Mass-total kinetic energy distribution for reaction ^{28}Si + ^{160}Gd populating ^{188}Pt compound nucleus

Vikas[1], Kavita[1], K. S. Golda[2], T. K. Ghosh[3], A. Jhingan[2], P. Sugathan[2], A. Chatterjee[2], Rakesh Kumar[1], N. Saneesh[2], Mohit[2], Abhishek Yadav[2], C. Yadav[2], Kavita Rani[4], S. K. Duggi[5], Rakesh Dubey[6], Neeraj Kumar[7], A. Banerjee[7], A. Rani[7], Kajal[1], Shoaib Noor[8], Jaimin Acharya[9], and Hardev Singh[1*]

[1] *Department of Physics, Kurukshetra University, Kurukshetra- 136119, Haryana, INDIA*
[2] *Inter University Accelerator Centre, Aruna Asaf Ali Marg, New Delhi-110067, India*
[3] *Variable Energy Cyclotron Centre, 1/AF, Bidhan Nagar, Kolkata-700064, India*
[4] *Department of Physics, Panjab University, Chandigarh-160014, India*
[5] *Department of Nuclear Physics, Andhra University, Visakhapatnam-530003, India*
[6] *iThemba LABS, National Research Foundation, Somerset West, South Africa*
[7] *Department of Physics and Astrophysics, University of Delhi, Delhi-110007, India*
[8] *Department of Physics, Thapar University, Patiala, Punjab-147004, India and*
[9] *Department of Physic, M. S. University of Baroda, Vadodara, Gujarat-390002, India*

Introduction

The study of heavy ion induced reactions is one of the most prominent areas of nuclear science research. In such reactions, two heavy nuclei interact to form a dinuclear system. This system may either lead to the formation of an equilibrated compound nucleus or split into fission-like fragments before an equilibrated compound nucleus is formed, a process termed as quasi-fission (QF). QF hinders the formation of a compound nucleus. An excited compound nucleus (CN) formed in a heavy ion induced reaction can split into symmetric or asymmetric fragments. Various factors such as the charge product Z_pZ_t, entrance channel mass asymmetry (α) of the interacting nuclei, proton-neutron configuration, and excitation energy of the fissioning system play a governing role in the dynamics of fusion-fission and QF or non-compound nucleus fission (NCNF) processes. Despite extensive research aimed at understanding the dynamics of fusion-fission and QF processes, significant gaps in understanding still remain, particularly in the relatively neutron deficient lighter preactinides. Fission fragment (FF) mass-total kinetic energy (TKE) distribution is a significant tool for probing the dynamics of fusion-fission and QF or NCNF processes [1, 2]. In this work, we have reported the mass-total kinetic energy distributions of fission fragments for reaction ^{28}Si + ^{160}Gd, having entrance channel mass asymmetry (α) less than α_{BG}, at various excitation energies.

Experimental Details

The experiment was carried out using the General Purpose Scattering Chamber (GPSC) facility at Inter University Accelerator Centre, New Delhi. Pulsed beam of ^{28}Si from Pelletron accelerator, in the laboratory energy of 120 – 140 MeV, was bombarded on ^{160}Gd target of thickness 220 μg/cm^2 on 60 μg/cm^2 carbon backing. To detect the complementary fission fragments in coincidence, two large area (16 cm x 11 cm) position-sensitive multiwire proportional counters (MWPCs) were used. These detectors were mounted at folding angle on the movable arms inside the general purpose scattering chamber (GPSC). Complete details of experimental setup are given in ref. [3].

*Electronic address: hardev79@gmail.com

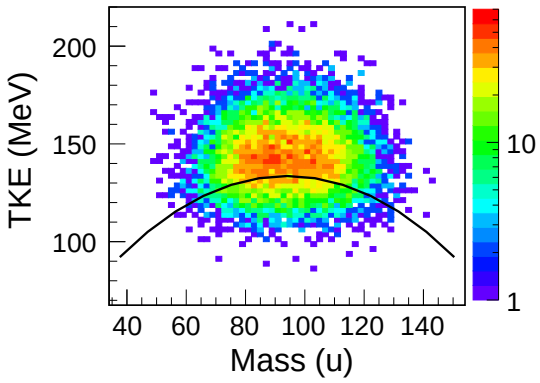

FIG. 1: Mass-total kinetic energy distribution for reaction ^{28}Si+^{160}Cd at excitation energy (E*) = 66.9 MeV. Black line shows LD predicted parabolic dependence of TKE on fragment mass.

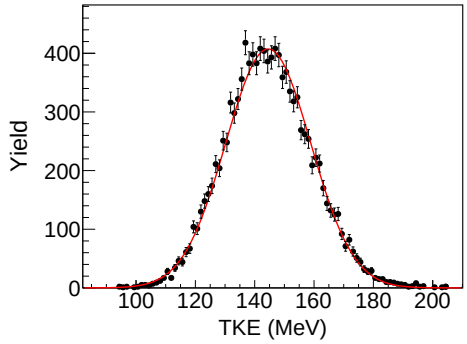

FIG. 2: TKE distribution for reaction ^{28}Si+^{160}Cd at excitation energy of 66.9 MeV. Solid red line represents the Single Gaussian fit to the data.

Analysis and Results

Fragment masses and their total kinetic energy were obtained for each fission event from the measured velocities of the fragments as given in ref. [2],

The measured mass-TKE distributions for reaction ^{28}Si + ^{160}Gd have typical triangular shape as expected based on LDM for symmetric CNF [4], though the mass-TKE distributions are relatively broader, as shown in Fig. 1, at an excitation energy of 66.9 MeV. Black line corresponds to the liquid drop (LD) predicted parabolic dependence of TKE on fragment mass. Although the TKE distributions are Gaussian type, these are relatively broader than the observed systematic liquid drop fission behaviour for nuclei in this mass region, (see Fig. 2), and peaked at TKE value $\approx$ 145 MeV which is higher than that ($\approx$ 133 MeV) predicted from Viola systematics [5]. The widths of measured TKE distributions ($\sigma_{TKE} \approx 14.28$ MeV) are also inconsistent with observed systematic behaviour ($\approx$ 10 MeV) for LD fission mode in this mass region [6, 7]. These observations suggest the contribution of QF or non-compound nucleus fission events. These findings are also consistent with the findings of measured fission fragments mass ratio distributions reported earlier [3], for the same reaction system.

Acknowledgments

Authors are thankful to the accelerator group of IUAC, New Delhi, for providing good quality pulsed beam throughout the experiment. One of the authors, Vikas acknowledges the Council of Scientific and Industrial Research (CSIR), New Delhi, for providing financial support through CSIR-SRF Fellowship.

References

[1] G. N. Knyazheva et al.,. Phys. Rev. C **75**, 064602 (2007).
[2] Vikas et al., J. Phys. G: Nucl. Part. Phys. **51**, 035103 (2024).
[3] Kavita et al., Phys. Rev. C **100**, 024626 (2019).
[4] J. Nix et al., Nucl. Phys. A **71**, 1 (1965).
[5] V. E. Viola et al., Phys. Rev. C **31**, 1550 (1985).
[6] M. G. Itkis et al., Phys. Part. Nucl. **29**, 160 (1998).
[7] E. M. Kozulin et al., Phys. Rev. C **105**, 014607 (2022).