Determination of Average Neutron Flux of an Am-Be Neutron Source by Instrumental Neutron Activation Analysis

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Average neutron flux of an old Am-Be neutron source was determined by Instrumental Neutron Activation Analysis (INAA) utilizing of ^{115}In(n, γ) reaction and measuring γ-ray activity of the ^{116}In. The average neutron activation cross section for the nuclear reaction was calculated using, effective cross section for the ^{115}In(n,γ)^{116}In reaction, which was computed using tabulated standard reference nuclear reaction cross section data library (TNDL) combined with the neutron distribution spectrum of ^{241}Am-Be source. The average neutron flux was measured by measuring the photo peak intensities of major γ-photons during the decay of ^{116}In. The average neutron flux of the facility was found to be 2.8 x10^5 n.cm^{-2}.sec^{-1}.

Isotopic neutron sources are used as standards for the calibration of neutron detectors and for neutron activation analysis. Due to its easy availability, convenient half life, high specific activity and low associated γ dose. All (α,n) neutron sources are made from a suitable α-emitting isotope such as ^{241}Am and suitably low Z targets for the α bombardment. ^{9}Be is the most important target, because, it offers the highest neutron yield from α induced nuclear reaction with neutron production. ^{241}Am has a long half life of 432.7 years, and is therefore used in many laboratories especially as a neutron and γ calibration source [1]. It is not only a common neutron source but also a γ source that produces 4.438 MeV photons [2]. It is necessary to calibrate neutron monitoring instruments by exposing them to known amount of neutron fields [3]. Attempts have been made in the past to accurately calculate the distribution of neutron in different energy range in these types of sources [4-5]. We have used the available distribution spectrum of ^{241}Am-Be source to compute average neutron capture cross section of ^{115}In in the energy spectrum of the source to determine neutron flux.

Experimentally an ^{241}Am–Be neutron source with approximately 10 Ci of ^{241}Am at the time of its fabrication was used. The source is a disk type neutron source with shielding of wax for neutrons and lead for 4.438 MeV photons. About 235.7 mg of indium foil was sealed in a polyethylene sheet and irradiated with neutrons from the source. The irradiated sample was cooled for 30 minutes. Then the γ-ray counting of the irradiated indium sample was done using energy and efficiency calibrated HPGe detector coupled to PC based 4k MCA. The resolution of the detector system during counting was 2.0 keV at 1332.0 keV γ-lines of ^{60}Co. Both the sample and standard were counted with same detector geometry. ^{151}Eu with source strength of 3900 Bq, was used for energy and efficiency calibration of the γ-ray spectrometer. The γ-ray counting of the sample was done in live time mode. Variation of efficiency as a function of γ-photon energy is shown in Fig.1.

Fig. 2 shows the γ- ray spectra of the irradiated indium foil. Taking into the fractional emission, of various energy photons, and count rate for the photo-peak of interest, the flux was computed using equation (1).

$$\varphi_{av} = C * \frac{\lambda}{(1-e^{-\lambda t_i}) e^{-\lambda t_d} (1-e^{-\lambda t_m}) * m_x * \sigma_{eff} * \Gamma * \varepsilon} * \frac{M_x}{\theta * N_{av}} \quad (1)$$

The available neutron spectra of ^{241}Am-Be source was broken down into narrow energy windows in the energy range of 0-5.5 MeV TNDL [6] and fraction of neutrons in each range were determined to get average neutron absorption cross section for the reaction ^{115}In(n,γ)^{116}In using equation (2). The average cross section was found to be 9.3012 b.

$$\sigma_a = \frac{\Sigma f_i * \sigma_i}{\Sigma f_i} \quad (2)$$

f_i,the fraction of neutrons in different energy range and σ_i is the cross section for ^{115}In(n, γ)^{116}In in ith range[6]. The average neutron flux of the ^{241}Am-Be source was found to be 2.8 x 10^5 n.cm^{-2}.sec^{-1}.

Thus using the present technique, the neutron absorption cross section of ^{115}In(n, γ)^{116}In reaction was calculated and neutron flux of ^{241}Am-Be source was determined by measuring induced radioactivity.

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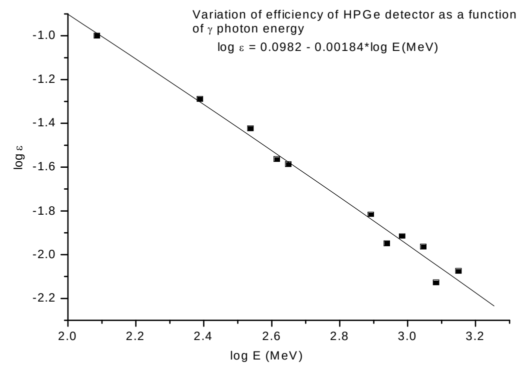

Fig. 1: Variation of efficiency of the detector system as a function of γ-ray energy.

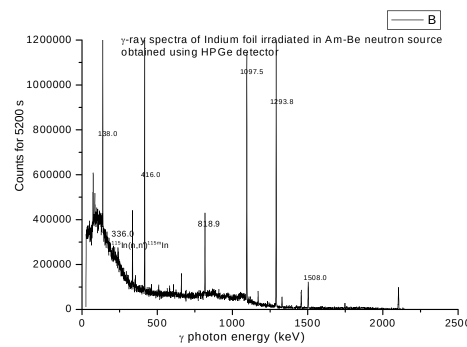

Fig. 2 : γ-ray spectrum of irradiated indium foil.