Estimating the excitation energy of the primary projectile like fragments in a dissipative binary collision

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Introduction

The study of multifragmentation reactions find relevance in understanding the dynamics of the reaction processes [1, 2]. These studies are also used to calculate the symmetry energy at subnormal densities, which is an important term in the nuclear equation of state. The knowledge of symmetry energy is also important for astrophysical studies where such terms are required to be known at subnormal densities. The multifragmentation process has unique features, like, large multiplicity of reaction events. The process also involves high incident energies as well as angular momentum. Since, in general, the reaction products detected in such experiments are the one after the evaporation and/or pre-equilibrium processes, so, it becomes difficult to know the exact nature (charge, mass, energy etc.) of reaction primaries. In the present study, we have tried to estimate the excitation energy of the primary projectile like fragments (PLFs) using the experimental data as well as simulation for the reaction ^{48}Ca + ^{124}Sn at 45 AMeV of lab energy.

Experimental Details

The experiment was carried out using the K800 cyclotron at Laboratori Nazionali del Sud (LNS), Catania, Italy. Isotopically enriched, self supporting target of ^{124}Sn having thickness of 689 $\mu g/cm^2$ placed inside the Charged Heavy Ion Mass and Energy Resolving Array (CHIMERA), was bombarded with ^{48}Ca beam of 45 AMeV energy. The pulsed beam had a repetition rate of 120 ns. Each telescope consists of a 300-μm thick silicon detector, while CsI(Tl) detectors have different thicknesses as a function of polar angle. More details about the array can be found in Ref. [3].

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Results and Discussion

In order to derive the temperature from the measurement, the data were fitted assuming the distribution of the type, exp($-\frac{E}{T}$). However, since the focus of present study was to understand the reaction dynamics and isoscaling using intermediate mass fragments (IMF), the experimental data available for such estimation were for fragments with Z $\geq$ 3. Also, temperature extracted from such fitting showed a sizeable variance for different fragments. The Coulombic factor could be the reason for such observation.
The ratio of isotopic yield of different fragments was also used to extract the temperature of the excited system and values obtained lies in the range of 4-5 MeV.
Another method of scaling of experimental yield ratios following the expression,

$$R_{21}(N,Z) \approx exp\left[\frac{B_2(N,Z) - B_1(N,Z)}{T}\right] \quad (1)$$

$$= exp(\Delta B/T),$$

was also tried to estimate the temperature of the system. Here, Δ B represents the difference in binding energies of a given IMF in the primary neutron rich and neutron poor PLF, respectively [4]. Following the relevant constraints for such fits, the value of temperature obtained from such fits lies around 4 MeV.

In the last, excited projectile like fragments were simulated at different excitation energies using the code CLAT. Those excited framgents were allowed to decay statistically in the

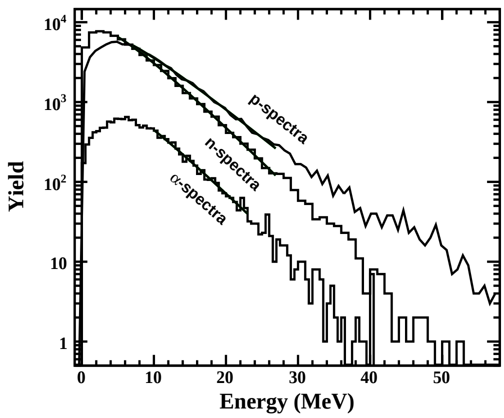

FIG. 1: Simulated light particles spectra for the decay of excited ^{48}Ca at 200 MeV of excitation energy.

code Gemini [5]. One such decay via light particles at 200 MeV of excitation energy is shown in the figure 1. The straight line fit shown is again for the exponential form as mentioned before.

Based on the data obtained from the experimental observables as well as simulation of the excited primary PLF, we conclude that the for a level density parameter of A/8, the energy of the excited primary projectile like fragments lies in the range of 150-200 MeV.

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References

[1] W. U. Schroeder and U. J. Huizenga, Treatise on Heavy Ion Science, edited by D. A. Bromley (Plenum Press, New York, 1984)

[2] J. Toke et al., Phys. Rev. Lett., 75, 2920 (1995).

[3] A. Pagano et al., Nucl. Phys. A., 734, 504 (2004).

[4] H. Singh et al., EPJ Web of Conferences 31 00014 (2012).

[5] R J Charity et al., Nucl Phys, A476:516, 1988.