Study of band structure of some odd mass neutron-rich Ruthenium and Palladium nuclei

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The study of the neutron-rich nuclei is one of the current topics in nuclear physics. The neutron-rich nuclei in the A ~ 100-110 region lie far from the β stability line and the identification of prompt γ-rays from fission fragments produced by fission has been the main avenue to study the nuclear structure of these nuclei.

The neutron-rich ^{107,109}Ru and ^{109,111}Pd isotopes belong to a transitional region between the spherical closed-proton-shell Sn isotopes and the strongly deformed Zr and Sr nuclei at the proton mid-shell [1]. Earlier, Zhu et al. [2,3] investigated the level schemes of ^{107,109}Ru and confirmed the transitions of $h_{11/2}$ band obtained previously and extended the $h_{11/2}$ sequence and positive parity ground state band of ^{107,109}Ru. Recently, Ding et al. [4] and Wu et al [5] studied the high-spin states of ^{109}Ru. The band structures built on the low-lying states in ^{109,111}Pd were observed for the first time by Kutsarova et al. [6]. Very recently, Stefanova et al. [7] have found positive parity rotational (quasirotational) bands in ^{109,111}Pd for the first time. It has been suggested by these authors that detailed theoretical studies are needed to explain the behaviour of positive-parity ground state bands in ^{109,111}Pd isotopes. In order to interpret the recent experimental data on yrast positive parity bands in ^{107,109}Ru and ^{109,111}Pd, the Projected Shell Model (PSM) [8] has been employed as a theoretical tool. The PSM calculations have been performed by using the Hamiltonian of the form:

$$\hat{H} = \hat{H}_0 - \frac{1}{2}\chi_{QQ}\sum_{\mu}\hat{Q}^{+}_{2\mu}\hat{Q}_{2\mu} - G_M\hat{P}^{+}\hat{P} - G_Q\sum_{\mu}\hat{P}^{+}_{2\mu}\hat{P}_{2\mu}$$

where, $\hat{H}_0$ is the spherical single-particle shell model Hamiltonian. The second, third and fourth terms represent quadrupole-quadrupole, monopole-pairing and quadrupole-pairing interactions, respectively. In PSM, angular momentum projected basis is constructed with appropriate deformations. Diagonalization of Hamiltonian in the space spanned by the projected basis gives energy states. The lowest energy for each spin is used to compare with experimental yrast energies. The strength of the quadrupole-quadrupole force is determined in a self-consistent manner so that it is related to the deformation of the basis.

The positive and negative parity yrast bands of ^{107,109}Ru and ^{109,111}Pd are compared with the experimentally observed one in Figs. 1 and 2, respectively. In case of ^{107,109}Ru, the positive parity bands are reproduced well up to spin I≈10.5ħ. The analysis of band diagrams for positive parity bands of ^{107,109}Ru predicts $1\nu g_{7/2}$[5/2],K=5/2 configuration at low spins. However, at high spins one more one-quasiparticle (qp) band contributes to the yrast states. The calculated yrast energies of negative parity bands for ^{107,109}Ru reproduce the experimental energies of unfavored states. At lower spins the negative parity bands have the dominant contribution from $1\nu h_{11/2}$[5/2],K=5/2 configuration in both the nuclei. The high spin states are seen to arise from mixing of low lying components of $1h_{11/2}$ sub-shell. The calculated yrast energy states of positive parity bands of ^{109,111}Pd reproduce the experimental yrast energy states at low spins. The low lying yrast energy states are predicted to have $1\nu g_{7/2}$[5/2],K=5/2 configuration whereas the high spin states are seen to arise from mixing of 1qp and 3qp bands. The available experimental levels of negative parity bands of ^{109,111}Pd are reproduced well by the PSM calculations. The low lying energy states are seen to arise from mixing of 1qp bands from $1h_{11/2}$ orbit whereas the high spin states are arising from mixing of 1qp and 3qp bands.

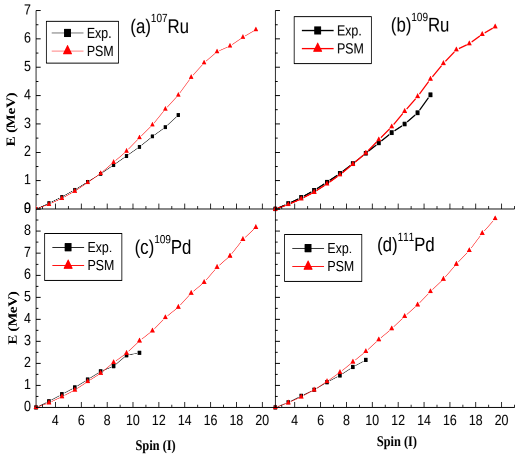

Fig. 1 Comparison of the calculated energies E(I) of the yrast positive parity bands with experimental data of ^{107,109}Ru and ^{109,111}Pd.

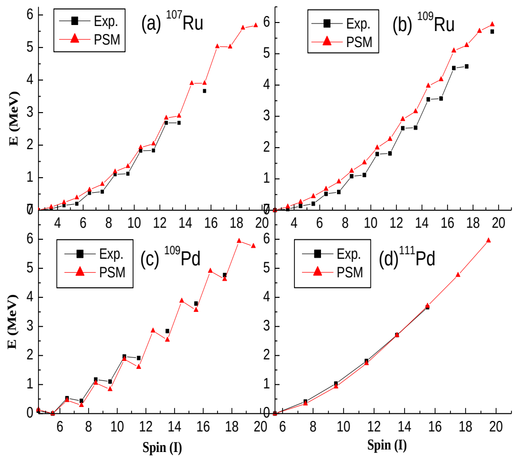

Fig. 2 Comparison of the calculated energies E(I) of the yrast negative parity bands with experimental data of ^{107,109}Ru and ^{109,111}Pd.

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