Study of light-particle evaporation spectra (*n*, *p*, *α*) in ^{4}He+ ^{93}Nb reaction.

Pratap Roy*, K. Banerjee, S. Kundu, T. K. Rana, C. Bhattacharya, M. Gohil, G. Mukherjee, J. K. Meena, R. Pandey, H. Pai, A. Dey, T.K. Ghosh, S. Mukhopadhyay, D. Pandit, S. Pal, S. R. Banerjee, and S. Bhattacharya
Variable Energy Cyclotron Centre, 1/AF, Bidhan Nagar, Kolkata - 700064, INDIA
* *email: roypratap@vecc.gov.in*

Introduction

The nuclear level density (NLD) is an important ingredient in the statistical model calculation of nuclear cross section. Even after substantial theoretical effort it is not yet possible to have a complete microscopic solution including all known nuclear effects that can lead to a complete analytical form of NLD. So the understanding of variation of NLD over a wide range of excitation energy and angular momentum comes only from the phenomenology based semi-empirical formulations [1]. Hence the experimental determination of nuclear level density parameter plays an important role. There have 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 [2]. Experimentally, the knowledge about level density parameter at high excitation energy and angular momentum can be obtained from the study of particle evaporation spectra in fusion reaction. The slope of the exponential tail of the kinetic-energy spectrum gives sensitivity to the value of NLD. In order to extract the value of the level density parameter and to see its angular momentum dependence, we have measured the light-particle evaporation spectra in ^{4}He on ^{93}Nb reaction.

Experimental Details

The experiment was performed using 35 MeV ^{4}He beam from the VECC K-130 cyclotron facility. A self-supporting foil of ^{93}Nb with the thickness ~1 mg/cm^2 was used as the target. The compound nucleus ^{97}Tc* was populated by the complete fusion reaction at an excitation energy of 36 MeV. To detect and identify the charged particles emitted during the compound nucleus evaporation process, a 3-element telescope consisting of a 50μm single-sided silicon strip detector (16 channels), 500μm double-sided silicon strip detector (16 X 16 channels) and backed by two CsI(Tl) crystals (thickness 4 cm) was mounted at the mean angle of 147^0 covering an angular range of ±17.5^0. The solid angle opening of the strip detector was kept about 21.3 mSr (3 X 4 strips) for charge particle detection. Four liquid-scintillator (BC501A) detectors, each covering a solid angle ~ 5.63 mSr, were placed outside the scattering chamber at angles 92^0, 107^0, 121^0 and 151^0 with respect to the beam direction at a distance of 150 cm from the target, to detect the emitted neutrons.

Neutron energy has been measured using the Time of Flight (TOF) technique whereas the neutron gamma discrimination was achieved by both pulse shape discrimination (PSD) and time of flight. In the present experiment, populated angular momentums were recorded by measuring the γ- multiplicity using a 50 element BaF_2 based low energy γ-ray filter array. In converting the neutron TOF to neutron energy, the prompt γ peak in TOF spectrum was used as the time reference. The efficiency correction for the neutron detectors were performed using Monte Carlo Computer code NEFF [3]. Data from the neutron and the charge particle detector were recorded in event by event mode in coincidence with γ- multiplicity. The fold-gated *α*-particle, proton, and neutron energy spectra were measured to study the angular momentum dependency of NLD. Here fold is defined as the number of BaF_2 detectors firing simultaneously in an event, which is directly related to the compound nucleus angular momentum. A further detail of the experimental setup can be seen in Ref. [4]. In this paper we report the preliminary results of the analysis of the inclusive neutron, proton and alpha particle data.

Results and Discussions

The background subtracted neutron, proton, and alpha particle energy spectra measured at various laboratory angles, were transformed to compound nucleus center-of-mass (c.m.) system using the standard Jacobian transformation. In the center-of-mass system, the spectra measured at different back angles overlapped very well, indicating that the spectra originated from an equilibrated compound nuclear source. The angle averaged experimental spectra for neutron, proton and α- particle are shown by the solid circles in Fig.1. The theoretical predictions of the statistical model calculations performed using the computer code CASCADE [5], are shown by solid lines in Fig.1. In the calculation the level density parameter was varied to get the best fit to the experimental data, whereas variation of the other parameters were observed to have less significance in determining the shape of the spectra. The best fits to the experimental data were obtained by the chi-square minimization technique.

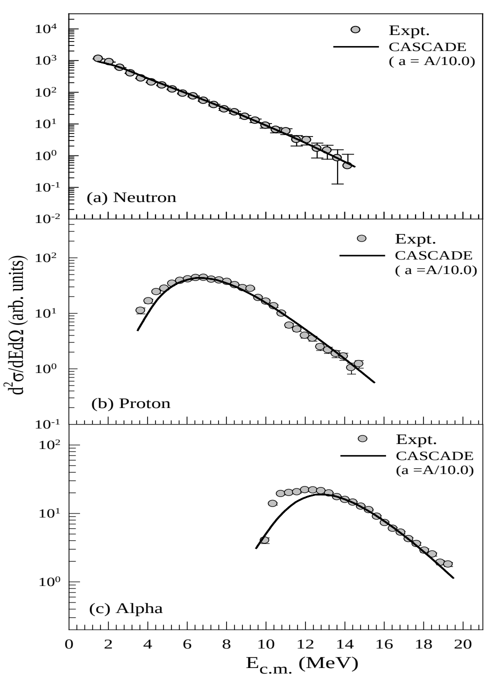

Fig.1 Experimental (a) neutron, (b) proton, and (c) alpha energy spectra alongwith the CASCADE predictions (solid lines).

The experimental neutron, proton, and alpha particle spectra have been fitted simultaneously and consistently by the CASCADE calculation using a level density parameter a=A/10.

The fold gated particle spectra have been extracted for all the three channels as shown in Fig.2. The analysis of the fold gated spectra is being carried out and will be presented. The simultaneous analysis of all light particle evaporation spectra in the same experiment will be helpful in understanding the angular momentum dependence of NLD in a better way.

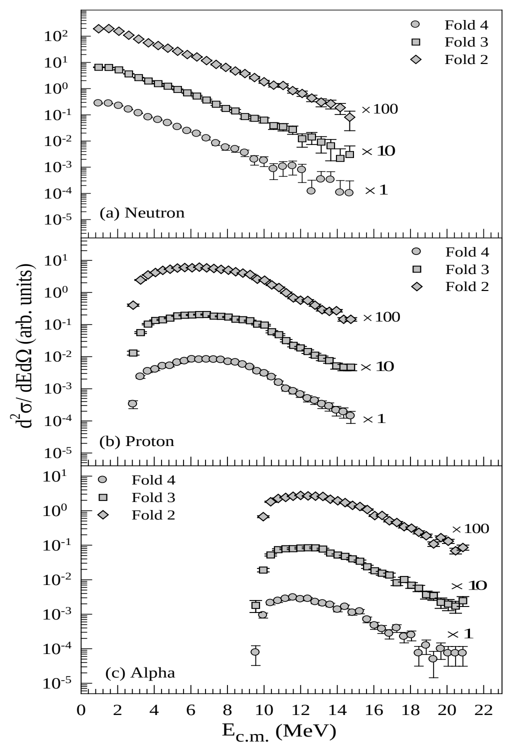

Fig. 2 (a) Neutron, (b) proton, and (c) alpha energy spectra for different folds.

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