Band structures in $^{98,99}$Rh Nuclei

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Introduction

The high spin structure of odd-A nuclei in mass region A $\sim$ 100 has attracted many experimental and theoretical investigations in recent years because of several structural phenomena such as prediction of high spin terminating bands, magnetic rotation, and chiral rotation[1]. Further the study of nuclei close to doubly magic provide necessary insight into evolution of collective degrees from single particle ones. The $^{98,99}$Rh isotopes have odd proton in the $g_{9/2}$ and $p_{1/2}$ orbitals situated below the Z=50 gap and neutron occupy high-$\Omega$ orbitals. Strongly prolate driving low- $\Omega$ unique parity $h_{11/2}$ neutron orbital is accessible at low excitation energies for the nuclei with neutron number receding the N=50 shell closure. The coexistence of spherical and deformed shapes increases the complexity of the level structures.

In the present work, high spin data obtained for the $^{98,99}$Rh isotopes are presented. Previously the $^{99}$Rh had been studied by Chattopadhyay et al. [2] and Ghugre et al. [3] using the heavy ion reactions. The level scheme of $^{98}$Rh is previously reported work by Singh et al. [4] using 8 Ge detector array.

Experimental details and data analysis

The present work reports in-beam $\gamma$-ray spectroscopic measurements to study level structures in $^{98,99}$Rh isotopes. Excited states in $^{98,99}$Rh were populated in fusion-evaporation reaction $^{75}$As ($^{28}$Si, xpy$n$) at $E_{lab} = 120$ MeV. The de-excitations have been investigated through in-beam $\gamma$-ray spectroscopic techniques. The $^{28}$Si beam was delivered by the 15UD Pelletron accelerator at Inter University Accelerator Centre (IUAC), New Delhi. The $^{75}$As target of thickness 3 mg/cm$^2$ onto a 10 mg/cm$^2$ thick Pb backing was prepared by vacuum evaporation followed by target and the de-excitations $\gamma$-rays were detected rolling. The recoiling nuclei were stopped within using the Indian National Gamma Array (INGA) equipped with 18 clover detectors mounted in a five rings configuration.

A total of about $300 \times 10^6$ triple or higher-fold coincidence events were recorded in the experiment. The clover detectors were calibrated for $\gamma$-ray energies and efficiencies using the $^{133}$Ba and $^{152}$Eu radioactive sources. The data were sorted offline using INGASORT program to produce symmetrised $E_\gamma-E_\gamma$ matrices and $E_\gamma-E_\gamma-E_\gamma$ cubes. The level schemes were establish using coincidence and intensity relationships for various gamma transitions. The spin-parity assignments to levels were made using DCO and polarization measurements. The previously known level scheme of $^{98}$Rh and $^{99}$Rh has been extended considerably with the addition of about 60 new $\gamma$-rays in each case. The placement of transitions observed in the previous work are revised and established.

Results and discussion

The present level scheme of $^{99}$Rh (Fig. 1) has been established up to $J = 59/2^+$. The identified bands have been labeled as B1-B5. The low lying band structures are based on $\pi g_{9/2}$ and $\nu h_{11/2}$ quasiparticles which further evolve into high spin structures following $(\nu h_{11/2})^2$ alignment. The level scheme is a significant extension to those reported in the earlier work by Singh et al. [4]. The present level scheme preserves major features of the previously observed band to be based on $\pi p_{1/2}$ and $\pi g_{9/2}$ quasiparticles which further evolve into high spin structures following $(\nu h_{11/2})^2$ alignment. The level scheme is a significant extension to those reported in the earlier work by Singh et al. [4]. The present level scheme preserves major features of the previously observed band to be based on $\pi g_{9/2}$ and $\nu h_{11/2}$ quasiparticles which further evolve into high spin structures following $(\nu h_{11/2})^2$ alignment. The previously observed single quasiparticle bands based on $h_{11/2}$, $g_{7/2}$, and $d_{5/2}$ neutron orbitals have been substantially extended.

Multifragmentations at the positive parity and negative parity bands at spins around 20$^+$ is observed, which are likely to be maximally spin aligned states similar to the ones observed in $^{100}$Rh [5].

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The present level scheme of $^{98}$Rh has been established up to $E \approx 10$ MeV and $J = 21h$. The level scheme has been extended substantially at the low excitation energies. A few low-lying states likely to be isomers are observed in the present level scheme with excitation energy lower than the previously assigned $2^+$ ground state. It suggests that the earlier proposed $2^+$ ground state needs to be reassigned. Major changes in the level scheme of $^{98}$Rh and its interpretation is expected in the present investigations.

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References