Study of Evaporation Residue gated spin distributions for the ^{224}Th compound nucleus

M. M. Hosamani[1],* N. M. Badiger[1], N. Madhavan[2], I. Mazumdar[3], S. Nath[2], J. Gehlot[2], A. K. Sinha[4], S. M. Patel[3], P. B. Chavan[3], T. Varughese[2], V. Srivastava[2], Md. Moin Shaikh[2], P. Sandya Devi[6], P. V. Laveen[5], A. Shamlath[5], M. Shareef[5], S. K. Duggi[6], P. V. Madhusudhana Rao[6], G. Naga Jyothi[6], A. Tejaswi[6], P. N. Patil[1], A. Vinayak[1], Rajesh K. K.[7], Abhishek Yadav[2], A. Parihari[2], Rohan Biswas[2], Monalisha Dhibar[11], D. P. Kaur[8], M. Ratna Raju[6], J. Joseph[9], and S. Pal[10]

[1]*Department of Studies in Physics, Karnatak University, Dharwad - 580003, INDIA*
[2]*Inter University Accelerator Centre, Aruna Asaf Ali Marg, New Delhi - 110067, INDIA*
[3]*Tata Institute of Fundamental Research, Mumbai - 400005, INDIA*
[4]*UGC-DAE Consortium for Scintific Research Centre, Kolkata 700098, INDIA*
[5]*Department of Physics, Central University of Kerala, Kasaragod - 671314, INDIA*
[6]*Department of Nuclear Physics, Andhra University - 530003, INDIA*
[7]*Department of Physics, University of Calicut,Kerala - 673635,INDIA*
[8]*Department of Physics, Panjab University, Chandigarh - 160014, INDIA*
[9]*Kuriakose Elias College, Mannanam, Kerala - 686561, INDIA*
[10]*CS-6/1 Golf Green, Kolkata-700095, (Formerly with VECC, Kolkata), INDIA and*
[11]*Department of Physics, Indian Institute of Technology, Roorkee-247667, INDIA*

Introduction

Heavy ion induced nuclear reaction is a well established probe to understand the nuclear dynamics at different stages of fusion-fission process. The dynamics of fusion-fission process can be understood by studying the emitted neutrons, charged particles, gamma rays and the evaporation residues (ERs) from the fissioning nucleus. During this observation the excess of pre-scission particles in comparison with standard statistical model predictions creates the interesting reason is that the fission process in heavy ion nuclear reaction is delayed. It was pointed out by Frobrich et al. [1] that ERs are the most sensitive probes for studying the dynamics of fusion-fission process. The fission delay is understood to be due to nuclear viscosity that leads to enhanced yield of ERs at higher spin values. In other words, survival probability of the CN against the fission is more at even maximum angular momentum than expected from statistical model. Therefore, measurements of ER cross sections and spin distributions would, undoubtedly, provide information on viscosity of nuclear fluid at high excitation energies. Regarding the ERs excitation functions at above barrier our group has already reported in [2] for the systems ^{16}O + ^{208}Pb and ^{18}O + ^{206}Pb. The exclusive measurements of the spin distributions for both the systems have not been reported by any group so far. In view of these, we have undertaken this work using dedicated well advanced facilities available at IUAC, New Delhi.

Experimental techniques

The measurement of ERs for the two reactions were carried out using the HYbrid Recoil mass Analyzer (HYRA) coupled with the TIFR 4pi-spin spectrometer at IUAC, New Delhi [3, 4]. The ^{16}O and ^{18}O pulsed beams were provided by the 15UD Pelletron accelerator and the first module of the LINAC accelerator at IUAC. The measurements of ^{16}O + ^{208}Pb and ^{18}O + ^{206}Pb systems, were carried out for the energies (E_{Lab}) from ∼85 MeV to ∼123 MeV. The ER cross sections and spin distributions measurements carried out at the same excitation energies by adjusting beam energies from 89 MeV to 125 MeV. The TIFR 4π spin spectrometer was used as a multiplicity filter to determine the ERs spin distributions for CN ^{224}Th. The multiplicity filter covers 91% of total solid angle [5]. In this measurement 29 of

