Prompt fission neutron spectrum measurement in n+^{238}U reaction at 2.0 MeV

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Introduction

The prompt neutron spectra for fast neutron induced fission of ^{238}U are of prime importance for the design of fast breeder reactors, accelerator driven systems (ADS) and also for the evaluation of nuclear data for actinide nuclei. The prompt fission neutron spectra for the fast neutron induced fission has been insufficiently studied experimentally[1].This situation is mainly due to the following difficulties: (a) Extremely small cross sections for fast neutrons; (b)large number of background neutrons produced in the same energy regime as that of fission neutrons; and (c) mono-energetic neutron source of required energy regime with appropriate intensity is often unaccessible.

So far few measurements of the prompt neutron spectra of ^{238}U from the fast neutron induced fission have been reported. However these data are not in good agreement with each other and some of them give only average prompt neutron energy($\bar{E}$) or Maxwellian temperature(T) without detailed fission neutron spectrum. Therefore new measurements are required with updated experimental techniques for refinement of data base and theoretical models[1–3]. We have a program to carry out measurements on prompt neutron spectrum for ^{232}Th, ^{235}U and ^{238}U targets in fast neutron induced fission. In the present work we report results on our first attempt to measure the prompt neutron emission spectra of ^{238}U fission induced by 2.0 MeV neutron produced via ^{7}Li(p,n)^{7}Be reaction. The obtained spectra have been compared with the Maxwellian function and calculated data taken from Vladuca and Tudora *et al.*[4]. The Maxwellian temperature has also been deduced from present data and compared with the other experimental data reported earlier in the literature[1, 2].

1. Experimental Details and Data Analysis

The experiment was performed at the 6MV Folded Tandem Ion Accelerator (FOTIA) facility, Bhabha Atomic Research Centre (BARC), Mumbai. The primary monoenergetic neutrons of energy 2.0 MeV were obtained via ^{7}Li(p,n)^{7}Be reaction by bombarding the proton beam on solid Li target of thickness 4mg/cm^2, mounted at the centre of the end glass flange of the beam line. The experimental set up used in the present experiment is shown schematically in Fig.1. The fission ionization chamber shown in Fig.1 with ^{238}U target mounted on one of its electrode was kept just outside the glass flange at 0° with respect to the beam direction. The fission event trigger were taken from this ionization chamber. The NE213 liquid organic scintillator detector (12.7 cm diam. and 5 cm thick) was kept at 90° with respect to beam direction to detect the fission neutrons. The distance between the fission chamber and neutron detector was approximately 67 cm. The NE213 has different responses to neutrons and γ rays. Thus the pulse shape discrimination is used to discriminate the neutron and γ incident on the scintillator detector. The time of flight technique (TOF) is used to determine the energy of fission neutrons. The start signal was taken from fission ionization chamber and stop signal from NE213 detector for TOF measurement. The prompt neutron energy spectrum so obtained for ^{238}U fission induced by 2.0 MeV neutron is shown in Fig.2(a).

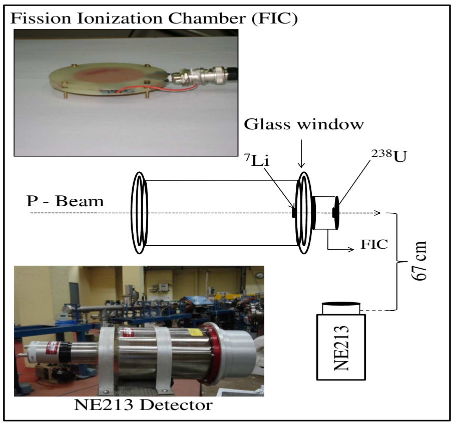

FIG. 1: (Color online) The experimental set up.

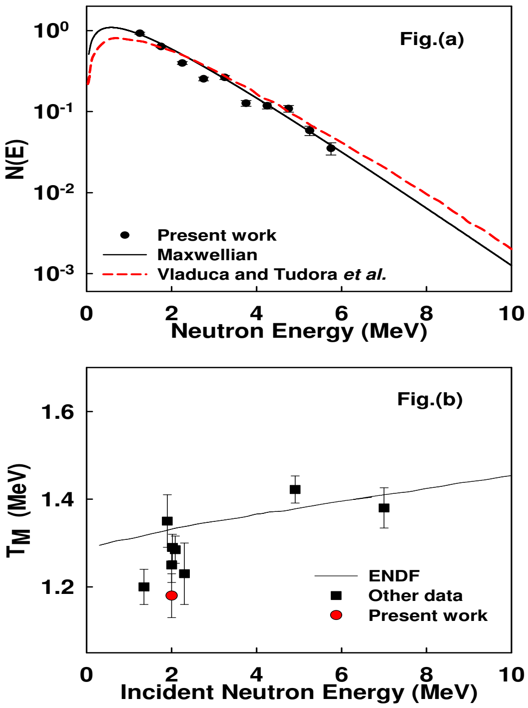

FIG. 2: (Color online) (a) The prompt neutron energy spectrum(solid circles) compared with the Maxwellian distribution (solid line) and the calculated data from Vladuca and Tudora *et al.*[4](dashed line) (b) Maxwellian temperature (T_M); present result (solid circle) in comparison with other experimental data[1] (solid squares) and ENDF/B-IV[5](solid line).

Results and Discussion

The prompt neutron energy spectrum obtained in the present experiment is then fitted by the Maxwellian distribution. The Maxwellian temperature (T_M) and multiplicity (ν_n) have been deduced by least square fitting. The best fit to the present experimental data yields; T_M = 1.18$\pm$ 0.025 or average prompt neutron kinetic energy $\bar{E}$ = 1.77 $\pm$ 0.04 and ν_n = 2.55$\pm$ 0.02

The present experimental spectra along with the best fit by Maxwellian and the data obtained from Vladuca and Tudora *et al.*[4] are shown in Fig.2(a). The Maxwellian temperatures T_M deduced in the present experiment have been compared with the other data[1] and ENDF/B-IV data[5] is shown in Fig.2(b).

Summary and conclusions

The preliminary results on prompt fission neutron spectra from ^{238}U fission is measured for incident neutron energy of 2.0 MeV. The Maxwellian temperature (T_M) and multiplicity (ν_n) have been deduced from the best fit to the present experimental data. The obtained values of T_M, ν_n and $\bar{E}$ are in good agreement with the data reported earlier within our experimental uncertainties. We have planned to carry out measurement for ^{238}U systems with improved accuracy and good statistics and further new measurements for ^{235}U and ^{232}Th systems.

We are thankful to the operating staff of the FOTIA facility, for the smooth operation of the accelerator during the experiment.

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