Fission fragment mass distribution for $^{16}O+^{175}Lu$ system

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Introduction

In heavy-ion (HI) reactions, fission is one of the dominant processes at moderate excitation energies. Recent studies show the presence of fission-like residues even at low energy below 10 MeV/nucleons, where fusion is expected to be dominant [1,2]. The fusion-fission process in HI-induced reactions can be understood by measuring the fission-fragment mass distribution [3]. The HI-induced fission experiments were carried out in the mass range of A≈180 [4]. As a typical case, the mass distributions for Iridium isotopes (^{185,187,189,191,193}Ir) at an excitation energy of 10 MeV above the saddle point showed a transition from symmetric to asymmetric mass distribution [5]. Although fusion-fission reactions with HI beams in the intermediate mass region have been the subject of numerous additional studies [6,7,8], a comprehensive analysis of the fission process is required.

To develop a better understanding of fission dynamics, a study of mass distribution of the fission products populated via composite system formed through Complete fusion (CF) [9] and Incomplete fusion (ICF) [10] processes in the $^{16}O+^{175}Lu$ system has been carried out.

Experimental Setup

The present experiments have been performed at the Inter-University Accelerator Centre (IUAC), New Delhi, India, using a beam of ^{16}O on the ^{175}Lu targets.

The highly pure (99.99%) ^{175}Lu targets (thickness~0.5-3.5 mg/cm^2) and aluminum catcher/energy-degrader foils (thickness ~1.5-2.5 mg/cm^2) were prepared by the rolling technique. Three stacks, each made up of three target-catcher foil combinations, were individually irradiated at 90, 100, and 104 MeV beam energies, having an average beam current of ~20 nA. The irradiation was carried out for ~8-10 h for each stack in the General Purpose Scattering Chamber (GPSC), employing an offline gamma-ray spectroscopy. The activities induced in samples were observed at several time intervals by a high-purity germanium (HPGe) detector with CAMAC based data acquisition system.

Data Analysis and Discussion

The mass distribution of fission fragments is one of the important observations in exploring the dynamics of fusion-fission processes. The variation of the width of the fission fragment mass distribution with excitation energies of the compound system is an important probe for studying the different types of fission processes, such as statistical fission, fast fission, pre-equilibrium fission and quasi-fission.

The present work is aimed to measure the fission fragment mass distribution for $^{16}O+^{175}Lu$ system at different energies varying from the Coulomb barrier to 104 MeV. The gamma-ray spectrum for the reaction $^{16}O+^{175}Lu$ at E_{lab} ~100 MeV is shown in Fig.1,

The gamma-ray spectrum for the reaction $^{16}O+^{175}Lu$ at E_{lab} ~100 MeV is shown in Fig.1, where gamma lines are assigned to the reaction products expected to be populated via the fission process, as listed in Table-1.

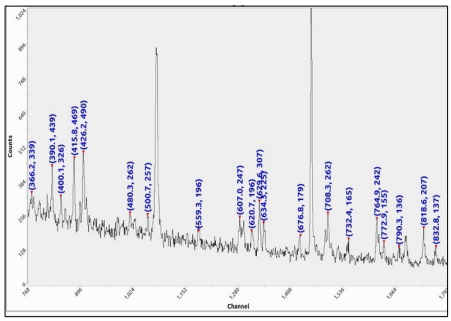

Fig. 1: A typical γ-ray spectrum for $^{16}O+175Lu$ systemat E_{lab} ~100 MeV

Further residue confirmation has been made by determining the half-lives of the fission fragments. As a typical case, the decay curves of fission fragments viz., ^{170}In, ^{70}Se, ^{68}Cu have been shown in Fig 2. which give the half-lives of 32.4, 41, 3.75 min respectively. The measured values of the half-lives are found to be satisfactory with their values quoted in the literature. The cross-section of fission fragments is also determined by standard formulation [9]. The preliminary analysis has been done and some fission residues has been observed.

Table-1: Fission-like residues populated via in $^{16}O+^{175}Lu$ system.

S.No	E_γ (keV)	Nuclide	Half-life
1	106.8	^{98}Pd	17.7 min
2	110.74	^{68}Cu	3.75 min
3	204.95	^{107}In	32.4 min
4	136	^{99}Pd	21.4 min
5	632.9	^{108}In	58 min
6	265.3	^{97}Pd	3.63 min
7	606.8	^{112}In	14.8 min
8	201.2	^{134}Te	41.8 min
9	426.2	^{70}Se	41.1 min
10	126.15	^{100}Pd	96 h

Further, analysis is under progress and will be presented at the time of the conference.

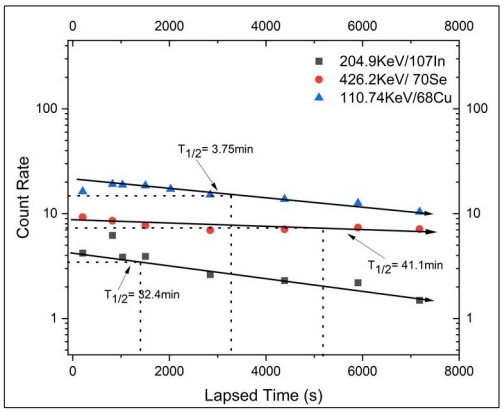

Fig. 1: Decay curve of the fission fragments populated in $^{16}O+^{175}Lu$

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References

[1] K. Nishio et al. Phys. Rev. Lett. 93, 162701 (2004)
[2] A. Pal, S. Santra, D. Chattopadhyay, Phys. Rev. C 99, 024620 (2019)
[3] W. J. Swiatecki, phys. Scr. 24, 113 (1981)
[4] I. Tsekhanovich, A. N. Andreyev, et al. Phys. Lett. B 790, 583 (2019)
[5] Chetan Sharma, Shruti Narang et al. Phys Rev C.107.064615 (2023)
[6] Rinku Prajapat, Moumita Maiti, et al. Phys. Rev. C 103, 014608 (2021)
[7] M. G. Itkis, et al. PHYSICS OF ATOMIC NUCLEI Vol. 66 No. 6 (2003).
[8] P.P. Singh et al. Phys. Rev. C 80, 064603 (2009).
[9] J. Rangel et.al., Physics Letters B,Vol 803, 135337 (2020).
[10] A. V. Andreev et. al, Phys. Rev. C 93, 034620 (2016).