Study of High Spin States of Odd Mass $^{103-107}$Rh Isotopes

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Introduction

In recent years, the developments in the experimental techniques in nuclear physics have put forth immense data for nuclear structure elucidation. The nuclei in the mass region $A\approx 100$ with $40 \leq Z \leq 50$ exhibit several shape transitions and the energy levels of the nuclei lying in this mass region have been extended to high spins. In the recent past [1-4], high spin states of odd mass $^{103,105,107}$Rh isotopes have been studied by various experimental techniques with the aim of extending knowledge of nuclides in $A\approx 100$ region and investigating possible shape transitional effects.

The neutron-rich nuclei $^{103,105,107}$Rh have 45 protons and 58, 60, 62 neutrons respectively and hence lie in a mass region rather far from the shell closures at $Z=50$ and $N=50$, but on the other hand, are also outside the islands of well deformed nuclei [5].

The Model

In the present work, we have applied a theoretical framework known as Projected Shell Model (PSM) [6] to study the high spin states of odd mass $^{103,105,107}$Rh isotopes and have also compared the data with the available experimental data.

The total Hamiltonian employed in the present work is

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

Where $\hat{H}_o$ is spherical single particle Hamiltonian. The second term in the Hamiltonian is the quadrupole- quadrupole interaction and the last two terms are the monopole and quadrupole pairing interactions, respectively.

The strength of the quadrupole force $\chi$ is adjusted in such a way that the known quadrupole deformation parameter $\varepsilon_2$ is obtained by the usual Hartree-BCS self-consistent procedure. The monopole pairing force constants $G_M$ are adjusted to give the known energy gaps. In the present calculations, the monopole pairing strength is taken as

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

where $\mp$ is for neutron (proton) while, in this work, $G_1$ and $G_2$ are chosen as 19.70 and 10.0 MeV for all the Rh isotopes under study. The strength parameter $G_Q$ for quadrupole pairing is assumed to be proportional to $G_M$ where the proportionality constant is adjusted to reproduce the $g_9/2$ crossing at the right place.

Fig. 1 Yrast spectra of a) $^{103}$Rh, b) $^{105}$Rh and c) $^{107}$Rh.
From the results of the calculations, it is found that:

- The experimental yrast states are very well reproduced by the present PSM calculations.
- The trend of experimental transition energies has also been reproduced qualitatively and quantitatively, which proves the reliability and validity of the applied framework in the region A≈100.
- The PSM calculations for $^{103}$Rh, $^{105}$Rh and $^{107}$Rh have been performed corresponding to prolate quadrupole deformation, which is in accordance with the experimental data.

In figures 1[a-c], yrast spectra of $^{103}$Rh, $^{105}$Rh and $^{107}$Rh respectively are presented whereas in figures 2[a-c], the transition energy versus spin is plotted for these isotopes, respectively.

![Fig. 1 Yrast spectra of $^{103}$Rh, $^{105}$Rh and $^{107}$Rh.](image_url)

**Fig. 2** Transition energy versus spin plots of a) $^{103}$Rh, b) $^{105}$Rh and c) $^{107}$Rh.

### References


