Angular momentum gated neutron evaporation studies

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The nuclear level density (NLD) parameter is an important ingredient in the statistical model calculation of nuclear cross section. There has been many attempts to refine our knowledge on the level density parameter, as there could be large uncertainty in the reaction cross section calculation due to the uncertainty in level density. Experimental information on the nuclear level density parameter comes from two major sources, i) thermal neutron capture resonance at low excitation energy and angular momentum ii) particle evaporation spectra in fusion reaction at high excitation energy and angular momentum. Experimental information on angular momentum dependence of the level density parameter is quite limited. Another motivation behind the present experiment is in connection with the measurement of high energy γ- ray spectrum. In the analysis of Giant dipole resonance (GDR) measurement the NLD parameter is a very important ingredient.

We investigated the inverse level density parameter k (k = A/a, where A is the mass number of the compound nucleus) as a function of angular momentum by measuring γ- ray fold gated neutron evaporation spectrum in ^{4}He + ^{115}In fusion reaction using 35 MeV ^{4}He ion beam from VECC K130 cyclotron. Charged particle detection telescope (50 μ Si -SSSD Δ E + 500 μ Si -DSSD Δ E/E + 4cm CsI(Tl) E) and TOF liquid Scintillator (BC501A) detectors [1] have been used to detect light charged particles and neutrons produced in this reaction. Event-by-event data of the populated angular momentum were recorded using a 50 element BaF_2 based low energy γ multiplicity filter array in coincidence with the emitted neutrons and charged particles. Actual experimental setup is shown in fig.1. 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. The charged particle detector telescope was placed at mean angle 140° and covering the angular range ± 18°. Here we report initial analysis of the neutron data.

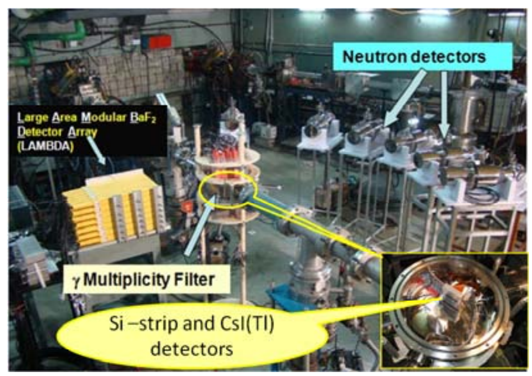

Fig. 1 Experimental setup.

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 [2]. The laboratory neutron energy spectra were thus transformed to the centre of mass system (C.M.) for further analysis. The details of the neutron analysis technique have been reported earlier [1].

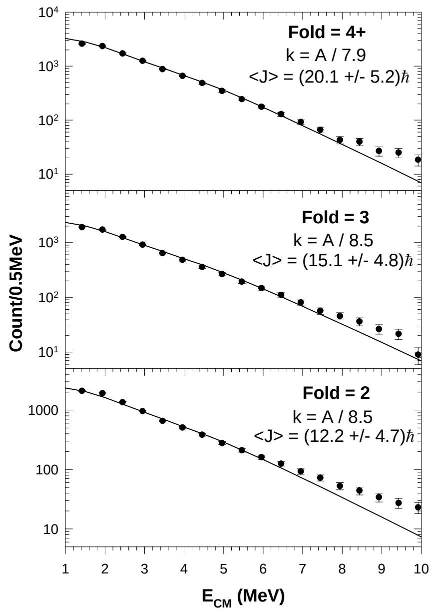

Fig. 2 Experimental neutron energy spectrum (filled circles) with CASCADE prediction (solid line).

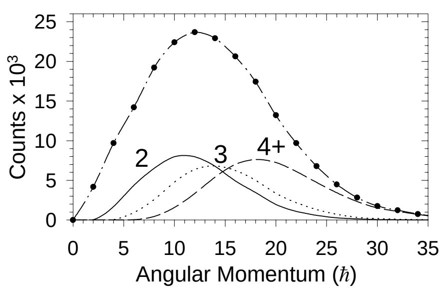

Fig. 3 The sampling of the total angular momentum distribution by gating different folds observed in the fold distribution of the multiplicity filter.

The C.M. neutron energy spectra thus obtained were compared with CASCADE calculation using Chi-square minimisation technique to derive level density parameter. Fig. 2 shows the experimental neutron energy spectra along with respective CASCADE predictions. Fig. 3 shows the angular momentum distribution obtained in this experiment. Each γ- ray fold corresponds to a window of the angular momentum populated in the residual nuclei. An average angular momentum < J >, corresponding to each γ- ray fold was assigned using the procedure as discussed in Ref [3].

In summary, we have measured the γ- ray fold gated neutron energy spectrum in the reaction that populate residue nuclei A ~ 118, Z~ 49, with an excitation energy ~36 MeV. The neutron energy spectrum for different fold were fitted with corresponding CASCADE calculation using Chi-square minimisation technique to determine the inverse level density parameter k = A/a. The k value for fold 2 and fold 3 are A/(8.5±0.5), whereas for fold 4 it is A/(7.9±0.5). The results have been summarised in Table 1. Detailed analysis is in progress.

Fold	Avg. Angular Momentum	k
2	12.2±4.7	A/(8.5±0.5)
3	15.1±4.8	A/(8.5±0.5
4+	20.1±5.2	A/(7.9±0.5)

Table.1 Measured values of fold, avg. angular momentum and k.

References

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