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Strangelet Search at Mountain Altitude

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Detection of strangelet is an important goal in the field of cosmic rays. It is also important for our understanding of the physics and astrophysics of strongly interacting matter. In our present work, we have used Solid State Nuclear Track Detectors (SSNTDs), which, being passive detectors, offer an alternative low cost detector option, to look for such rare events in cosmic rays. We have placed CR-39 along with Polyethylene Terephthalate (PET) to study the background radiation at mountain altitudes and variations in detector response with different environmental conditions. Observations for the present work have been made at different mountain altitudes. Some preliminary results of the study are presented here.

Key Words : Strangelet; Cosmic Ray; PET; SSNTD

Introduction

Existing theories (Witten, 1984) suggest small lumps of strange quark matter i.e., strangelets, consisting of roughly equal numbers of up, down and strange quarks, could be the true ground state of Quantum Chromodynamics. Before being detected in the detectors placed at mountain altitudes, strangelets have to pass through the earth's atmosphere. During propagation through the atmosphere the strangelets are expected to lose their energy through ionization but simultaneously they gain mass and charge (Banerjee *et al*., 2000). The prime signature for a strangelet is its very low charge to mass ratio (Z/A). When charged particles pass through the passive detector material, they produce narrow damage trails. Conical etch pits form after chemical etching with a suitable etchant (6.25N aqueous solution of NaOH in this case), which can be viewed under an optical microscope.

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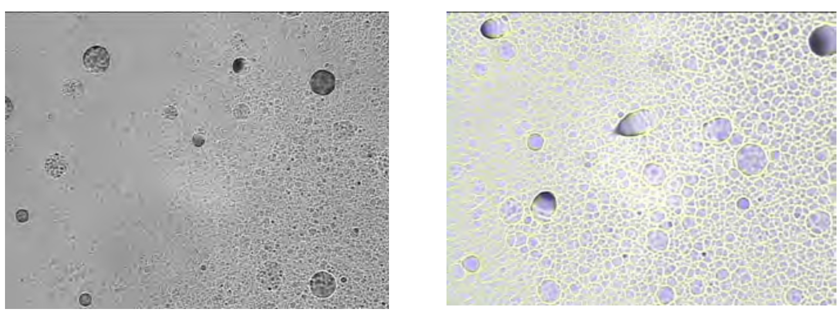
Experiment and Observation

Systematic studies, carried out at Bose Institute, Kolkata (Bhowmik *et al*., 2011; Dey *et al*., 2011), revealed that a particular kind of polymer, identified as Polyethylene Terephthalate (PET) with chemical formula $(C_{10}H_8O_4)_n$ can be very effective as a SSNTD. It was found that PET has a much higher detection threshold (Basu *et al*., 2008) compared to CR-39 or other SSNTDs. So PET can offer a simple way to suppress the low charge (Z) background (mainly proton and alpha) in cosmic rays in which low Z particles are abundant. To detect exotic events (e.g., strangelets) predicted to be present in cosmic radiation at mountain altitude (Banerjee *et al*., 2000), we have placed PET detectors, along with CR-39, for preliminary study. The locations chosen for these observations are Darjeeling (Geographic Latitude 28^0 N, Longitude 88^0 E and Altitude 2.13 km asl), Ooty (Geographic Latitude 11^0 N, Longitude 76^0 E and Altitude 2.23 km asl) and Hanle (Geographic Latitude 32^0 N, Longitude 79^0 E and Altitude 4.5 km asl).

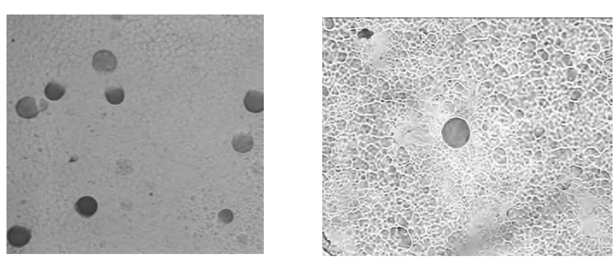
Results and Conclusions

In our work, it has been observed that there are many tracks (mostly with open end diameter$\sim 10^{-6}$m) in CR-39 (due to protons and alphas) where as PET has only a few large diameter tracks, when same period of time of open air exposure is given to both of them. In fact, it is as expected since PET has much higher detection threshold than CR-39.



A B

Fig. 1: (A) Tracks observed on CR-39 at Ooty, (B) Tracks observed on CR-39 at Hanle



A B

Fig. 2: (A) Tracks observed on CR-39 at Darjeeling, (B) Track observed on PET at Darjeeling

On scanning the PET films, exposed at Darjeeling, it was observed that only 2 percent of the image frames contain a single track and the rest of the image frames are vacant. However there is one particular image frame which contains six tracks. This is highly unusual. Each of these is identified as due to a particle of Z~ 20 , A~ 60 and Energy $\sim$ 1MeV/nucleon.

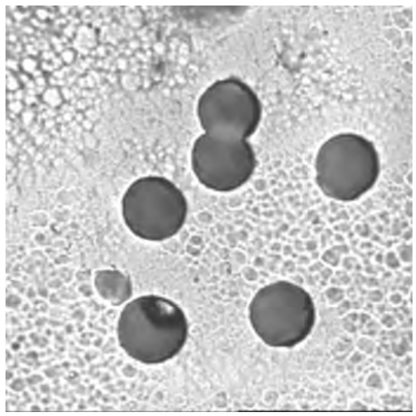


Fig. 3: Unusual event on PET at Darjeeling

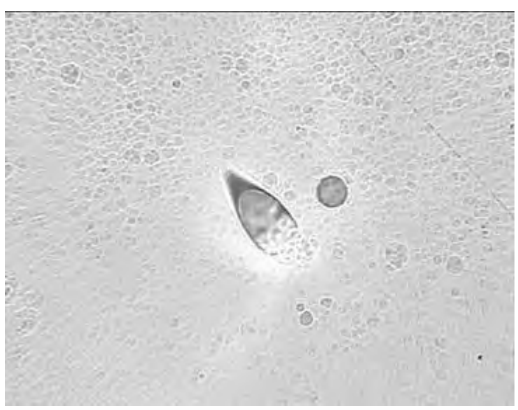


Fig. 4: Heavy ion track on CR-39 at Hanle

We have observed one heavy ion track at Hanle. This ion apparently passed through the CR-39 plate. From the track parameter measurements and from the use of the calibration curves (Bhowmik *et al.*, 2011; Dey *et al.*, 2011, Basu *et al.*, 2008) we have found Z=(25$\pm$2) and from range measurements we have determined the energy of the ion when it impinged on the CR-39 plate, to be (2$\pm$0.2) GeV.

Flux of nonstopping tracks, viewed on the back side of the CR-39 plate after 6 hours of etching, have following values of flux : 9.29x10^{-7}/(cm^2.s.sr) at Darjeeling, 1.95x10^{-7}/(cm^2.s.sr) at Ooty, 2.11x10^{-7}/(cm^2.s.sr) at Hanle. Flux of all particles as found on the top side (facing sky) of the CR-39 plate after 4 hours of etching, are given by : 6.47x10^{-4}/(cm^2.s.sr) at Darjeeling, 1.07x10^{-4}/(cm^2.s.sr) at Ooty and 3.66x10^{-4}/(cm^2.s.sr) at Hanle.

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