Multi-nucleon transfer and fission cross sections for ^{28}Si + ^{197}Au, ^{209}Bi and ^{232}Th reactions at 179 MeV

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Introduction:

In heavy ion reactions, there is a strong coupling of inelastic and transfer channels to fusion process at energies near the Coulomb barrier. Multi-nucleon transfer in heavy ion induced reactions is important from the point of understanding the role of particle correlations and possible formation of cluster states in nuclei [1]. In the reactions between two complex nuclei, there is a possibility of different reaction paths via sequential transfer, cluster transfer and multi-nucleon exchange. The role of projectile structure on the multi-nucleon and cluster transfer has been reported earlier [2]. For reaction with heavy fissile targets, nuclear fission is also a dominant reaction channel. At near barrier energies the relative cross sections of multi-nucleon transfer as well as fission is important to understand the heavy ion reaction mechanism [3].

Thus a detailed understanding of the heavy ion reaction dynamics requires, a systematic and simultaneous study of the different reaction channels. In the present work, we have measured simultaneously the multi-nucleon transfer as well as fission cross sections at 179 MeV for ^{28}Si + ^{197}Au, ^{209}Bi, ^{232}Th systems to understand role of the target nucleus on multi-nucleon transfer cross section and fission cross section.

Experimental details and results:

The experiment was performed using ^{28}Si beam from BARC-TIFR LINAC facility, Mumbai, India. The targets of ^{197}Au (300 μg/cm^2), ^{209}Bi (300 μg/cm^2) and ^{232}Th (1.2 mg/cm^2) were bombarded with ^{28}Si beam of 179 MeV energy. The elastically scattered particles, projectile-like fragments and fission fragments were detected by using two Silicon detector telescopes, consisting of ΔE (25 μm)–E detectors (300 μm). These telescopes were mounted at a distance of 26 cm from the target on a rotating arm inside the general purpose scattering chamber.

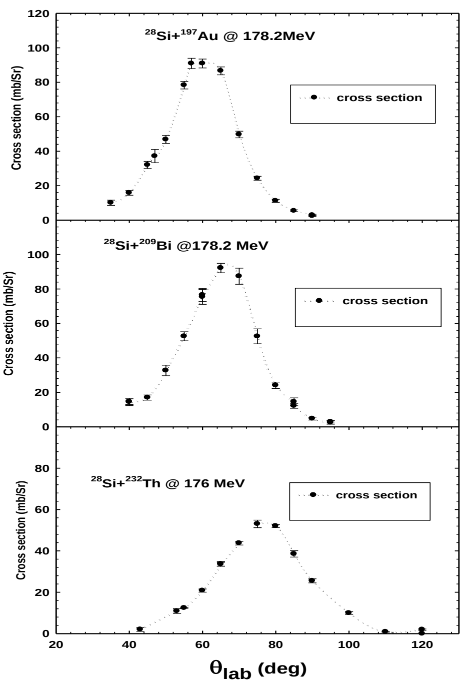

Fig.2. Multi-nucleon transfer cross section as a function of angles (dashed lines are smooth connections of the data).

A collimator with 5 mm diameter was placed in front of the telescopes. Another silicon detector of 300 μm thick was placed at an angle 15^o with respect to beam direction at a distance of 60 cm, having a collimator of 2.0 mm. This detector was used to measure Rutherford scattering events and for normalization of the angular distribution data, measured by the telescopes at various angles. The transfer angular distribution measurements have been carried out in a wide angular range from 30^0 to 120^0 and the fission cross section data were measured in the angular range of 80^0 to 170^0. The total integrated transfer cross section have been plotted as a function of scattering angle (θ_{lab}) for all the three systems as shown in Fig.1.

The measured fission fragment angular distributions are shown in Fig. 2 (solid circles) along with the least squares fit using Legendre polynomial expression up to fourth order (solid lines).

The angular anisotropy is defined as,

A= W(180)/W(90),

Here, W(180) and W(90) are the cross section values at 180º and 90º. From the angular distribution, we have obtained the total fission cross section and angular anisotropies for all the systems. The transfer cross section and fission cross section values along with angular anisotropy values are given in Table-I.

These cross section data will provide valuable information in the understanding of the heavy-ion reaction mechanism. Further analysis on the role of multi-nucleon cross section on the nuclear fission process is in progress.

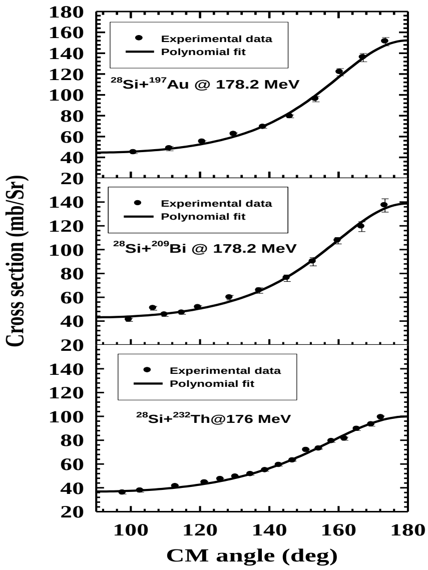

Fig.2. Fission fragment cross section as a function of CM angles for $^{28}Si + ^{197}Au$, ^{209}Bi and ^{232}Th reactions (solid lines are polynomial fit to the data).

References:

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TABLE-I: Experimental transfer and fission cross section along with fission fragment anisotropies for $^{28}Si + ^{197}Au$, ^{209}Bi, ^{232}Th reactions.

Systems	Transfer cross section (σ_{tr})	Fission cross section (σ_f)	Ratio $\sigma_{tr}/(\sigma_{tr} + \sigma_f)$	Anisotropy (A)
$^{28}Si + ^{197}Au$	213 ± 8.8 mb	799 ± 20 mb	0.210	3.41 ± 0.22
$^{28}Si + ^{209}Bi$	229 ± 16.0 mb	761 ± 25 mb	0.231	3.21 ± 0.3
$^{28}Si + ^{232}Th$	173 ± 4.9 mb	623 ± 9 mb	0.217	2.71 ± 0.1