Deexcitation of three particle - three hole structure in ^{142}Eu

Sajad Ali[1],* S. Rajbanshi[2], Prithwijita Ray[1], Abhijit Bisoi[3], Somnath Nag[4], S. Saha[5], J. Sethi[5], T. Trivedi[5], T. Bhattacharjee[6], S. Bhattacharyya[6], S. Chattopadhyay[1], G. Gangopadhyay[7], G. Mukherjee[6], R. Palit[5], R. Raut[8], M. Saha Sarkar[1], A. K. Singh[4], and A. Goswami[1]

[1]*Saha Institute of Nuclear Physics, HBNI, Kolkata 700064, India*
[2]*Presidency University, Kolkata 700073, India*
[3]*Indian Institute of Engineering Science and Technology, Howrah 711103, India*
[4]*Indian Institute of Technology, Kharagpur 721302, India*
[5]*Tata Institute of Fundamental Research, Mumbai 400005, India*
[6]*Variable Energy Cyclotron Center, Kolkata 700064, India*
[7]*Department of Physics, University of Calcutta, Kolkata 700009, India and*
[8]*UGC-DAE-Consortium for Scientific Research, Kolkata 700098, India*

Spectroscopic investigation of weakly deformed nuclei in mass A ~ 140 region with Z ~ 64 and N ~ 82 has generated considerable interest because they exhibit large variety of excitation mechanism. The available particles and holes in the high j-orbital, such as $\pi h^{n}_{11/2}$ and $\nu h^{-n}_{11/2}$ in mass ~ 140 region enable us to search for different exotic excitation mechanism through the coupling of angular momentum vectors of the quasiparticles.

To study such particle-hole coupling in A ~ 140 region the ^{142}Eu nulceus has been populated by the fusion evaporation reaction ^{31}P + ^{116}Cd at a beam energy of 148 MeV obtained from the Pelletron-Linac facility at TIFR, Mumbai. The de-exciting γ transitions were detected by the Indian National Gamma Array (INGA) which was consisted of nineteen Compton-suppressed clover detectors at the time of experiment [1].

The partial level scheme (Fig. 1) of ^{142}Eu was established using the coincidence relationship, I_γ, R_{DCO}, $R(\theta)$ and P measurements [3]. Intensity was normalized with respect to 283-keV ($8^+ \rightarrow 8^-$) transition. R_{DCO} values were calculated using 723 and 1032-keV as the gating transition which were of pure E2 type.

A negative parity dipole band (DB II) with band-head at 13^- with rotational like energy spacing is shown in Fig. 1. The origin of the band is proposed due to Shears mechanism in ref. [4] by the transition probability ($B(M1)$) measurement from the extracted level lifetime of the states of DB II.

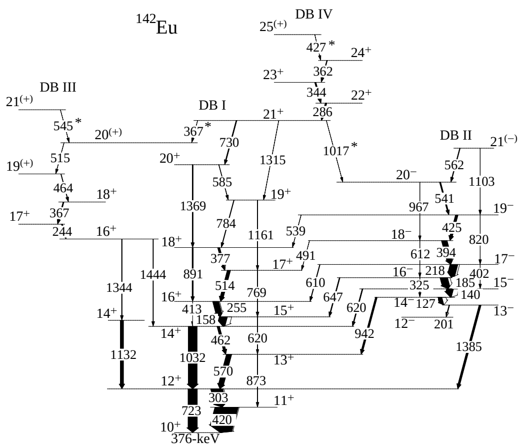

FIG. 1: The partial level scheme of ^{142}Eu obtained from the coincidence relationship, I_γ, R_{DCO}, $R(\theta)$ and P measurements.

In addition, a positive parity dipole band is also observed starting from 16^+ to $20^{(+)}$ states with transition enrgies 244.2-, 367.1-, 464.0- and 515.4-keV respectively as in ref. [2]. A new transition of energy 545.0-keV is placed at top of the band (DB III). The energy spacing in this band also shows rotational like $I(I+1)$ behaviour.

