Exploring collective enhancement of nuclear level density

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Introduction

Axially deformed nuclei are predicted to have nuclear level density which is σ^2 times higher over the intinsic level density [1, 2] where, σ is spin cut off factor. This is known as Collective Enhancement of nuclear Level Density (CELD). The enhancement vanishes with increase in energy as the nucleus becomes spherical. First experimental signature of CELD was found on fission fragment yield distribution [3]. In recent years, evaporated neutron spectra and high energy γ-ray spectra have been used to explore CELD and its fadeout [4–6]. However, similar study using evaporation α-particles was reported for ^{18}O+^{160}Gd at excitation energy of $54-124$ MeV but no evidence of CELD was found [7]. In this study we have measured evaporated α-particle spectra for reactions ^{12}C+^{116}Sn and ^{12}C+^{159}Tb at lower excitation energy to search for experimental evidence of CELD.

Experiment

Experiment was carried out at BARC-TIFR pelletron using beam of ^{12}C of energy $47-63$ MeV. Self supporting targets of ^{116}Sn and ^{159}Tb were used for this experiment. Two $E-\Delta E$ telescope detectors, made of silicon strip detectors were placed at angle of $\pm155^\circ$ with respect to the beam direction. Evaporated α-particles were detected at five beam energies and converted into α-particle spectra.

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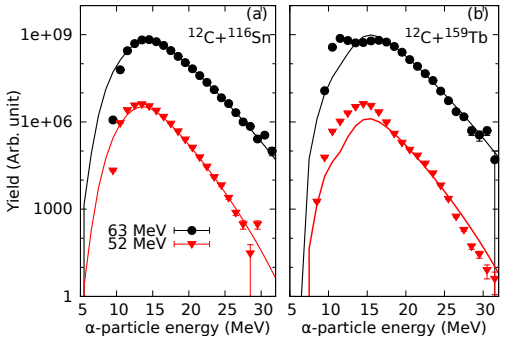

FIG. 1: Evaporated α-particle spectra for reactions (a) ^{12}C+^{116}Sn and (b) ^{12}C+^{159}Tb. Calculated spectra are shown by lines.

Result and analysis

Evaporated α-particle spectra were compared with statistical model prediction using the code CASCADE. Fig.1 shows experimental spectra for both the reactions at beam energies of 52 and 63 MeV. Inverse level density parameter k was treated as free parameter to get the best fit of the experimental spectra. Chi square minimization method was used to obtain best fits over the particle energy range of $17.5-30.5$ MeV. The value of k, obtained from best fits, are shown in Fig.2 as a function of CN excitation energy. It is found that for ^{12}C+^{116}Sn, the value of k varies little over the studied energy range whereas, for ^{12}C+^{159}Tb, k increases with decreasing beam energy. Similar trend was observed for ^{11}B+^{181}Ta when k was extracted from evaporated neutron spectra and this was attributed to the fadeout of

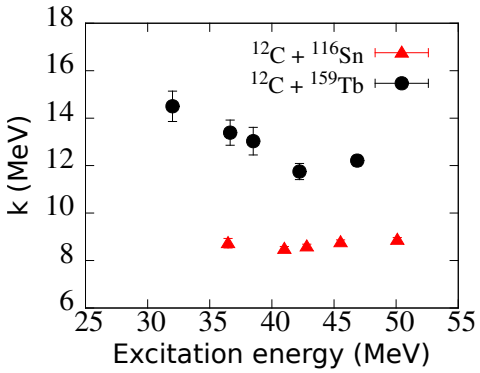

FIG. 2: k, extracted by fitting α-particle spectra, as a function of excitation energy .

CELD [6].

To explore the origin of high k value at low energy for ^{12}C+^{159}Tb, experimental α-particle spectra were compared with statistical model calculation after incorporating CELD. The value of $k(= 9.5)$ for these calculations was taken from ^{4}He+^{169}Tm reaction [4] which populates daughter nuclei in the same mass region. The amplitute of the enhancement was 4 and the critical energy of fadeout was taken as 15.0 MeV. Calculations were done with and without the collective enhancement which are shown in fig. 3 for two beam energies. Experimental spectra are shown by symbols and calculations with and without CELD are shown by red and black lines, respectively. It can be seen from the figure that with enhancement factor, α-spectrun at 52 MeV beam energy is better expleined by the calculation. All other experimental spectra can also be explained with same value of $k = 9.5$ after including CELD. This indicates that the higher k value at low beam energy is due to CELD and its fadeout. This study shows that evaporated α-particle spectra can be used to probe CELD and its faceout.

Acknowledgments

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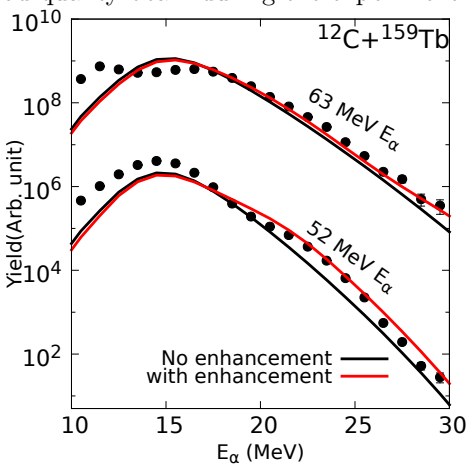

FIG. 3: α-particle spectra for ^{12}C+^{159}Tb. Black and red lines show calculations without and with collective enhancement.

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