Experimental photofission cross-section of ^{232}Th and ^{237}Np using Microtron Accelerator

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Introduction

The dependence of photofission cross-sections on energy and target nucleus at energies approaching the fission threshold has important information's for the fission process [1]. The fission of thorium has been the subject of much research, both experimental and theoretical. Many measurements near threshold which have been made with neutrons using the even-even nuclei, producing odd mass systems with several open fission channels. However, if measurements are made using photons, then only a very few fission channels are involved, an indeed for ^{232}Th, experimental photofission angular distributions have shown that the $J^{\pi}K=1^{-}$ 0 channel is predominant by at least an order of magnitude near threshold. The predominance of one fission channel eases the interpretation of data. There have been many previous photofission experiments on ^{232}Th. Experiments in the energy region near threshold include those performed with bremsstrahlung, quasi-monochromatic photons form photon annihilation, variable energy Compton scattered gammas, proton capture gammas and tagged photons [2]. On the other hand, there are very few data available for an odd-A nuclei with spin 5/2 at threshold, because of the unavailability of intense variable energy gamma rays. Most of earlier work on the photofission of ^{237}Np was done with bremsstrahlung beams and monoenergetic neutron capture γ rays [3]. In most experiments only the photofission cross section $\sigma_{\gamma f}$ was measured, usually by detecting the fission fragments. The present measurements were made using bremsstrahlung, employing a technique to ensure reliable results, and a high efficiency SSNTD Lexan polycarbonate detector to record the fission fragments.

Methodology

The Photofission cross-section of ^{232}Th and ^{237}Np nuclei measurements were made using bremsstrahlung radiation from the Microtron at Mangalore University. A Self supporting 2 mg/cm^2 thickness of ^{232}Th and ^{237}Np target of thickness 200 μg/ cm^2 deposited on aluminium backing was bombarded by bremsstrahlung radiation. It was kept at 45° to the beam axis and at a distance of 15 cm from the tantalum target. The fission fragments emitted from the target were detected by SSNTD Lexan polycarbonate films with a dimension of 12.6 cm X 4.5 cm X 175 μm which were kept at a distance of 8 cm from the target. The film was placed on the surface of the fission chamber covering 0° to 90° . The SSNTD Lexan films were calibrated using ^{252}Cf source. After the irradiation Lexan films were cut in to equal strips, each strips intended for particular angle. These strips were etched in 6N NaOH at 60° C temperatures for one hour. After etching strips were washed, dried and then analyzed for the tracks formed by the fission fragments under an optical microscope of magnification 400X [4].

Results and discussion

The fission yield for particular electron end point energy is related to fission cross-section σ (E) and bremsstrahlung intensity N (E, E_{max}) as follows:

$$Y(E_{max}) = C\int_0^{E_{max}} \sigma(E)N(E, E_{max})dE$$

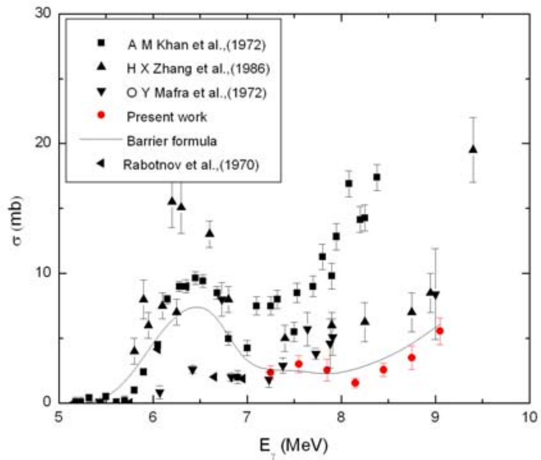

Fig 1: Photofission cross-section of ^{232}Th as a function of photon energy

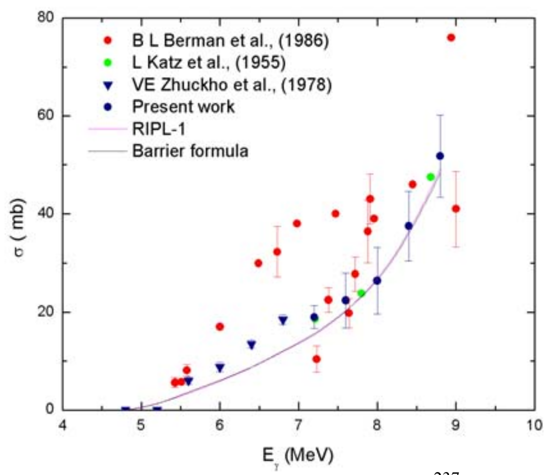

Fig 2: Photofission cross-section of ^{237}Np as a function of photon energy

The measurement of the photofission yields of ^{232}Th and ^{237}Np as a function of the maximum photon energy 7.4 to 9.0 MeV was obtained from the angular distribution of fission fragments. The fission fragment angular distributions were obtained at various energies by normalizing the fission track counts to the solid angle and photon intensity. The obtained fission yield of ^{232}Th from 7.4 MeV to 9.0 MeV were folded with Rabotnov et al., [5] and the fission yield of ^{237}Np were folded with a Zhuckho et al., [6] photo fission cross-section with the bremsstrahlung spectrum simulated using EGS-4 code to obtain Photofission yield curve from threshold 4.8MeV to 7.4 MeV. This yield curve is in close agreement with the present experimental results above 7.4 MeV. The total yield curve unfolded using photon difference method [7]. The resulting photofission cross-section of ^{232}Th and ^{237}Np of the present investigation was compared with the experimental data from EXFOR library [8] is shown in Fig. 1 and 2. From the various analysis carried out, it clear that σ_f (E) for ^{232}Th and ^{237}Np exhibits almost the same patterns in all investigation. In the present investigation, the resulting photofission cross-section of ^{232}Th is consistent with the results of Mafra et al [9] and the resulting photofission cross-section of ^{237}Np is consistent with the results of Katz et al [10].

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