Isospin dependence of nuclear level density parameter at A∼120 mass region

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An explicit knowledge of nuclear level density (NLD) is a crucial ingredient to determine the nuclear reaction cross sections and nuclear reaction rates. Over the past few decades a significant amount of research has been carried out to understand the nature of variation of NLD parameter on various factors such as excitation energy E^*, angular momentum, pairing, shell structure, deformation, and parity etc. But one of the key issues, which still needs attention is the dependence of NLD parameter "a" on isospin component $T_3 = (N - Z)/2$ or N-Z asymmetry, where N and Z are the neutron and proton numbers, respectively.

The general form of the NLD parameter, which smoothly depends on the mass number A [1] can be expressed as shown in Eq. 1.

$$a = \alpha_1 A \tag{1}$$

$$a = \frac{\alpha_2 A}{\exp\left[\beta(N - Z)^2\right]} \tag{2}$$

$$a = \frac{\alpha_3 A}{\exp\left[\gamma(Z - Z_0)^2\right]} \tag{3}$$

However, an explicit dependence on N and Z is expected rather than only on A. Two analytical expressions which include the N and Z dependence of NLD parameter have been suggested by Al-Quraishi et al. [2, 3] and are given in Eqs.2 and 3. Here α's, β and γ are the constant factors. These expressions were obtained by analysing the measured data in the mass region $20 \leq A \leq 110$ and E* $\sim$ up to 8 MeV.

A few experimental attempts have been made to explore the isospin dependence of NLD in A $>$ 110 and E* $>$ 8 MeV region. Evaporated particle spectra measured at $A \sim 160$ mass region showed a very weak dependence on N-Z asymmetry [4]. However, a recent measurement at mass region $A \approx 110$ has indicated a strong isospin dependence of NLD parameter [6]. Another measurement performed in A $\sim$ 140 mass region found, $N - Z$ prescription described the data better than the other available prescriptions [5]. However, in a recent work $Z - Z_0$ dependence is found to be the most suitable one in explaining the evaporated neutron spectra in A $\sim$ 110 mass region [7]. More investigations are required to explore the isospin dependence of "a", in particular for a chain of isotopes. This is attempted in the present work by measuring the neutron evaporation spectra from ^{116,120,128}Te isotopes populated with $25 \leq E^* \leq 42$ MeV.

The experiment was carried out using ^{4}He-ion beam in the energy range of 26 to 44 MeV from the K130 cyclotron at VECC. Isotopically enriched ^{112,116,124}Sn targets of thickness $\sim$2.0 mg/cm^2 were used. Emitted neutrons were detected using four liquid scintillator (BC501A) based detectors placed at the

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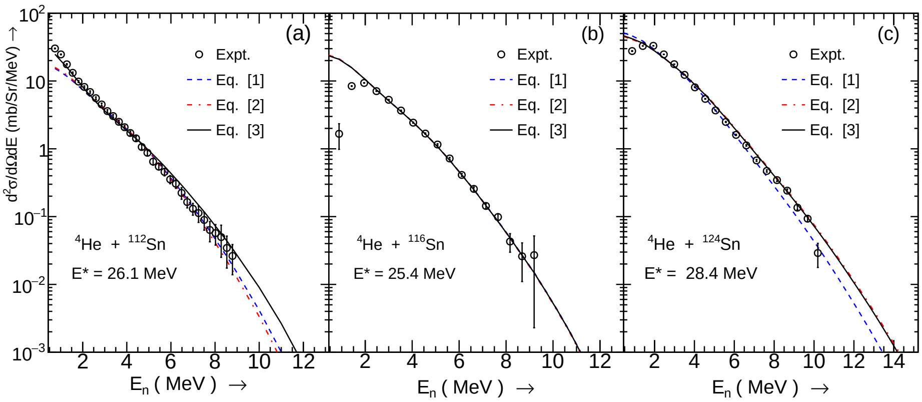

FIG. 1: Neutron energy spectra from the reactions, ^{4}He + ^{112,116,124}Sn measured at 150^o are shown in symbols. The calculated spectra using the BSFG model for three different prescriptions of NLD parameter are shown in lines.

laboratory angles of 55°, 120°, 135°, and 150° and kept at a distance of 1.5 m from the target center. A 50-element BaF_2 gamma-ray detector array was used to generate the master trigger for the time of flight (TOF) measurement. The neutron and gamma separation was achieved by both TOF and pulse shape discrimination using zero cross over (ZCO) measurements. The neutron TOF spectrum was converted to energy spectrum using the prompt gamma-peak as time reference and using the standard jacobian. The neutron energy spectra were also corrected for detector efficiency and the scattered neutrons contribution. Since the pre-equilirium contribution is less at the backward angles, hence 150° angle data were used for the study of NLD parameter. Measured neutron energy spectra from the three reactions are shown in Fig. 1(a)-(c).

Measured spectra were then compared with the spectra calculated using the TALYS-1.8 code in which Hauser-Feshbach (HF) compound nucleus reaction model was used. NLD was calculated using the phenomenological Back-shifted Fermi Gas (BSFG) model. Among the three nuclei, ^{119}Te which lies near the β-stability valley was taken as a reference nucleus, for which the parameter α's (see Eqs. 1, 2 and 3) were changed in the calculation to get the best fit with the measured data. Other parameters β and γ were taken from global systematics [3]. For the other two nuclei, the same set of parameters were used as in ^{119}Te. However, a E^* dependence of parameter α's were considered. The calculated spectra using three different prescriptions are shown in Fig. 1(a)-(c) which shows that the isospin dependent prescription in the form of $(Z - Z_0)$ is the most suitable to explain the evaporated neutron data for all three reactions. Further details will be discussed during the symposium.

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