Lifetime measurement in the positive parity non-yrast band in ^{177}Re

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Introduction

The Re nuclei with mass A~175 are also known as '*gamma-soft nuclei*' as their nuclear potential is soft towards gamma degree of deformation.In this mass region the presence of various shape driving orbital's near the fermi surface make the nuclear structure studies more interesting. The high-K orbital's like $h_{11/2}$ orbital with K = 9/2 and $d_{5/2}$orbital's with K = 5/2 orbital's, found near the proton fermi surface, are up-sloping as a function of deformation and therefore have a tendency to drive the nucleus to smaller deformations. As the deformation affects the energy of the entire band, the band crossing frequencies corresponding to the alignment of the $i_{13/2}$ neutron pair also observe a shift to lower values for these bands. In fact in the high spin studies done for ^{177}Re nucleus in the past [1-4], a gradual alignment gain is observed for these two high-K bands and has been understood in terms of β–stretching of the nucleus. The gradual alignment shifts the band crossing frequency to lower rotational frequencies relative to the crossing frequency for the intruder $\pi h_{9/2}(K=1/2^-)$ yrast configuration [5]. The shift of the band crossing frequency due to the alignment of a pair of $i_{13/2}$ neutrons for different quasi-proton configurations is asensitive test of the single quasi-particle basis of the nuclear shape. With this motivation, the lifetime measurements of various quasi-particle proton bands in ^{177}Re nucleus have been done with recoil distance Doppler Shift technique [6] using the plunger setup available at the Inter-University Accelerator (IUAC), Delhi. Some part of the data obtained from the experiment is already been published in an earlier communication [7]. In the present work, we intend to report the results obtained for the highly coupled proton $d_{5/2}$ band (K = 5/2).

Experimental Details

In the experiment the high spin states of interest in ^{177}Re nucleus were populated using the heavy ion fusion reaction ^{165}Ho (^{16}O, 4n) at beam energy of 84 MeV, provided by the 15 UD Pelletron accelerator facility at the IUAC, Delhi. In the experiment, the self-supporting foil of ^{165}Ho of thickness ~ 780 μg/cm^2 as target and thick gold foil of thickness ~ 8 mg/cm^2 as stopper was used. To detect the de-exciting gamma rays the GDA setup, consisting of 12 HPGe detectors, was used. The data in singles mode was taken at 22 target-stopper distances ranging from 10-10,000 µm. The quality of data obtained with detectors at the backward angle (144^0 with the beam direction) in theexperiment is shown in Figure 1. In the figure, the shifted (S) and unshifted (U) energy peaks at two different target–stopper distances (D_{T-S}) for gamma transitions of interest have been clearly marked.

Data Analysis and Results

The data analysis has been done using LIFETIME code [8,9]. An extensive account of data analysis is given in [7]. From the extracted level lifetimes, the B(E2) values and the transition quadrupole moments (Q_t) have been obtained using the following formalism.

$$B(E2;\, I \rightarrow\, I-2) = \frac{0.0816}{\tau E_\gamma^5(1+\alpha)}$$

$$B(E2; I\ \rightarrow I-2) = \left(\frac{5}{16\pi}\right) Q_t^2 < I2K0 \mid I-2 >^2$$

Where K is the projection of total angular momentum on the symmetry axis, Q_t is transition quadrupole moment, B(E2) is reduced transition probability and τ is nuclear level lifetime. The variations of experimental Q_t values with rotational frequency along the $\pi d_{5/2}$ band have been shown in Figure 2.

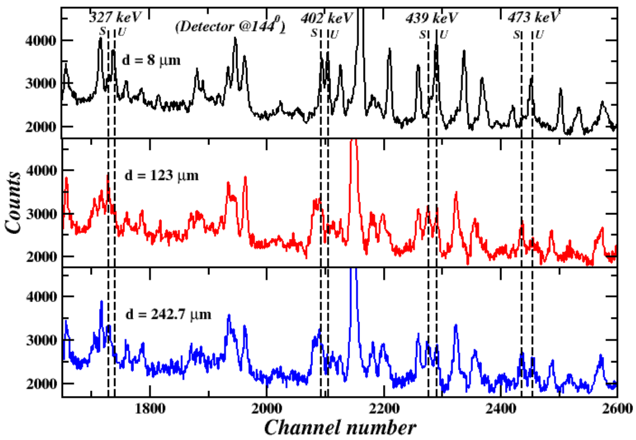

Figure 1. The shifted (S) and unshifted (U) energy peaks for few γ-ray transitions of interest taken at three different target-stopper distances (D_{t-s}) with a gamma detector at backward angle (144^0) with respect to beam direction.

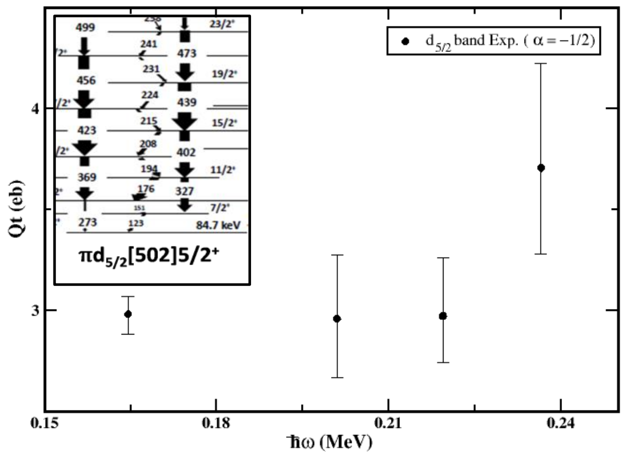

Figure 2. The variation of transition quadrupole (Q_t) moment with rotational frequency for the negative signature partner (α = -1/2) partner of the positive parity $\pi d_{5/2}$ band in ^{177}Re. Inset shows the states of interest in the $\pi d_{5/2}$ band in ^{177}Re [10].

The low but almost steady (with in the error bars) values of the transition quadrupole moment with rotational frequency along the $\pi d_{5/2}$ band, indeed provides justify the small β-stretching of ^{177}Re nucleus in this high –K configuration.

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