Extraction of angular momentum gated nuclear level density parameter

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Nuclear level density (NLD) parameter is an important ingredient in all statistical model codes, which are generally used for reaction modelling such as fusion, multifragmentation and spallation. An accurate determination of NLD is essential for better prediction of statistical model codes. There are several studies on the variation of NLD with temperature and mass. However, the information on the variation of NLD as a function of angular momentum is quite limited. In recent years, there have been a few experimental studies on the variation of NLD with angular momentum for medium mass nuclei using α-particle evaporation spectra [1], which showed that for some nuclei (^{109}In, ^{122}Te, ^{123}I) the inverse level density parameter k (k = A/a ; a is the level density parameter and A is the mass number of the compound nucleus) increases with the increase in angular momentum (J), whereas for ^{113}Sb it decreases with the increase in J. However, the theoretical calculation [2] on ^{113}Sb predicts that the k value should increase with J. The charged particle evaporation spectra are in general affected by the coulomb barrier and its modification under nuclear deformation at higher spin, which may introduce some uncertainty in the determination of k . So, it is worthwhile to re-investigate the system using neutron as a probe, which is least effected by the above effects. Here, we report our recent results on the experimental determination of NLD as a function of angular momentum for ^{119}Sb using neutron evaporation as probe. We extracted the values of k as function of angular momentum by measuring γ-ray fold gated neutron evaporation spectrum in ^{4}He + ^{115}In fusion reaction using 30, 35 and 42 MeV ^{4}He ion beams from VECC K130 cyclotron. Seven TOF liquid Scintillator (BC501A) detectors have been used to detect neutrons produced in this reaction in coincidence with a 50 element BaF2 based low energy γ multiplicity filter array which records the γ-ray fold (and vis-a-vis the angular momentum population) on event-by-event basis. The neutron detectors were placed outside the scattering chamber at angles 30°, 45°, 75°, 90°, 105°, 120° and 150° with respect to the beam direction at a distance of 150 cm from the target. Neutron energy has been measured using Time of Flight (TOF) technique whereas the neutron gamma discrimination was achieved by pulse shape discrimination (PSD) and time of flight. Neutron TOF was converted to neutron energy using prompt gamma peak in TOF spectrum as time reference. The efficiency correction for neutron detector was done using Monte Carlo Computer code NEFF. The laboratory neutron energy spectra were then corrected for background for further analysis.

The neutron energy spectrum was also calculated using the statistical model code CASCADE [3]. The CASCADE calculated neutron energy spectrum thus obtained was converted to lab system using the proper Jacobian transformation. The CASCADE spectra in lab frame have been folded with the time of flight energy resolution. The most sensitive parameter influencing the shape of the calculated particle spectra is the NLD parameter. The sensitivity is more for high energy part of

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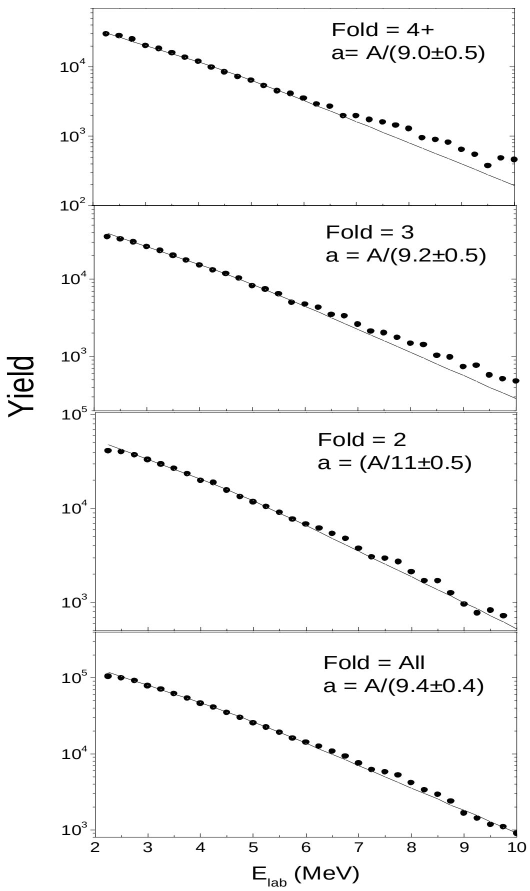

FIG. 1: Experimental neutron energy spectrum (filled circle) with CASCADE prediction (solid line) at $\theta_{lab} = 150^{\circ}$, $E_x = 42.9MeV$. Statistical errors are within the symbol.

the spectra well above the evaporation peak. The folded spectra thus obtained were compared with the measured neutron energy spectra using Chi-square minimisation technique within the range 3 MeV to 7 MeV to derive level density parameter. Fig. 1 shows the experimental neutron energy spectra along with respective CASCADE predictions. An average angular momentum $< J >$, corresponding to each γ- ray fold was assigned using the procedure as discussed in [4].

The extracted inverse level density parameters with uncertainty corresponding to different folds are shown in Table 1. It is evident from Table- 1 that the k value decreases with increase in J. Similar trend has also been observed for data taken at $E_x \sim 31$, 36 MeV for the same system (not shown). This is consistent with the earlier measurement [1]. It is also evident from Fig. 1 that for higher fold (4+) data, the statistical model calculation cannot properly explain the high energy tail, which should be investigated further.

TABLE I: Measured values of gamma fold, avg. angular momentum and inverse level density parameter.

Fold	$< J >$	k
All	16.9±6.4	9.4±0.4
2	14.1±5.2	11.0±0.5
3	16.8±5.4	9.2±0.5
4 or more	21.1±6.8	9.0±0.5

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