Multi-pronged tracks observed in a Rutherford scattering experiment

Sandhya Dey[1*], S K Ghosh[1,2], A Maulik[1,3], S Raha[1,2], and D Syam[1]
[1]*Center for Astro-particle Physics, Bose Institute, Kolkata, India*
[2]*Deptartment of Physics, Bose Institute, Kolkata, India*
[3]*INFN, Section of Bologna, Bologna, Italy*
** email: dey_s2001@yahoo.com*

Introduction

Solid state nuclear track detector (SSNTD) is a device that has very high detection efficiency for ions [1]. The plastic CR-39 is a well-known nuclear track detector. In a track detector, the path of an energetic charged particle can be clearly seen under an optical microscope, after etching the detector in appropriate condition by a suitable reagent. We have used this detector in Rutherford back-scattering experiments with a ^{197}Au target and ^{56}Fe and ^{32}S beams for calibration purposes [2]. We have observed multi-prong tracks in the detector resulting from this experiment. Direct impingement by ^{16}O beam produces no such event in the detector. Here we report on multi-pronged tracks observed in the CR-39 detector which was exposed to backscattered Fe ions.

Experimental details

We have performed the experiment at the 14 UD pelletron accelerator, New Delhi, India. Beams of 2.7 MeV/A ^{56}Fe and 3.9 MeV/A ^{32}S at a current of 1 pnA were used as projectiles and ^{197}Au foil of thickness 250µg/cm^2 was used as target. General purpose scattering chamber (GPSC) of 150 cm diameter was used for the experiment. Experimental arrangement is shown in fig.1.

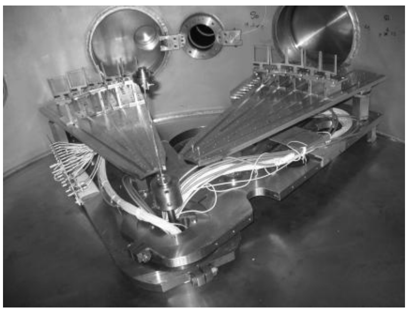

Fig.1. Experimental arrangement

CR-39, which is poly-allyl diglycol carbonate, was used for the detection of the scattered particles. The detectors were placed inside the scattering chamber at 23°, 59° and130° with respect to the incident beam for the detection of scattered and recoiling ions. Target to detector distances were 50cm for 23° and 59° angles and 25cm for the backward angle of 130°. Distance and time of exposure were calculated based on Rutherford scattering for obtaining required fluxes on detector such that good statistics of events could be obtained yet there would be no overlapping of tracks. Detectors were placed at an inclination of 30° with respect to the radial direction.

Exposed plates were etched in a constant temperature bath in an aqueous solution of 6.25N NaOH at a temperature of 70° C. The plates were scanned under the dry objective of a Leica DM4000 optical microscope.

Observation

We have observed two pronged, three pronged and multi-pronged tracks along with single tracks in Rutherford back scattering experiments involving ^{56}Fe ion beam. Microphotographs of tracks are shown in Fig. 2. Average track diameter is 10 µm. Numbers of multi- pronged events of different multiplicity along with single tracks observed in the scanned area of the plate are presented in Table 1.

Discussion and conclusion

Multiple tracks may be found in a single event due to various reasons e.g. (i) as a result of collisions between the scattered Fe ions and carbon or oxygen atoms of the plastic detector and (ii) possibly fragmentation of the excited back scattered ^{56}Fe ions when more than two tracks originates from single track at a point . Some of the projectile ions on approaching the

^{197}Au target nuclei may get excited due to spending of longer time in the coulomb field

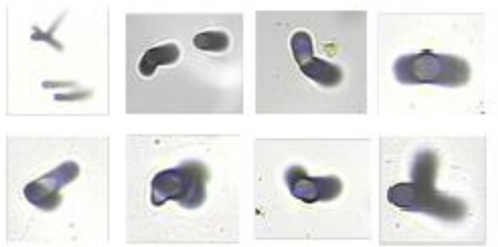

Fig.2. Micro photograph of multi-pronged tracks in CR-39 exposed to scattered Fe ions

Table 1. Number of events observed in the scanned area of a plate

Angle of detection	Target to detector distance (cm)	Time of exposure (sec)	Number of image frames examined at 100X objective	No. of single prong events	No. of two prong events	No. of three prong events
130°	25	3600	2545	1095	82 (324/cm^2)	7
59°	50	1800	1640	1386	34 (208/cm^2)	6
23°	50	180	595	1687	36 (610/cm^2)	3

of the heavy target nuclei and subsequently undergo fission. Note that at the scattering angle of 130° only the backscattered projectile ions, that is the ^{56}Fe ions and not the recoiling gold nuclei, may reach the detector. Guth and Wilets suggested in 1966 that very heavy ions with atomic no. Z > 50 may be utilized to induce fission of Actinide nuclei through coulomb interaction between the projectile and target nucleus and proposed the term 'Coulomb fission' for this phenomenon [3]. (A brief review of Coulomb fission (CF) including a semi-quantal theory has been presented by V.E. Oberacker et al [4]).No multi-prong tracks have been observed when ion beams of different nuclei impinged on the nuclear track detector directly i.e. in the absence of scattering of the projectile by the strong nuclear Coulomb field of a heavy target.

Acknowledgements:
The work is funded by IRHPA (IR/S2/PF-01/2011 dated 26.06.2012) of the Science and Engineering Research Council (SERC), DST, Government of India, New Delhi. It was performed under the aegis of the IRHPA (Intensification of Research in High Priority Areas) Project (IR/S2/PF-01/2003) of the Science and Engineering Research Council (SERC), DST, Government of India, New Delhi. Thanks are due to Dr. Rupamoy Bhattacharyya for some useful discussions.

References:

[1] Nuclear Tracks in Solids: Principles and Applications: R L Fleischer, P B Price, R M Walker.
[2] D. Bhowmik, S. Dey, A. Maulik, S. Raha, S. K. Saha, D. Syam NIM B 269(2):197-201, 2011.
[3] Wilets L, Guth E and Tenn J S 1967 Phys. Rev. 156 1349
[4] Oberacker V E, Pinkston W T and Kruse H G W 1985 Rep. Prog. Phys.48327