Study of nuclear level density parameter using neutron

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A systematic investigation of properties of hot nuclei can be studied by detecting particles evaporated from it. The distribution of evaporated particles can be studied using statistical model. Neutron (or light-particle) evaporation is very sensitive to the excitation energy, nuclear level density and transmission coefficients. The nuclear level density of the compound nucleus is an essential quantity in statistical model based calculation. In present report, the inverse level density parameter is estimated by detecting evaporated neutron spectra from the compound nucleus $^{185}Re^{*}_{75}$ populated using system $^{4}He_{2} +^{181} Ta_{73}$ and comparing it with CASCADE [1] prediction.

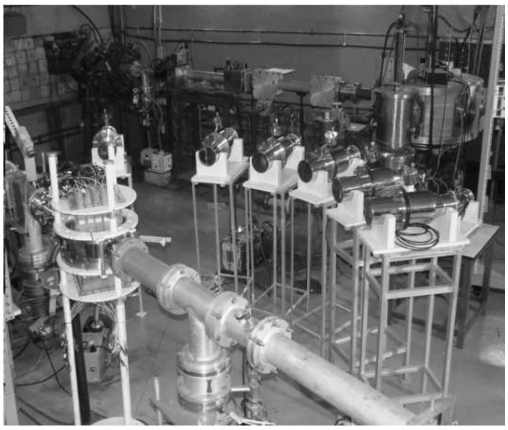

FIG. 1: Experimental Setup

Experiment has been performed using α (28, 30 , 35 and 40 MeV) beam from K130 Cyclotron at VECC. The evaporated neutron was measured using the liquid scintillator (BC501A) detectors [2] of size 5" × 5" placed at a distance 150 cm from the target at angles 46^0, 77^0, 92^0, 107^0, 120^0 and 150^0 with respect to the beam direction. 5 × 5 array of BaF_2 detector are placed on top and bottom of scattering chamber to detect gamma rays evaporated in coincidence with neutron to estimate the populated angular momentum in the event. Experimental neutron energy spectra was obtain using time of flight (TOF) technique whereas $n-\gamma$ seperation was achieved by pulse shape discrimination (PSD) technique. Neutron yield was corrected using the neutron detector efficiency (detector efficiency was calculated using code NEFF [3]) and constant background was subtracted.

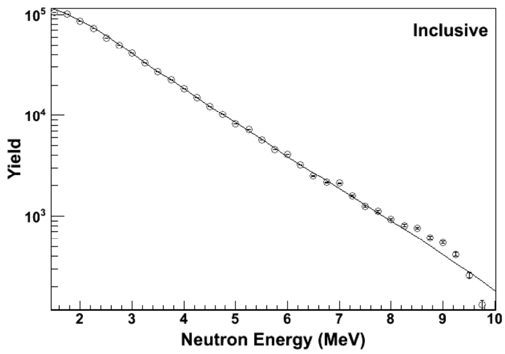

FIG. 2: Experimental neutron spectra (circle) with spectra calculated using CASCADE (line)

Theoretical neutron spectra was estimated using the statistical model based code CASCADE. Theoretical spectra was transformed

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into lab frame using proper jacobian transformation and convoluted with the Time-Of-Flight energy resolution as given below

$$\left(\frac{\Delta E}{E}\right)^2 = \left(\frac{2\Delta\tau}{t}\right)^2 + \left(\frac{2\Delta l}{l}\right)^2 \qquad (1)$$

where $\Delta\tau$ is the time resolution, l is flight path of neutron, Δl is the flight path spread due to the length of detector.

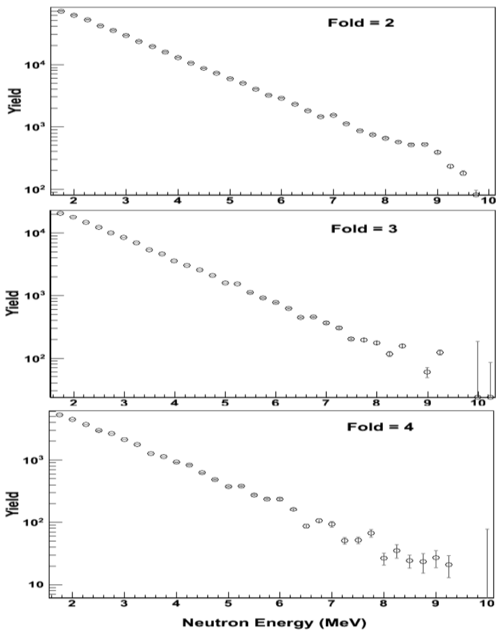

FIG. 3: Experimental neutron spectra for different γ- fold.

In the CASCADE calculation, we have used the Ignatyuk prescription [4] to include shell effects into statistical calculation. According to this prescription, level density parameter a is expressed as

$$a = \tilde{a}[1 - \frac{\triangle S}{U}(1 - exp(-\gamma U))] \qquad (2)$$

$$\gamma^{-1} = \frac{0.4A^{4/3}}{\tilde{a}} \qquad (3)$$

where $\tilde{a}$ is the asymptotic Fermi gas value of the liquid drop level density, $\triangle S$ is the shell correction and U is the thermal energy.

Experimental neutron energy spectra (from 40 MeV α on Ta) was fitted with spectra obtained using code CASCADE using χ^2 square minimization technique by varying inverse level density parameter $k(k = A/\tilde{a}$, where A is mass number.). The inverse level density parameter was found to be $k = A/(7.9 \pm 0.5)$ by fitting experimental spectra with CASCADE as shown in Fig.2.

In summary, inclusive neutron energy spectrum was very well reproduced by CASCADE with inverse level density parameter k = $A/(7.9 \pm 0.5)$. We have also extracted the γ-ray fold gated neutron energy spectrum from the compound nucleus ${}^{185}Re^*_{75}$ with an excitation energy 36.9 MeV (as ahown in Fig.3) to study angular momentum dependance of nuclear level density parameter. Detailed analysis is in progress.

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References

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