Study of neutron and alpha particle induced events in superheated droplet detector

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Introduction

The superheated droplet detector (SDD) consists of a large number of drops of superheated liquid, suspended in another immiscible liquid like, soft gel medium or a firm polymer matrix. It is used to detect neutrons, gamma-rays and other charged particles under different operating conditions [1]. It is also one of the promising detectors to search for weakly interacting massive particles (WIMPs), one of the favored candidates for cold dark matter [2, 3]. For such experiment, the strong possible candidates as sources of background are neutrons, gamma-rays and alpha-particles. The discrimination between these backgrounds are important for detection both the neutron and WIMP search experiment. The discrimination technique of neutron and gamma induced events in SDD with R114 liquid ($C_2Cl_2F_4$; b.p. 3.7 ^{0}C) was discussed in the literature [1].

In present work, SDD with R12 (CCl_2F_2; b.p. -29.8^{0}C) as the sensitive liquid has been fabricated. Events are recorded in presence of ^{241}Am-Be, neutron source and ^{241}Am, alpha source. The analysis of acoustic signal has been carried out to find the variables to discriminate between the neutron and alpha particle induced events.

Experiment

The superheated drops of R-12 has been fabricated in aquasonic gel matrix which was kept in a perspex box. Experimental set up is shown in Fig. 1. Temperature was varied by wrapping the perspex box with a heating wire and it was controlled by using a temperature controller (Metravi) of precision $\pm1^0$C.

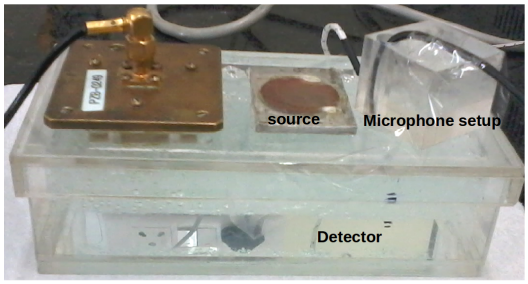

FIG. 1: Experimental setup.

The signals from the detector, due to neutrons and alpha particles, in presence of neutron source, ^{241}Am-Be (3 Ci) and alpha source, ^{241}Am (30 particles s^{-1}) were recorded at the temperature of 34^{0}C. When the particles fall on a drop, if the energy deposition within the critical length is larger than the critical energy, the superheated liquid drop undergoes a phase transition to vapour phase i.e. bubble nucleation occurs. The acoustic signal associated with the bubble nucleation is converted to electrical signal using a condenser microphone based acoustic sensor. Amplitude of the electrical signal depends on intensity of the acoustic signal falling on it. The traces of the electrical signal output was recorded in digital storage oscilloscope and labview.

Results and discussion

The raw signals from the recorded data are first passed through 150 Hz high-pass filter us-

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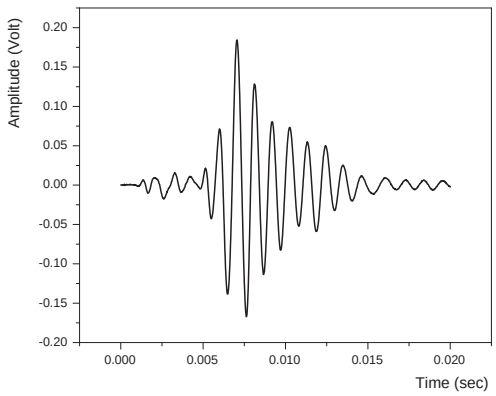

FIG. 2: Typical signal by microphone after passing through 150 Hz high-pass filter.

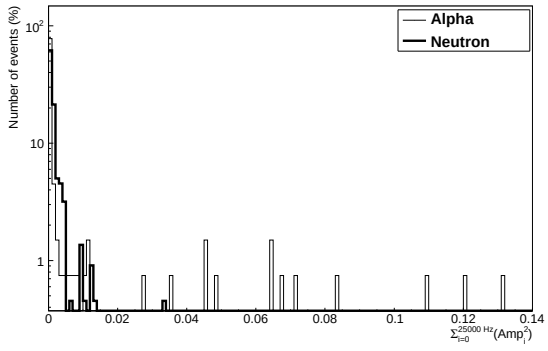

FIG. 3: Distribution of $\sum_i Amp_i^2$.

ing a labview program. This will remove the frequency components below 150 Hz due to noises. Fig 2 shows the typical event measured by the microphone after passing through the previously mentioned high-pass filter.

The distribution has been obtained for a variable, defined as $P_A = \sum_i Amp_i^2$, where i is the time bin of the signal. This variable is related to energy released during the nucleation process. To calculate the variable, we have taken the filtered signal with time span of 20 ms for both the neutron and alpha particle induced events. The distribution of the defined variable (shown in Fig 3) shows that the neutron induced events are in the lower value of the variable, P_A. Whereas at the higher value of the variable, P_A, only the alpha particle induced events are present.

This can be explained by the fact that if alpha particle decays in a drop, the alpha particle induced event produces a signal with a larger acoustic energy than that observed in neutron induced event. The signal carries the imprint of the process of nucleation. The ranges of neutron induced recoils are comparable in size to the critical length. Therefore these events are able to trigger only one primary nucleation. However for alpha particles at least two vaporisation occurs: one from recoiling nucleus and the second one or more on the alpha particle track [3]. These several nucleation sites along the track contribute to the total signal. As a result, the value of P_A variable for alpha induced events are larger than neutron induced events. The variable (P_A), discussed in the present work can be used as a discrimination tool for neutron and alpha particle induced events, in case of the neutron detectors and WIMP search experiment using such detector.

Acknowledgments

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