Observation of Magnetic Rotational band in ^{131}Xe

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Introduction

In shears mechanism, the observed angular momenta along a band are generated by the gradual closing of the quasi proton and quasi neutron angular momentum blades *i.e.* gradual alignment towards the total angular momentum. This kind of alignment of angular momentum blades results bands consisting of dipole transitions. Such dipole bands are observed in the A ~ 100, 140 and 200 regions and described as Magnetic Rotational (MR) bands in the theoretical framework of shears mechanism [1-3].

Xe isotopes in mass 130 region can be considered as a candidate to exhibit magnetic rotational nature at moderately high spin. Available high-j orbital such as $h_{11/2}$ for both proton particle and neutron holes can possibly act as two angular momentum blades in order to generate high spin states. Such dipole band at high spin was observed in ^{123}Xe (N=69) [4], and proposed to be magnetic rotational one involving $\pi h_{11/2}$ particles and $\nu h_{11/2}$ holes. As one approaches N=82 shell closure, the expected spherical shape of the nucleus makes it favorable to have shears mechanism. In this connection ^{131}Xe (N=77) is an ideal candidate to look for such magnetic rotational bands.

Results

The details of the newly observed yrast and non-yrast structures as obtained in ^{130}Te (α, 3n) ^{131}Xe reaction and Indian National Gamma Array (INGA) detection system is reported in Ref. [5].

One sequence of positive parity dipole transitions is observed above the $21/2^+$ (2249 keV) level which is extended upto $33/2^+$ (5172 keV) level. This band is consist of 1105, 295, 503, 119, 311 and 592 keV transitions. Fig. 1 shows the coincidence spectrum corresponding to 444 keV gate where the new transitions are clearly visible.

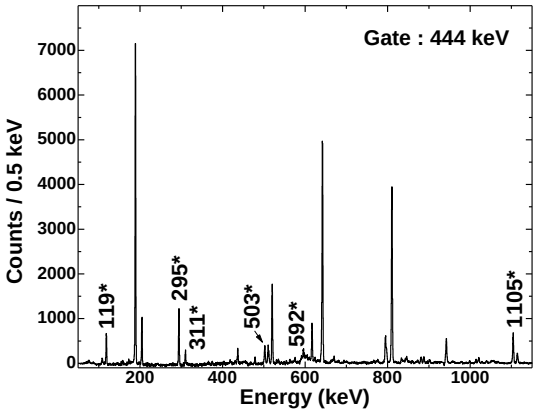

Fig. 1: Coincidence spectrum corresponding to 444 keV gate. Only the γ-rays of interest are marked with '*'.

The dipole and magnetic nature of these transitions are established from their measured DCO ratio (R_{DCO}) and Polarization asymmetry (Δ_{asym}) measurements respectively.

Discussion

The interesting observation for this band is that the upper part of the band is connected to the lower part by a relatively high energy 1105 keV transition. As lower part of this band has a 3 qp configuration thus the upper part of this can have a 5 qp nature. Configuration of the $27/2^+$ state at the upper part of the band can

be obtained from an additional proton alignment in $g_{7/2}/d_{5/2}$ orbital coupled to the 3 qp configuration of the lower part. Therefore, a 5 qp configuration of $(d_{5/2}g_{7/2})^3h_{11/2}^{1}$ X $h_{11/2}^{-1}$ is assigned to this band.

The dipole transitions of energy 119, 311 and 592 keV above the $27/2^+$ state is interpreted in terms of theoretical formalism of Shears mechanism with the Principal Axis Cranking (SPAC) model. In this model we assume, that the angular momentum Vectors $\mathbf{J_1}$ and $\mathbf{J_2}$, produced by the proton particles and neutron holes, respectively, is coupled to the core (**R**) to generate the total spin (I) of the level. This model is a powerful tool to describe the intrinsic characteristics of shears bands. Following this model the energy of each level of this band has been minimized for the band using J_1 = 12 and J_2 = 5.5. This calculation leads to an interaction strength of V_2 = 1.90 MeV. Fig. 2 shows the decreasing nature of B(M1) values as obtained from present SPAC calculation which is one of the signature of MR bands. This calculation also indicates that the 91% of the total angular momentum is generated via shears mechanism.

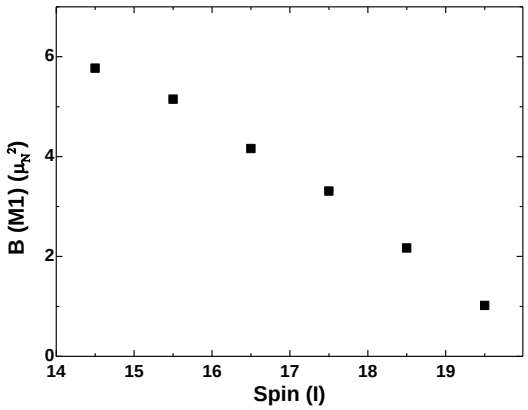

Fig. 2: Variation of B(M1) values as function of level spin as obtained from present SPAC calculations.

Semi-empirical calculation prescribed in ref. [3] is also carried out to characterize this band. According to this the proton and neutron blades interacts by a term $V_2P_2(\cos\theta)$, θ being the angle between the blades. V[I(θ)]=E(I)-E(band head) is plotted as a function of θ in Fig. 3 and fitted with a function $(3/2)V_2\cos^2\theta$. This leads to an interaction strength (V_2) = 1.6 MeV which is in good agreement with SPAC calculations.

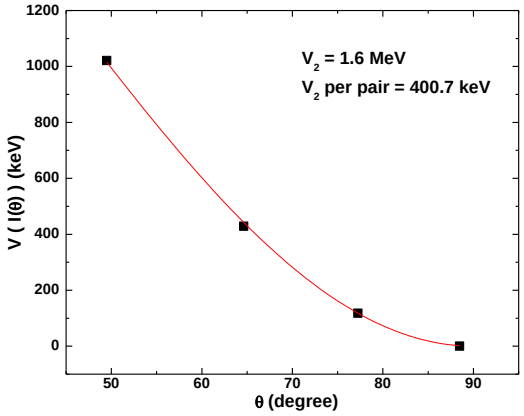

Fig. 2: Variation of V[I(θ)] as function of shears angle.

Thus the present SPAC and semi-empirical calculations describes the MR nature of the 5 qp band of ^{131}Xe quite successfully.

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