Measurement of cross-section of the radioisotope ^{27}Mg @ low energy neutron induced reactions

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Introduction

Neutron capture reactions in neutron–rich light isotopes play a vital role in astrophysical scenarios because of the simulations of the evolution of the stars[1] and the synthesis of the heavy elements required capture cross-sections as an input. Earlier, most of the studies focused to obtain the cross-section for the neutron induced fission. Recently[3,4], the measurements of neutron capture cross-section with the high accuracy gain resurgent interest used direct as well indirect methods. Apart from the direct method, there are various way to measure the cross-section for the neutron capture reactions e.g., i) Surrogate-reaction based on the Bohr model of compound nucleus(CN), ii) Fast-cyclic-activation-technique [3], iii) fission-reaction and iv) inverse- reaction[4] etc.

Several studies[5-8] has been done to probe the chemical evaluation and nucleosynthesis processes in the Galaxy & Supernova. A confusing trend of α-elements and their abundance ratios[3] have also been reported in metal-poor-stars. The presence of magnesium (Mg) has been reported in massive Red Giant Stars via hydrostatic C and Ne burning[3]. It is also proposed that in Asymptotic Giant Branch (AGB) magnesium is produced via α- capture by Ne as well as neutron capture via ^{26}Mg and decay of ^{26}Al. The magnesium is one of the elements of interest in stellar nucleo-synthesis because it is one of the most abundant[3] isotopes in the cosmos and all isotopes show a deviation from the normal 1/v–behavior of their cross sections. The present work, measurement of neutron capture cross-section of ^{27}Mg by direct method is a part of a programme. The measurement of cross-sections of all the radioisotope lie near the line of stability has been planned. For the measurements of activity in short-lived nuclei, surrogate-reaction method which is based on Bohr hypothesis will be used. And to measure the low-activity nuclei the fast-cyclic-activation technique will be employed. Data obtained in low energy neutron induced reactions will be analyzed with the Geometry Depended Hybrid (GDH) model and the data available in the Literature[9].

Experimental details

In the present work, the activation technique has been employed. The measurements have been carried out at the Nuclear Physics Laboratory and the irradiation of the magnesium done using the neutron facility of the Department of Physics and Astrophysics, University of Delhi (DU), Delhi.

The target of natural Mg (contains ^{24}Mg 78.9%, ^{25}Mg 10% and ^{26}Mg 11%) has been irradiated with neutrons of flux 10^4 neutron.m^{-2} for 3 days. To detect the γ-radiations the High Purity Germanium (HPGe) detector of 129cc active volume supplied by ORTEC[10] is used., the resolution of the detector was 0.2% at γ-ray energy 661.7 keV of ^{137}Cs. The detector was calibrated for energy as well as the efficiency, the calibration is carried out using standard radioactive source ^{154}Eu. To determine the efficiency of the detector, the standard γ-ray sources viz. ^{22}Na, ^{137}Cs, ^{60}Co, ^{57}Co and ^{133}Ba were used and curve obtained for the efficiency is given in Fig. 1. The spectroscopic data of ^{27}Mg[11] is given in Table 1. Before obtain, the γ-ray spectra of the irradiated magnesium target, the background of the laboratory has been recorded for an 5 hrs in intervals of half an hour. As a representative case, a spectrum of 5hrs duration is shown in Fig. 2. After the taking the background, the spectra of Mg have been recorded, the duration of the counting was 1800s.

Table 1: Characteristic decay data of ^{27}Mg[11].

E_γ(keV)	I(%)	Half-life
170.68	0.85	
843.74	71.8	9.465 m
1014.42	28.0	

A comparison of Mg spectrum with the background recorded for the same time has also been made and is shown in Fig.3. The analysis spectra has been done using the software CANDLE[12]. The cross-section of the radioisotope produced in neutron capture is determined through the standard formulation.

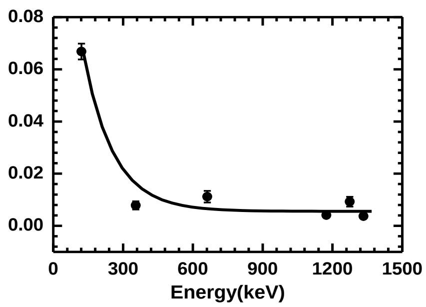

Fig. 1 Efficiency curve of the HPGe detector.

Result and Discussion

With aiming the astrophysical interest measurement of the cross-section of the ^{27}Mg has been carried out. However, present measurements are also in need for other nuclear applications viz., nuclear energy and nuclear medicines. In order to measure the cross-section, the background spectrum has been compared with the magnesium spectrum, a comparison is shown in Fig. 3. It has been observed from the spectra, the expected γ-ray energy 843.7 keV is suppressed by the background. To improve the yield of ^{27}Mg a modification in experimental set-up is under consideration. Further, analysis of the data is in progress and will present during the symposium.

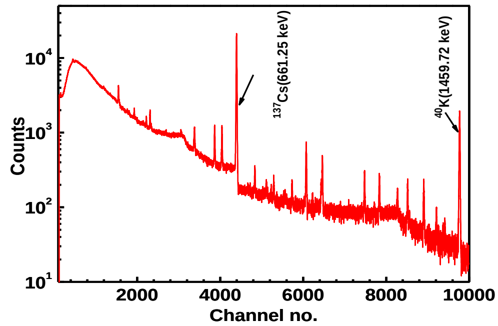

Fig. 2 The spectrum of the background of Nuclear Physics Lab, duration of the collection of the spectrum was 5 hrs.

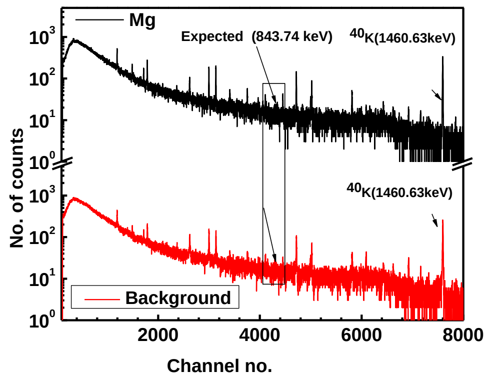

Fig. 3 The spectrum of the Mg after irradiation along with the background, duration of counting was 30m.

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