Neutron induced reactions using ^{241}Am source

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Introduction

The neutron induced reactions often produce continuous background in the measurements of γ-ray spectroscopy. The researchers try to minimize the background to improve the peak to background ratio in the γ-ray spectrum. However, some neutron induced reactions produce discrete gamma peaks which can give valuable information in the forensic analysis, impurity determination [1].

In the past, the radioactive source ^{241}Am has been utilized extensively, as an α-emitter, a source of fast as well as slow neutrons and x-ray fluorescence studies. O. Häusser *et al.* [2] have studied the response of fast neutrons in the energy range of 0.4-10 MeV in NaI(Tl) and BGO detectors [2]. The discrete γ-peaks mostly appear below 1 MeV in the (n, γ) reactions. These peaks have large width because of Doppler broadening and multiple excitations of the discrete states which are close in energy. Recently, we have initiated some studies based on neutron induced reactions in the low energy regime (< 0.06 MeV).

Experiment and result

In the first experiment, we utilized a strong radioactive source ^{241}Am as the primary source of photon in the x-ray fluorescence studies using HpGe (planar) detector. In all the x-ray spectra, we observed two broad peaks at energy values 48.6 keV and 53.5 keV. An example is presented in Fig. 1. The width of the broad peaks can be distinguished from the narrow γ-peak (59.6 keV) of ^{241}Am. We have identified one neutron induced reaction Ge(n, γ)Ge*; it is a reaction with the detector element appearing as a broad peak at 53.5 keV. A similar peak at 48.6 (†), marked in red, is under investigation. In the second experiment, we measured γ-ray spectra using $2'' \times 2''$ NaI(Tl) detector in the following three situations:

(a) Detector was positioned in front of the ^{241}Am source, so that the intense 59.6 keV (^{241}Am) γ-ray peak was observed. The peaks corresponding to neutron induced reactions were not visible clearly (Fig.2(a)).

(b) To avoid 59.6 keV γ-ray being detected by the detector, we positioned the source and detector in the L-shaped geometry with some lead absorbers in between. We were able to observe two pairs of unknown peaks, (†) marked in red, as shown in Fig.2(b). In Fig.2(a), these peaks were buried in the background and could not be observed.

(c) We covered approximately 70% of the detector with Cadmium keeping the other arrangement same as in part (b). This reduced the peak intensity to a large extent, as shown in Fig.2(c). Since the absorption cross-section of neutrons in Cadmium is very high, we inferred that the unknown peaks were definitely due to neutron induced reactions. However, the identification of individual peaks is still being carried out.

We have further performed measurements using different absorbing materials e.g. water, plastic, aluminum and lead to see the effect on the neutron induced peaks. Interestingly, we not only found the change in the relative intensity of the peaks, the new peaks appeared at different energy values. We are currently analyzing all the observed spectra quantitatively using the reaction kinematics.

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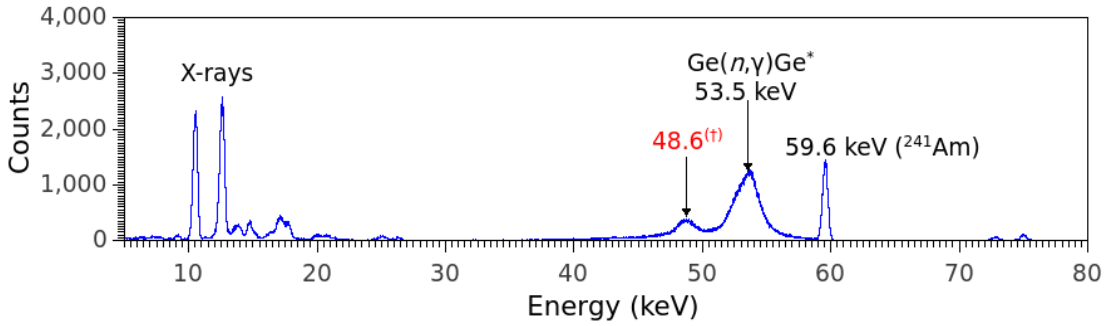

FIG. 1: γ - ray spectrum observed using HPGe (planar) detector. Unknown neutron induced peak is marked in red (†).

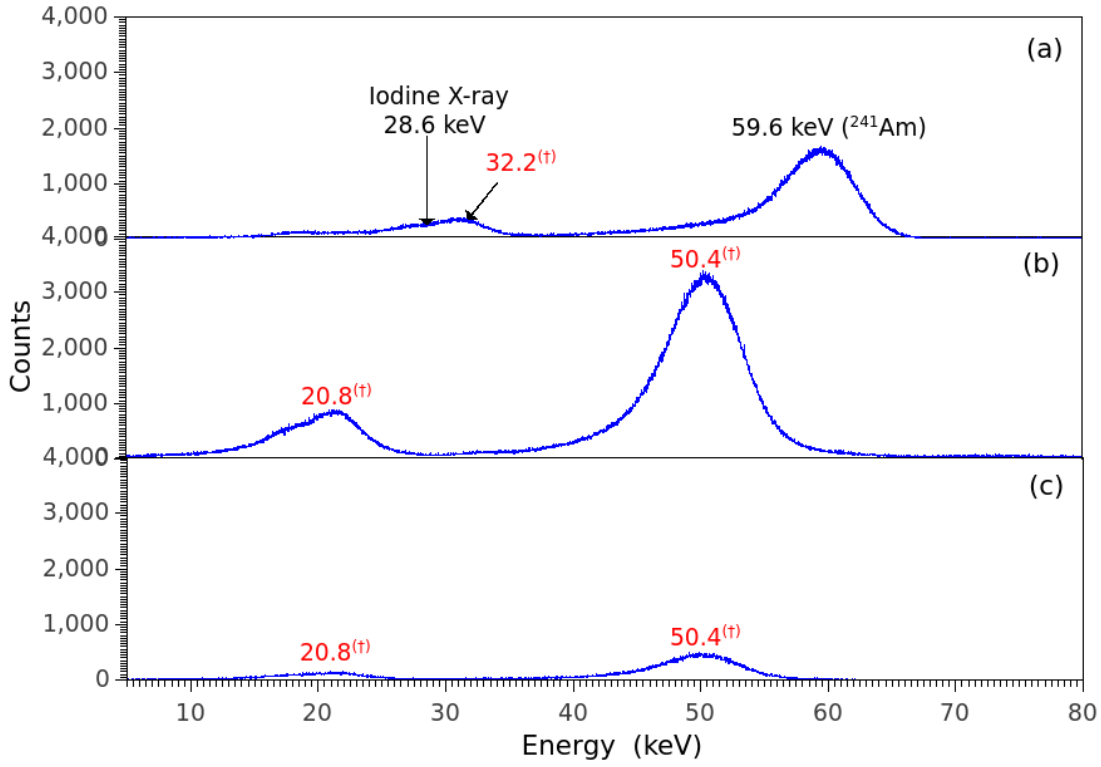

FIG. 2: γ - ray spectrum observed using $2'' \times 2''$ NaI(Tl) detector. Unknown neutron induced peaks are marked in red (†). Parts (a), (b) and (c) of the figure are described in text.

References

[1] A. Vesterlund *et al.*, Appl. Radiat. Isot., 99 (2015), 162.

[2] O. Häusser *et al.*, Nucl. Instr. and Meth., 213 (1983), 301.