*Electronic address: mutturajh735@gmail.com

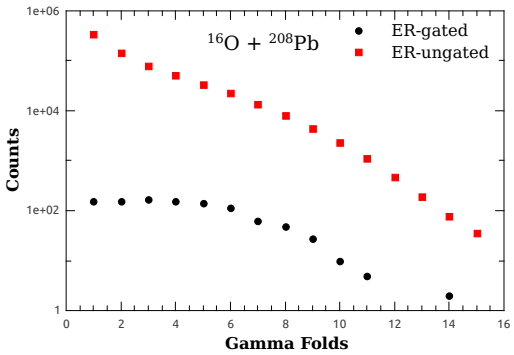

FIG. 1: The ER-gated and ER-ungated gamma folds distributions for the system ^{16}O + ^{208}Pb .

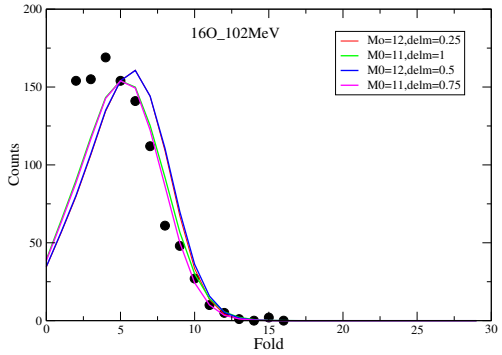

FIG. 2: Gamma folds distribution for ^{16}O + ^{208}Pb system at $E_{Lab} = 102MeV$ with preliminary fits.

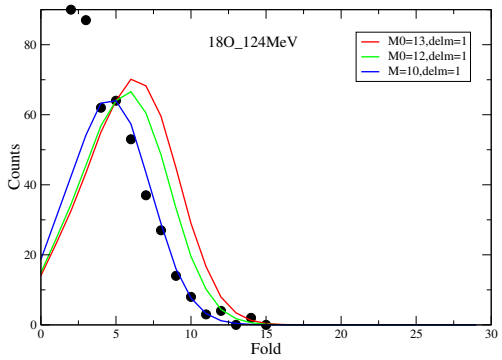

FIG. 3: Gamma folds distribution for ^{18}O + ^{206}Pb system at $E_{Lab} = 124MeV$ with preliminary fits.

the total 32 detectors were used. Out of which 10 are having pentagonal and 19 are hexagonal cross sectional geometry. Each detector of pentagon and hexagon having 2.08% and 3.05% efficiencies at the energy 661.6 keV of ^{137}Cs [6]. The efficiency of the complete array in soccer ball configuration has been determined using radioactive gamma sources. Efficiency of the TIFR 4π spin spectrometer has been simulated with appropriate parameters using GEANT4 Monte Carlo simulation code [7].

Preliminary results

The ER gated spin distributions have been measured for both the systems using HYRA coupled with 4π spin spectrometer. The typical gamma folds distributions, both gated with ERs and ungated, are shown in fig. 1. The response matrix of the array, generated by GEANT4 has been convoluted with a chosen spin distribution to reproduce the experimentally measured fold distribution. The theoretical preciseness in the reproducibility of the experimental fold can fit with adjusting the Fermi-function free parameters M_o and ΔM [5] in multiplicity distribution. In fig. 2 and fig. 3 it is shown that, the possible best fits are achieved by adjusting the free parameters with minimizing the Chi-square for both the systems respectively.

Acknowledgments

The Pelletron and the LINAC groups are acknowledged for providing good quality beams during the experiment. Also thanks to IUAC Target lab and RBS lab for fabrication of isotopic enrich target and its characterization.

References

[1] P. Frobrich et al., Nucl. Phys. A 563 (1993) 326.
[2] M. M. Hosamani et al., Proceedings of the DAE Symp. on Nucl. Phys. 62 (2017).
[3] N. Madhavan et al., Pramana - J. Phys., 75 (2010) 317.
[4] N. Madhavan et al., EPJ Web of Conferences 17 (2011) 14003.
[5] G. Mohanto et al., Nucl. Phys. A 890-891 (2012) 62.
[6] G. Mohanto et al., Phys. Rev. C 88 (2013) 034606.
[7] G. Anil Kumar et al., Nucl. Instr. and Meth. A 611 (2009) 76.