Investigation of nuclear level density parameter

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Introduction

The level density is one of the most important quantities for describing the statistical properties of excited nuclei. Study of evaporated charge particle energy spectra give information about the main ingredient of statistical model, the nuclear level density and its dependence on excitation energy. Measurement of these properties has applications in current research into fusion-fission dynamics and nuclear reaction cross sections calculations. The major source of knowledge about level densities at higher excitation energies and spins arises from particle-evaporation spectra in heavy-ion fusion reactions analysed in the framework of the statistical model [1]. It have been observed that NLD parameter a have variation with excitation energy. The energy variation of NLD parameter *a* have been measured by several theoretical approaches and experimental methods. It was observed from experimental analysis of evaporation spectra that for low excitation energy nuclei, $a \sim A/8$ MeV; but for high excitation energy *a* is around A/13 MeV^{-1}. It is prime interest to carry out further measurement to understand the NLD parameter *a* as function of excitation energy.

In the present report we have measured alpha particle energy spectra from two systems $^{126}Xe^*$ and $^{208}Po^*$ produced in heavy ion induced fusion reaction at excitation energy 63 MeV and 52 MeV respectively.

Experimental Details

The experiment was carried out using BARC TIFR Pelletron-Linac Accelerator facility at Mumbai. ^{11}B beam of 60 MeV energy was bombarded on self-supporting targets ^{115}In (750 μg/cm2 thickness) and ^{197}Au (800 μg/cm2 thickness). To detect the reaction product we used ΔE-E telescope of solid angle 13 msr mounted in the reaction plain. Telescope Consisted Silicon Pad detector of 300 μm thickness as ΔE and CsI (Tl) detector of 10mm thickness as E detectors. Measurement was carried out at angular range of 155^o to 124^o in lab frame. Two silicon monitor detectors were also used to ascertain the quality of beam and for normalization purpose at 30^o. Energy calibration of Silicon pad detectors were done with alpha particle from radioactive source $^{229,232}Th$ and in beam measurement using Rutherford back scattering (RBS) from ^{181}Ta at a low beam energy (39 MeV ^{11}B). Simulations of RBS spectra were made using SIMNRA code [2]. CsI(Tl) detectors were energy calibrated using alpha particle spectra from $^{228,229}Th$ source.

We are interested in the high energy tail part of the energy spectra of alpha particle generating form evaporation of excitation nucleus. Total energy of alpha particle is obtained by summing the alpha particle energy which was stopped in ΔE, was obtained by using the pulse shape discrimination method (PSD) and transmitted alpha particle energy which was separated by telescope method. The laboratory alpha particle energy spectra were converted in the centre of mass frame using standard Jacobian method. The energy spectra measured in centre of mass frame at different angle is overlapped very well which shown in Fig.1 for two system, indicating that the spectra originated from the evaporation process.

Data Analysis

For theoretical calculation we used Empire [3] reaction code, which is the most sophisticated publicly available code designed for reaction cross-section calculations. Measured α particle energy spectra in centre of mass frame were compared to empire reaction model code prediction. In Empire code there are four options for level density calculations and we used the default Enhanced Generalized Superfluid Model (EGSM) options.

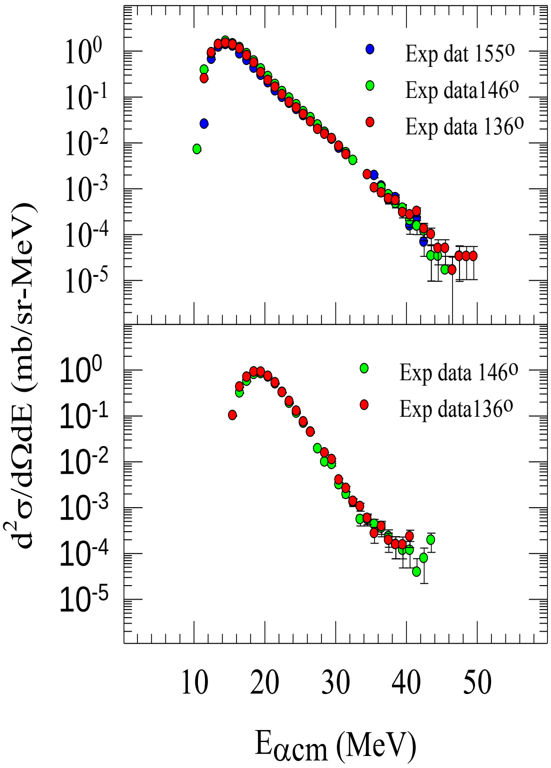

Fig1: Centre of mass α energy spectra measured for $^{11}B+^{115}In$ and $^{11}B+^{197}Au$ reaction at different angle.

The level density parameter is obtained by comparing the Empire code prediction to experimentally measured spectra. The best fit of experimental data at high energy tail part was obtained with NLD parameter a~A/16.7 for ^{11}B + ^{115}In and a~ A/16 for ^{11}B + ^{197}Au. Experimental data were also fitted with exponential decay equation. Derived nuclear level density parameter using the exponential decay fit for above systems are A/15.7 and A/15.35 respectively. This is preliminary results. The detail analysis and results will be presented.

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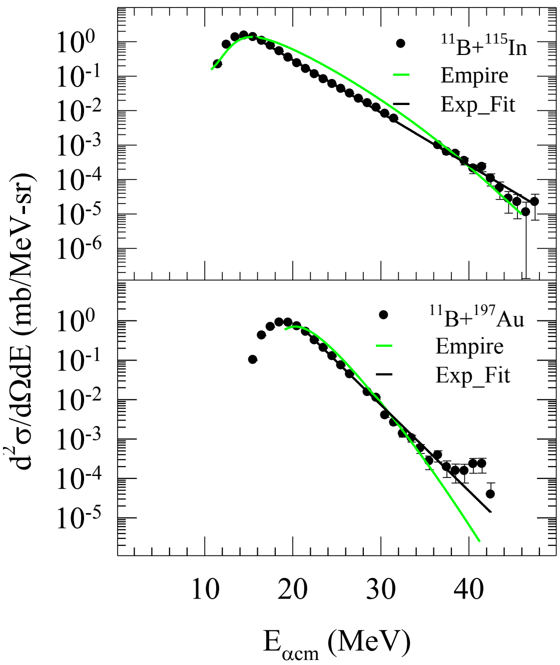

Fig2: α particle energy spectra in centre of mass system along with result of EMPIRE code calculation (solid histogram) for ^{11}B + ^{115}In and for ^{11}B + ^{197}Au system.

References:

[1] H. A. Bethe, Phys. Rev. 50, 332 (1936)

[2] M. Mayer, AIP Conf. Proc. 475, 541 (1999).

[3] M.Herman et al., Nuclear Data Sheet 108, 12 (2007).