ^{233}U, ^{235}U, ^{241}Pu and ^{243}Pu isotopes are compared with the experimental data [3,4]. In case of ^{233}U the experimental data is available on positive and negative parity bands but the yrast band is of negative parity. In this nucleus the band head of yrast band is $5/2^-$ and level scheme is known up to $I=49/2^-$. From Fig.1 (a), it is seen that the experimental energies are reproduced by the PSM calculation qualitatively. In case of ^{235}U the yrast band is of positive parity and the band head of this band is $7/2^+$ and experimental data is available up to $57/2^+$. One can observe from Fig. 1 (b) that the experimental levels of this band are reproduced nicely by the PSM calculation. In case of ^{241}Pu and ^{243}Pu isotopes the yrast bands are of positive parity and the experimental data is available up to $13/2^+$, and $59/2^+$, respectively. The PSM calculation is performed up to $I=59/2^+$ for both the nuclei. The comparison of experimental and theoretical energies in Fig. 1(c,d) show a good agreement. From the analysis of the band diagrams of $^{233,235}U$ and $^{241,243}Pu$ nuclei, it is seen that the yrast band arises from single quasi-particle configuration at low spins. In case of positive parity bands the one quasi-particle configuration is from $1i_{13/2}$ orbit and in case of negative parity bands it is from $1j_{15/2}$ orbit. The calculation of other bands in odd mass nuclei and even-even nuclei is under progress.

References

[1] S. Zhu et al, Phys. Lett. **B618**, 51 (2005**)**
[2] K. Hara and Y. Sun, Int. J. of Mod. Phys. **E4**, 637 (1995)
[3] E. Browne, Nucl. Data Sheets **98**, 665 (2003)
[4] M.J. Martin, Nucl. Data Sheets **106**, 89 (2005)

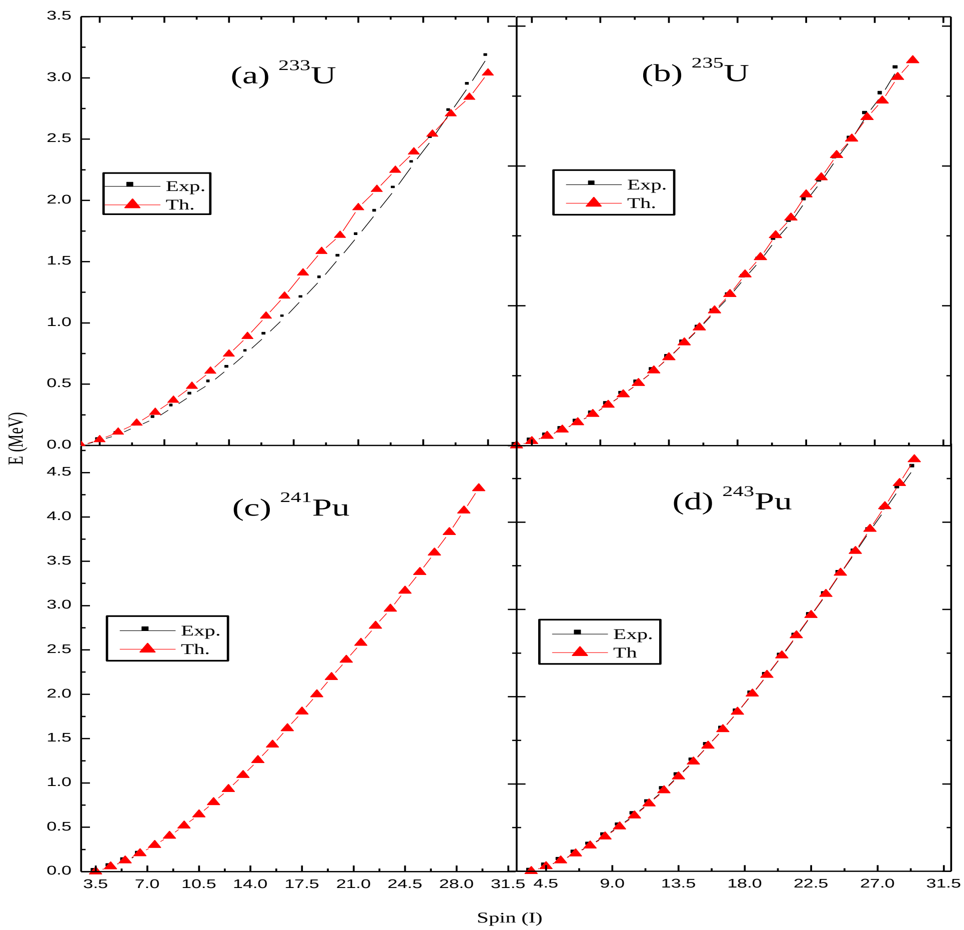

Fig. 1 Comparison of experimental and calculated yrast bands of $^{233,235}U$ and $^{241,243}Pu$.