Photoneutrons from Bismuth.

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Summary. — The energy spectrum of photoneutrons from bismuth irradiated with 31 MeV bremsstrahlung is studied at \( \theta \) angles of 30\(^\circ\), 60\(^\circ\), 90\(^\circ\), 120\(^\circ\) and 150\(^\circ\), by means of nuclear emulsion. A comparison between the experimental energy spectra and an evaporative spectrum calculated according the expression \( F(E_n) = kE_n \exp[-E_n/T] \), shows a surprisingly high contribution of high energy neutrons around \( \theta = 90^\circ \). The angular distribution is isotropic in the region \( 2 < E_n < 4 \) MeV, is approximately of the form \( 1 + 0.7 \sin^2 \theta \) for \( 4 < E_n < 5 \) MeV, and shows back and front asymmetry for \( E_n > 5 \) MeV. The contribution of the photoneutrons arising from the Bi(\( \gamma \), 2\( n \)) process is evaluated.

1. — Introduction.

The energy spectra of photoneutrons from Bi irradiated with bremsstrahlung have been studied by Price (\(^1\)) at \( E_{\gamma \text{max}} = 22 \) MeV, by Zatsepin et al. (\(^2\)) at \( E_{\gamma \text{max}} = 18.9 \) MeV, and by Bertozzi et al. (\(^3\)) at \( E_{\gamma \text{max}} = 14.3 \) and 15.8 MeV. These spectra show a greater contribution of high energy neutrons

(E_n > (3 \div 4) \text{ MeV}) which cannot be accounted for by an evaporative process than that found for instance in the photoneutron spectrum from Au \(^{(4)}\). A remarkable contribution of high energy neutrons has been found also in the photoneutron spectrum from Ta \(^{(5)}\), but this contribution is explained as being due to neutrons emitted by direct interaction and coming in part from a second resonance in the (\gamma; n) cross-section. In the case of Bi, the known cross-sections \(^{(6-8)}\) give no evidence of a second resonance as in the case of Cr, As, I, Ta \(^{(5-9)}\). So the high percentage of high energy neutrons from Bi seems to be a peculiarity of this element.

In the present experiment the energy spectra and the angular distribution of the photoneutrons from bismuth are studied by irradiation with a 30 MeV bremsstrahlung beam. At this irradiation energy, the study of the photoneutrons includes a large region beyond the giant resonance in the \(\sigma(\gamma, n)\) process so that, far from the giant resonance, the contribution of other processes may also be investigated.

2. - Experimental procedure.

A cylindrical target of Bi was irradiated by a collimated \(\gamma\)-ray beam from the Betatron of the University of Turin, working at the maximum energy of 30 MeV. The photoneutrons emitted at \(\theta\) angles of 30\(^\circ\), 60\(^\circ\), 90\(^\circ\), 120\(^\circ\) and 150\(^\circ\) with the photon beam where recorded by means of proton recoil tracks in L4 plates 400 \(\mu\text{m}\) thick.

The experimental arrangement was analogous to that used in a previous work \(^{(10)}\). The only difference being the substitution of the water wall—screening the plates against the neutrons from the betatron—with a paraffin moderator as shown in Fig. 1.

The scanning of the plates exposed with no target in the beam shows that the background was negligible (<1\%).