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Discrimination of neutrons and gamma-rays induced events in Superheated Emulsion Detector

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A liquid which maintains its liquid state above its boiling point is called the superheated liquid. It is a metastable state of the liquid. The superheated state can be reached by slowly increasing the temperature or by slowly reducing the pressure starting from its liquid state. The superheated state moves to a more stable vapour state by a small disturbances as a consequence of thermal motion or temperature fluctuation of the liquid. The transition from the metastable liquid state to the more stable vapour state occurs by forming a nucleus of a new phase known as nucleation. The radiation interaction of ions, charged particles, neutrons, photons etc can nucleate the superheated liquid. In the present study, the Superheated Emulsion Detector (SED) has been fabricated at the laboratory that consists of the droplets of the superheated liquid suspended in a viscous gel. The liquids, CCl2F2 (R12) b.p. -21.6 oC and C2H2F4 (R-134a), b.p. -26.3oC were used as active material in the detector though in the present abstract only the result with R12 is shown. When an energetic particle or radiation falls on the drops, if the energy deposition in the liquid exceeds the critical energy and radius of the nucleus is greater than the critical radius, bubbles are formed inside the drops. The critical energy depends on the temperature and pressure of the liquid and the detector can be made insensitive to specific particles by varying the temperature and pressure of the liquid. Here we have studied neutrons and gamma-rays induced bubble nucleation events by irradiating the SED with 241Am-Be (10 mCi) and 137Cs (5 mCi) as a neutron and gamma rays sources respectively and tried to discriminate the events. The usefulness of the discrimination lies in the WIMPs (Weakly Interacting Massive Particles) dark matter (DM) search experiment using SED as one of the important backgrounds for such experiment is gamma-rays. Therefore efficient discrimination techniques are important for the detection of WIMPs. WIMP and neutron interact similarly and hence the neutron source is used to calibrate the WIMPs detector. The SED is also used as a neutron detector/dosimeter in several applications. The acoustic signals produced from the nucleation of superheated liquid drops have been detected using an acoustic sensor (frequency range - few kHz to 1 MHz) and stored in the LabVIEW. These acoustical signals have been analysed and the frequency corresponding to the maximum power in its FFT spectrum is collected from each signal denoted as the fundamental frequency (FF). It has been observed that the FF of the neutron induced events lies within 80 to 90 kHz but the FF of the gamma-rays induced events lies in the range of 20 to 30 kHz. The high frequency events are produced due to the localised energy deposition of the recoil nuclei originating from the neutrons. The electrons are produced from the gamma-rays inside the liquid and those electrons deposit energy and produce the low frequency events. The range of the electron is larger than the range of the recoil nucleus and it deposits less energy within the critical radius, hence producing the low frequency events. The FF variable discriminates about 83.47 % of the neutrons induced events from that of the gamma-rays. The present study is important in discriminating the background events in WIMPs DM search experiment and also in the neutron detection in a background of gamma-rays.

What is your experiment?

Experiment with nuclear emulsion detector (SED)

Primary authors: Dr DAS, Mala (Saha Institute of Nuclear Physics); Mr ALI, Suraj (Saha Institute of Nuclear Physics)

Presenter: Mr ALI, Suraj (Saha Institute of Nuclear Physics)

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