*Electronic address: sajad.ali@saha.ac.in

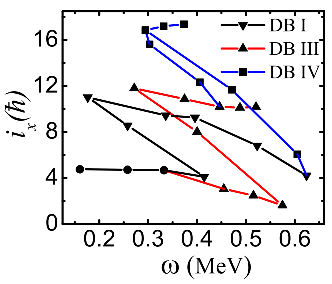

FIG. 2: The nature of the quasiparticle alignment (i_x) against the rotational frequency (ω) of the states are shown for DB I, DB III and DB IV.

In the earlier proposed level scheme [2] another dipole band (DB IV) is also reported which started above the dipole band I (DB I) at very high angular momentum state (21^+). A new dipole transition 427.0-keV is placed at the top of this band (above 24^+) from the coincidence analysis.

The DB IV is feeding into DB I by 729.8-keV ($21^+ \rightarrow 20^+$) and 1314.8-keV ($21^+ \rightarrow 19^+$) transitions. The coincidence measurements between the transitions of DB III and DB IV shows the presence of a connecting transitions of 367.1-keV between 21^+ state DB IV and 20^+ state of DB III. In the gated spectrum of the transitions of DB II, the transitions of DB IV with a new transitions of energy 1017.0-keV is observed which is confirmed as a connecting transition between 21^+ state DB IV and 20^- state of DB II.

In the earlier work the configuration of states up to 11^+ of dipole band I (DB I) was conclusively assigned as $\pi h^{+1}_{11/2} \otimes \nu h^{-1}_{11/2}$ by the shell model calculation [2]. The experimental alignment and routhian for the DB I and DB II above the 11^+ state are in agreement with the theoretical calculations using the Wood-Saxon potential within the deformed harmonic oscillator basis assuming $\pi h^{+3}_{11/2} \otimes \nu h^{-1}_{11/2}$ and $\pi(d_{5/2}/g_{7/2})^{-1} h^{+2}_{11/2} \otimes \nu h^{-1}_{11/2}$ respectively as in the ref. [4]. Beyond the 12^+ state of DB I, two $E2$ transitions of energy 1131.6- and 1343.3-keV is generating angular momentum up to 16^+ which is the band-head of dipole band III. The configuration of the DB III is assigned as $\pi h^{+1}_{11/2} \otimes \nu h^{-3}_{11/2}$ from the alignment and quasiparticle routhian plot comparing it with theoretical single particle routhians.

The assignment of configuration of DB IV needs very careful analysis of the alignment plot of both DB I and DB III (Fig. 2). In the DB I, four quasi-particles configuration $\pi h^{+3}_{11/2} \otimes \nu h^{-1}_{11/2}$ generates a maximum observed angular momentum state 20^+. Angular momentum generation beyond 20^+ is occurred via a band crossing at the crossing frequency ($\hbar\omega$) $\sim$ 0.43 MeV with gain in alignment of $\sim 10\hbar$ and the dipole band DB IV generated with 21^+ as band-head. Thus the crossing of the $h_{11/2}$ neutrons formed DB IV with six quasi-particles $\pi h^{+3}_{11/2} \otimes \nu h^{-3}_{11/2}$ configuration. This six quasi-particles configuration can also be understood from the alignment plot of DB III. Dipole band III (DB III) has four quasi-particles configuration $\pi h^{+1}_{11/2} \otimes \nu h^{-3}_{11/2}$. In the alignment plot DB III also shows back-bending having gain in angular momentum $\sim 7\hbar$ at rotational frequency ($\hbar\omega$) $\sim$ 0.33 MeV and develop DB IV. As a result two aligned $h_{11/2}$ proton quasi-particles couples with the four quasi-particles $\pi h^{+3}_{11/2} \otimes \nu h^{-1}_{11/2}$ configuration and formed the six quasi-particles $\pi h^{+3}_{11/2} \otimes \nu h^{-3}_{11/2}$ which is configuration of the DB IV proposed also from the alignment plot of the DB I. The intrinsic structure of the dipole band DB IV will be explored and present.

References

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