Fusion excitation functions around the Coulomb barrier for ^{16}O + ^{61}Ni system

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Introduction

Nuclear fusion cross section around the Coulomb barrier reveals varieties of phenomena. One such phenomenon is the enhancement of the sub-barrier fusion cross section as compared to the theoretical predictions of one dimensional barrier penetration model [1, 2]. Such enhancement occurs due to the coupling of relative motion to internal degrees of freedom of the colliding nuclei such as deformation [3], vibration [4], nucleon transfer [5] and neck formation [6] between the two colliding nuclei.

The multinucleon transfer can take place either sequentially or simultaneously making it difficult to incorporate transfer channels in theoretical fusion cross section calculations. In order to probe the role of nucleon transfer on the sub barrier fusion cross section enhancement, we measured fusion excitation functions for ^{16}O + ^{61}Ni system around the Coulomb barrier, using Heavy Ion Reaction Analyzer (HIRA) at the Inter University Accelerator Centre (IUAC), New Delhi [7]. In this system the Q-values are negative for up to two neutron stripping or pickup channel. By measuring the fusion cross-section data, couplings of the nuclei in the sub-barrier region can be studied.

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Experimental Setup

Pulsed beam of ^{16}O (with 4 μs pulse separation) was bombarded on ^{61}Ni target (99.6% enriched) of 100 $\mu g/cm^2$ thickness prepared on 30 $\mu g/cm^2$ carbon backings in the target development laboratory at IUAC. In the target chamber of HIRA, two silicon surface barrier detectors were mounted in the forward direction at 15.5^o in the horizontal plane to monitor the beam and for normalization of cross section. A carbon charge reset foil of 30 $\mu g/cm^2$ thickness was used for charge re-equilibration of evaporation residues, after probable internal conversion processes, coming out of the target. At the focal plane of HIRA, a Multi Wire Proportional Counter (MWPC) of 150 × 50 mm^2 active area was used for the detection of evaporation residues. Time of flight was defined for particles reaching the focal plane with respect to RF of beam to separate multiple-scattered beam-like particles and evaporation residues at the focal plane. The fusion excitation function measurements were performed from 35 MeV to 50 MeV in steps of 1 MeV below the Coulomb barrier, ∼1-2 MeV near the barrier and 3 MeV above the barrier. This energy range covers 15% below to 25% above the Coulomb barrier. The solid angle of acceptance for HIRA was kept 10 mSr for the measurements. A raw spectrum of data taken for 50 MeV beam energy is shown in Fig. 1,

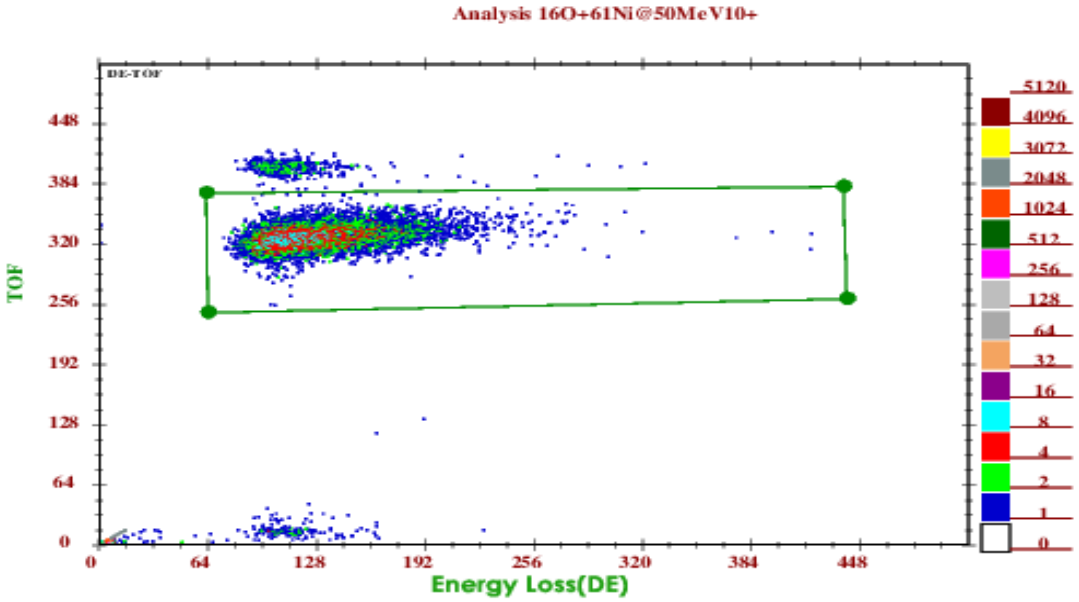

FIG. 1: Energy loss versus TOF spectra for $^{16}O+^{61}Ni$ at E_{lab} = 50 MeV, showing clear separation between evaporation residues and background events.

with the energy loss (ΔE) along x-axis and the corresponding time of flight (TOF) along y-axis. From the spectrum, it can be clearly seen that beam-like particles are very well separated from the evaporation residues. In the measurement of the fusion cross section, the evaporation residues cross section was taken to be equal to the total fusion cross section since the fission contribution in this mass region is negligible.

Results and Discussion

Data analysis is under progress in order to measure the fusion excitation functions. Results after analysis will be presented in the Symposium. Corrections for the loss of beam energy in carbon backing and half target thickness were appropriately taken into account. This result will be further compared with the theoretical coupling code CCFULL [8] and FRESCO [9] to see the behaviour of the sub-barrier fusion cross section and its corresponding fusion dynamics. The ion - ion potential to be used in this calculation will be Woods-Saxon parameterization of Akyuz-Winther potential.

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