Evidence of nuclear temperature anomaly in the mass region A ≈ 100

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Introduction

It was found from the study of A=105 systems, involving two different entrance channels $^{16}O+^{89}Y$ and $^{12}C+^{93}Nb$, that the observed nuclear temperatures extracted from different fragment spectra showed anomalously higher temperatures [1-3] compared to statistical model expectations. The inference stems from the observation that the slopes of the fragments spectra did not become steeper for the heavier fragments as expected from the statistical model calculations based on eq.(1) given below.

$$U_{Thermal}(residual) = (E_{c.m.} - Q) - \frac{\lambda(\lambda+1)\hbar^2}{2I} - E_{rot}(spin) \quad \ldots.(1)$$

where $E_{c.m.}$, Q, $E_{rot}(spin)$, I and λ denote the entrance channel center of mass energy, Q-value of the reaction, spin rotational energy of the nuclei, moment of inertia and orbital angular momentum of the system, respectively. In order to further study these observations, we have carried out similar investigation on a different system ($^{16}O + ^{93}Nb$) in the same mass region.

The experiment

A 5 pnA 116 MeV ^{16}O beam from the Variable Energy Cyclotron at VECC, Kolkata, India was bombarded on a 1.2 mg/cm^2 thick ^{93}Nb target. Emitted particles from alpha to oxygen were detected in the angular region from $\theta_{c.m.}$=100^o to 150^o using standard ΔE-E telescopes.

Results and discussions

Experimentally observed angle integrated cross-sections as well as those obtained from statistical model calculations using CASCADE code, as a function of exit channel kinetic energy in the center of mass system were fitted with Moretto's algebraic formula [4] for statistical emission of particles as given below:

$$P(x) \propto \exp\left(-\frac{x}{T}\right) erfc\left(\frac{p-2x}{2\sqrt{pT}}\right) \ldots \quad \ldots (2)$$

Where x=E_{kin}(c.m.)-V_C, ,$E_{kin}(c.m.)$, V_C, p, T and, $P(x)$ are the exit channel center of mass kinetic energy, Coulomb barrier, amplification parameter, temperature of the ensemble of the residual nuclei and the corresponding probability of the emission of the particle, respectively. Extracted temperatures are graphically displayed in Fig. 1 while typical fits to both experimental and theoretical distributions are displayed, along with other fitted parameters (V_C & p) in Fig 2A, B and 3a, b, respectively. We find that the present investigation also shows results similar to what was found earlier for the A=105

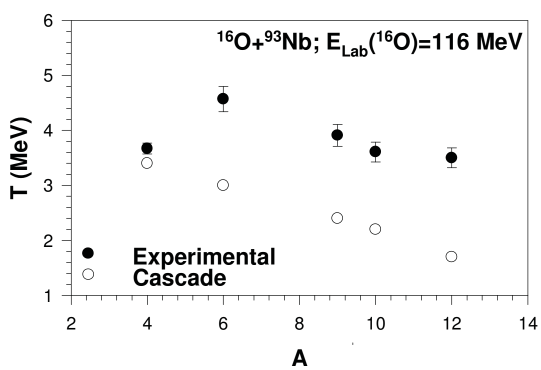

Fig 1: Temperature as a function of evaporation fragment mass number for $^{16}O+^{93}Nb$ reaction at E_{Lab}=116 MeV. Solid and open spheres correspond to experimental and CASCADE calculation, respectively.

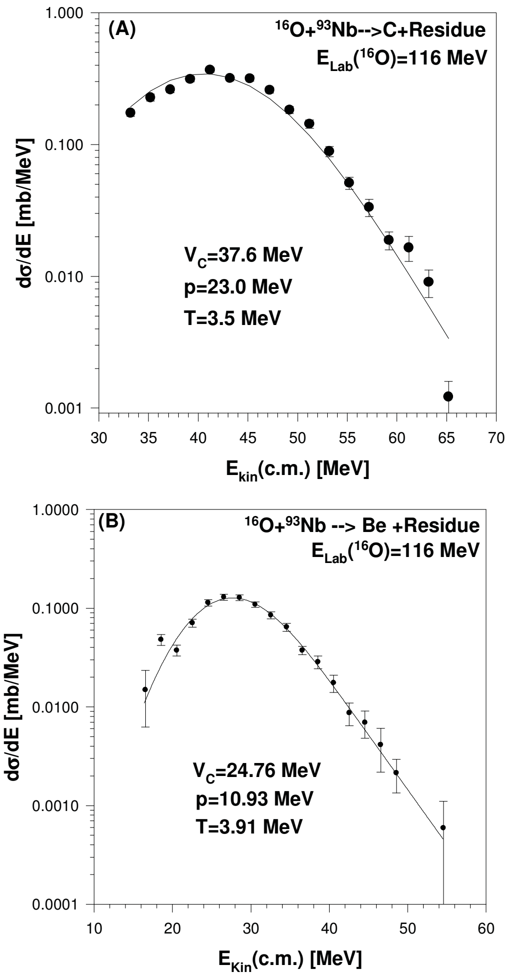

Fig 2: Experimental angle integrated C and Be spectra from $^{16}O+^{93}Nb$ reaction at $E_{c.m.}$ = 99 MeV; the smooth curve corresponds to eq. (2).

systems, showing a sharp difference between theoretical predictions and the experimental observation, so far as the variation of temperatures of residual nuclei as a function of ejectile masses are concerned. Further study, involving nuclear level widths and non-exponential decay is in progress to explain the observed anomaly.

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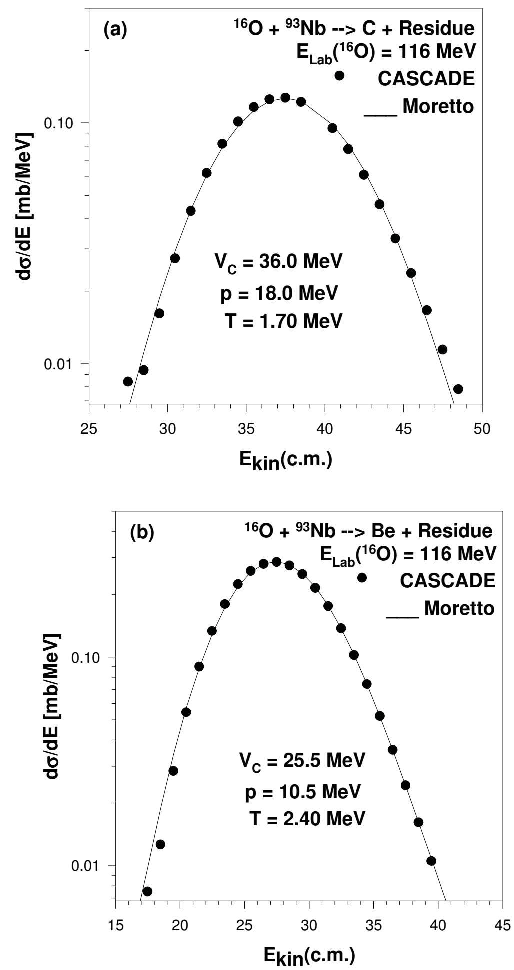

Fig 3: Theoretical angle integrated C and Be spectra from $^{16}O+^{93}Nb$ reaction at $E_{c.m.}$ = 99 MeV; the smooth curve corresponds to eq. (2).

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