Role of neutrons and protons in MR bands in ^{137}Nd and ^{137}Pr nuclei

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Introduction

Magnetic Rotation (MR) bands consisting of regular cascades of strongly enhanced magnetic dipole ($M1$) transitions are observed in nearly spherical nuclei in A=80, 110, 135, 190 regions. An updated version of the data table prepared by Jain and co-workers [1] lists 178 MR bands in 76 nuclides. MR bands arise due to anisotropic current distribution resulting from proton particles(hole) and neutron holes(particles) in high-j orbits [2]. In the A=135 region, a pair of neighboring nuclei $^{137}_{60}$Nd$_{77}$ and $^{137}_{59}$Pr$_{78}$ exhibit mirror MR configurations $\pi(h_{11/2})^2 \otimes \nu(h_{11/2})^{-1}$ [1] and $\pi(h_{11/2}) \otimes \nu(h_{11/2})^{-2}$ [3] respectively. This provides an interesting situation to delineate the role of protons and neutrons in MR. The previous spectroscopic studies on ^{137}Nd and ^{137}Pr were done by Petrache et al. [4] and Priyanka et al. [3] respectively. In the present work we focus on the study of these MR bands by measuring the lifetimes of the states.

Experimantal details

High spin states in ^{137}Nd and ^{137}Pr nuclei were simultaneously populated through the ^{123}Sb(^{19}F, 5n, p4n) reaction at a beam energy of 95 MeV. An isotopically enriched ^{123}Sb target of thickness 840 $\mu g/cm^2$ with ^{197}Au backing of thickness 7 mg/cm^2 was used to carry out lifetime measurements by the Doppler Shift Attenuation Method (DSAM). Gamma ray coincidence events were collected using the Indian National Gamma Array (INGA) at IUAC, New Delhi consisting of 18 Compton suppressed clover detectors, distributed in 5 different angles (32°, 57°, 90°, 123°, 148°) with respect to the beam direction. Three fold coincidence data in list-mode form were acquired online using CANDLE, an acquisition system developed at IUAC.

Data analysis and Results

The offline calibration, gain matching and sorting of the data were carried out using INGASORT program. The coincidence events were then sorted into $4K \times 4K$ $E_\gamma - E_\gamma$ symmetric as well as asymmetric matrices. The RADWARE program was used for coincidence analysis. Previously known level schemes of ^{137}Nd and ^{137}Pr have been confirmed. Fig. 1 shows the partial level schemes containing the MR bands in these nuclei as obtained from the present work. Using the angle dependent asymmetric matrices (all vs 57°, all vs 90° and all vs 148°), lifetimes of the states in the MR bands of these nuclei are being determined by fitting the Doppler broadened $\gamma-$ray energies using the LINESHAPE code. Fig. 2 shows preliminary lineshape fits for the transition energy 474.8 keV ($39/2^- \rightarrow 37/2^-$) in the MR band of ^{137}Nd for the backward (148°) and forward (57°) angle spectra with gate on 285.1 keV ($33/2^- \rightarrow 31/2^-$) transition.

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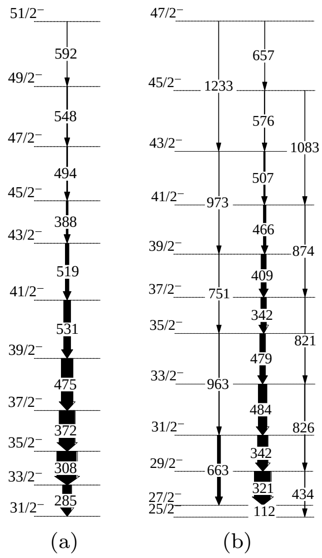

FIG. 1: Partial level schemes of (a)^{137}Nd and (b)^{137}Pr showing the MR bands.

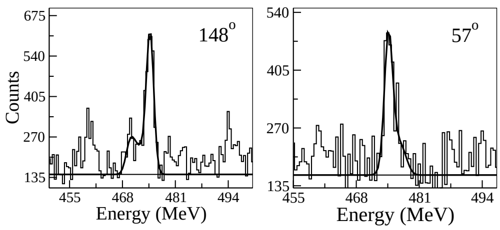

FIG. 2: Doppler broadened lineshapes for 474.8 keV transition for the MR band in ^{137}Nd.

Discussions

In the two nuclei ^{137}Nd (Z=60 and N=77) and ^{137}Pr (Z=59 and N=78) there is a similar crossing of the MR bands as shown in Fig. 3. We note that the MR bands in ^{137}Nd and ^{137}Pr have the configurations $\pi(h_{11/2})^2 \otimes \nu(h_{11/2})^{-1}$ [1] and $\pi(h_{11/2}) \otimes \nu(h_{11/2})^{-2}$ [3] respectively, before the band crossing. Thus the proton particle and neutron hole exchange their characters in the two nuclei. This is an interesting situation. The crossing of MR band in ^{137}Pr is due to the alignment of a pair of low$-\Omega$ $g_{7/2}$ protons [3]. We expect the crossing in MR band in ^{137}Nd is due to the alignment of a pair of high$-\Omega$ neutrons. As shown in Fig. 1, the MR band in ^{137}Pr has weak crossover $E2$ transitions whereas no crossover $E2$ transitions were found in the MR band of ^{137}Nd. This difference in the nature of

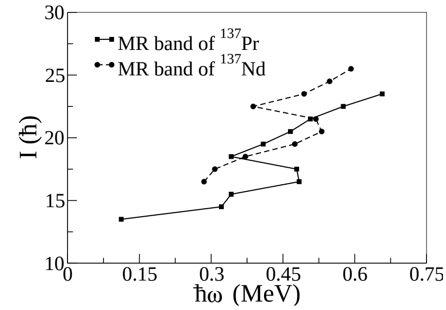

FIG. 3: I $vs.$ $\hbar\omega$ plot for the MR bands in ^{137}Nd and ^{137}Pr.

the MR bands in the two nuclei is interpreted to be due to the difference in the alignments of pair of low/high$-\Omega$ proton/neutron particles/holes in the MR bands of these two nuclei. On determining the lifetimes of the states (analysis in progress), the obtained $B(M1)$ values shall be compared for the MR bands in the two nuclei and the roles of proton/neutron in the MR phenomenon in these nuclei shall be delineated with more certainty. Detailed results will be shown in the presentation.

Acknowledgments

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