Possible antimagnetic rotation in ^{101}Ru

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Introduction

The antimagnetic rotation (AMR) phenomenon was proposed by Frauendorf as a distinctive proton-neutron spin coupling mechanism similar to the spin arrangement observed in anti-ferromagnetism [1]. Anti-magnetic geometric structure in a nucleus retains the $R_z(\pi)$ symmetry wherein twin shears with two proton blades symmetrically coupled to the neutron blade. The perpendicular component of the magnetic moments ($\mu_\perp$) of two protons cancels each other, allowing only E2 transition to occur for AMR bands within the shears mechanism. This coupling mechanism leads to the formation of rotation-like band structures in nearly spherical nuclei. For the existence of AMR band in Cd and Pd isotopes, proton holes are responsible. However, in Ru nuclei despite having three proton holes, AMR bands based on experimental lifetime measurements have not been reported so far. So, it would be interesting to theoretically investigate the possibility of AMR bands in Ru nuclei. Recently, AMR character in ^{102}Ru was predicted using semiclassical particle rotor model [SCM] calculations. Hence, to investigate the possibility of the AMR character for $\nu h_{11/2}$ band in ^{101}Ru [2], semiclassical particle rotor model calculations have also been performed in the present work.

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Methodology

The detailed formalism of SCM is given in refs. [3, 4]. The total angular momentum, generated by the shear mechanism, is given by

$$I = aj + 2j cos\theta + \frac{1.5\Im V_{\pi\nu} cos\theta}{j} - \frac{6\Im V_{\pi\pi} cos2\theta cos\theta}{nj}, \quad (1)$$

The ratio of the magnitude of angular momentum of neutron particle and proton hole for a particular single-particle configuration is given by a=j_ν/j_π. The angle between j_π and j_ν is known as shear angle θ. The total number of particle-hole pairs for a single particle state is used to determine n which is a scaling factor between $V_{\pi\nu}$ and $V_{\pi\pi}$ which are proton-neutron and proton-proton interactions, respectively. The reduced electric quadrupole transition rates B(E2) values can be calculated by using the deduced shears angle θ and is given as

$$B(E2) = \frac{15}{32\pi}\,(eQ_{eff})^2 sin^4\theta \quad (2)$$

where eQ_{eff} is the effective quadrupole moment.

Results and discussion

For the investigation of possible AMR three configurations i.e., $\pi(g_{9/2})^{-2} \otimes \nu[h_{11/2}\ (g_{7/2})^2]$, $\pi(g_{9/2})^{-2} \otimes \nu[h_{11/2}\ (g_{7/2})^2]$ +2 $\hbar$ core, and $\pi(g_{9/2})^{-4} \otimes \nu[h_{11/2}\ (g_{7/2})^2]$ were used. Out of these, the SCM calculations

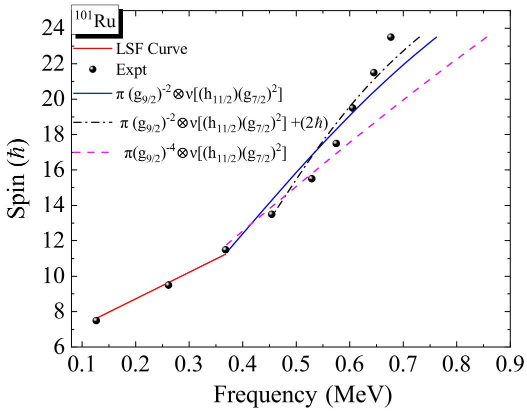

FIG. 1: Plot of spin ($\hbar$) *vs* frequency (MeV) for ^{101}Ru. The circles represent the experimental values [2] and the line corresponds to the values calculated using SCM.

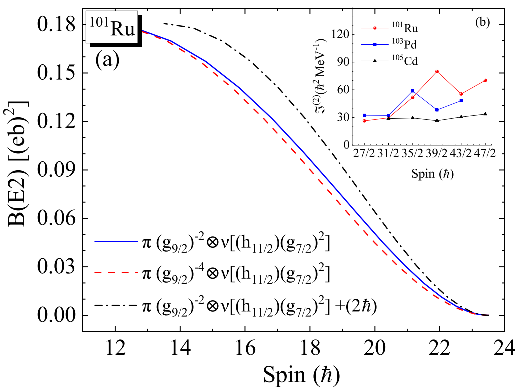

FIG. 2: (a) Plot of calculated reduced transition probability B(E2) *vs* spin in ^{101}Ru. (b) Comparison of experimental dynamic moment of inertia ($\Im^{(2)}$) *vs* spin for the negative parity bands in ^{101}Ru, ^{103}Pd, ^{105}Cd (N=57 isotones)

which have been performed by shifting the position of bandhead spin by 2 $\hbar$ to include the contribution of core rotation in configuration $\pi(g_{9/2})^{-2} \otimes \nu[h_{11/2}\ (g_{7/2})^2]$ exhibit good agreement with experimental results. Here, the symmetric shears established between j_π = 4 $\hbar$ and j_ν = 13.5 $\hbar$. The particle-hole pairs formed are six i.e., $n = 6$ and the shears parameter used for calculation are j = 4 $\hbar$, a = 3.375, $V_{\pi\nu}$ = 1.2 MeV, and $V_{\pi\pi}$ = 0.15 MeV. Additionally, other relevant parameters used are I_{sh}^{max} = 21.5 $\hbar$, I_{max} = 23.5 $\hbar$, and $\Im$ = 4.85 $\hbar^2$ MeV^{-1}. The bandhead frequency is estimated to be $\hbar\omega \sim 0.5015$ MeV at I = 13.5 $\hbar$. The value of ($\Im_c$) is estimated to be 14.6 $\hbar^2$ MeV^{-1} by analyzing the slope of the spin ($\hbar$) vs frequency (MeV) plot (see figure 1) corresponding to the band before neutron alignment. The spin ($\hbar$) *vs* frequency (MeV) plots for the $\pi g_{9/2}^{-2}$ based configuration, incorporating core contribution, exhibit good agreement with the experimental values for $I \geq 13.5$ $\hbar$. The predicted $B(E2)$ values from the SCM calculations for the discussed configurations are plotted as a function of spin in Fig. 2 (a). The presence of large $\Im^{(2)}$ values in the spin range 27/2 $\hbar \leq$ I $\leq$ 43/2 $\hbar$ (as shown in Fig. 2 (b)) and the decreasing trend of theoretically predicted $B(E2)$ values suggest potential AMR behavior in the upper spin portion of this band.

Conclusion

AMR character is predicted at higher spin values in the negative parity band of ^{101}Ru using SCM calculations. However, to confirm this prediction based on the SCM calculation, experimental values of reduced electric transition probability B(E2) based on the lifetime measurements are required.

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