Collective enhancement of nuclear level density in ^{162}Ho

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Nuclear level density (NLD) is an essential ingredient in the Hauser-Feshbach (HF) theory which is widely used in statistical models of nuclear evaporation. Over the years, several efforts have been made to study NLD and its dependency on various key parameters such as excitation energy (E^*), angular momentum, pairing, shell structure, and isospin. But an accurate knowledge of the variation of NLD as a function of nuclear deformation is still absent. For axially deformed nuclei, an enhancement in NLD with respect to the single particle NLD is expected at low excitation energies (E* $\sim$ 8 MeV). This is due to the coupling of the rotational as well as the vibrational degrees of freedom with the single particle excitations. Collective contribution can be counted on top of the single particle NLD $\rho_{int}(E^*)$ for obtaining the total NLD $\rho_{tot}(E^*)$ by using the relation: $\rho_{tot}(E^*) = K_{coll}(E^*)\rho_{int}(E^*)$, where K_{coll}(E*) is the collective enhancement factor. This enhancement is however expected to fade out at higher E^*.

Experimentally, it is non-trivial to identify the signature of collectivity and its fadeout at a finite excitation energy. A Few attempts were already made to understand this effect. Jungans *et al.* [1] first reported the fade-out of collectivity, which was found to be independent of ground state deformation. Another measurement around A$\sim$178 mass region [2], showed a null result over the E^* range of 54-124 MeV. In our previous work, signature of collective enhancementat was observed in the measured neutron spectra for A$\sim$169 and 185 mass regions [3]. In our further work a direct signature of fadeout has been obseved at the residue excitation energy E^*_{res} = 14-21 MeV [4] in a similar mass regions. Recently, Pandit *et al.* [5] and Mohanto *et al.* [6] have tried to estimate the K_{coll} by GDR -γ and α-particle measurements, respectively. However, the measured values are found to be much lower than the predicted K_{coll}. It is therefore important to study the collective enhancement in NLD and its fadeout in different mass regions. In this work, the evaporated neutrons were measured from ^{4}He + ^{144}Sm and ^{4}He + ^{159}Tb reactions involving spherical and deformed target nuclei, respectively.

The experiment was performed using ^{4}He ion beam of energy 26- 42 MeV from the K-130 Cyclotron at VECC. A 4.5mg/cm^2 ^{144}Sm$_2$O$_3$ target sandwitched bewteen two myler foils and a 2.5mg/cm^2 self supporting ^{159}Tb targets were used. Emitted neutrons were detected using eight liquid scintillator (BC501A) based neutron detectors placed at the laboratory angles of 45^o-150^o and kept at a distance of 1.5m from the target center. A 50-element BaF$_2$ detector array was used to generate the start signal for the time-of-flight (TOF) measurement. The neutron and γ discrimination was achieved by both TOF and pulse shape discrimination (PSD) methods using zero cross over (ZCO) technique. The neutron TOF spectrum was converted to energy spectrum using the prompt γ-peak as time reference and proper jacobian transformation. Since the pre-equilibrium contribu-

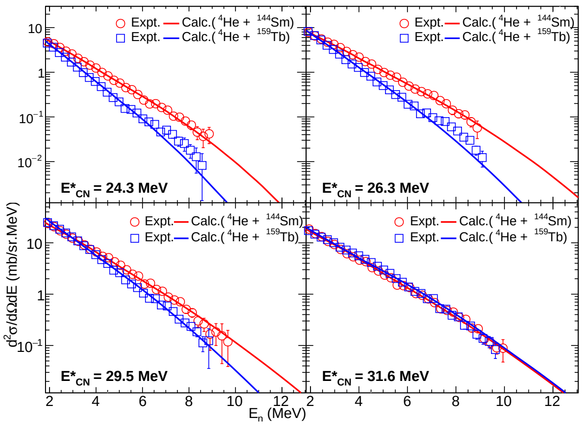

FIG. 1: Neutron energy spectra from the reactions, ^{4}He + ^{144}Sm and ^{159}Tb measured at 150^o are shown in symbols. The calculated spectra using the TALYS code are shown in lines.

tion is known to be minimum at the most backward angle, hence the data received at 150^o were used for further analysis. Measured energy spectra from the two reactions are shown in Fig. 1. The major residue produced in these reactions at the lowest energy are the ^{147}Gd and ^{162}Ho. Measurement has been done at the matching compound nuclear excitation energy E^*_{CN} so that "*fadeout energy*" can be sharply identified from the emitted neutron spectra of these two reactions.

The measured neutron energy spectra were compared with the theoretical spectra calculated with the TALYS-v1.96 code, which uses HF theory. In the above calculation, isospin dependent (Z-Z$_0$) prescription of the NLD parameter ($\tilde{a}$) was included in the BSFG model for the estimation of NLD [7]. Here, Z_0 is the atomic number of the β-stable isobar for a given nuclear mass. The calculated spectra are compared in Fig. 1. The neutron energy spectra for the deformed residue ^{162}Ho, show a rapid change in the slope with beam energy. On the other hand, the spectra obtained for the spherical ^{147}Gd show a minimum change in the slope. Inverse NLD parameter K obtained for ^{162}Ho changes from 8.4 to 11.9, whereas for ^{147}Gd it changes from 12.0 to 11.7 in the chosen beam energy range. At E^*_{CN}=31.6 MeV, slope of the neutron energy spectra corresponding to deformed ^{162}Ho matches with that from the spherical ^{147}Gd, indicating a fadeout of collective enhancement for ^{162}Ho corresponding to E^*_{res} $\sim$ 18 MeV. Further details will be discussed during the symposium.

Two of the authors (R. Shil and A. Chakraborty) would like to thank UGC-DAE CSR, Kolkata for providing financial assistance through CRS project no. UGC-DAE-CSR-KC/CRS/19/NP10/0921/0963.

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