PHOTODEUTERONS FROM Al^{27}

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The ratio of the photodeuteron to photoproton yield was measured for Al^{27} irradiated with γ rays with $E_{\gamma max} = 35$ Mev. Within an energy range from 2.9 to 10 Mev the ratio was found to be 0.009 ± 0.007 (which is much smaller than the ratio for Cu at $E_{\gamma max} = 70$ Mev [3]).

THE experimental data on photodeuterons of energies > 15 Mev can be interpreted on the basis of the so-called pickup process.[1,2] The study of photodeuterons of energy < 15 Mev has met with difficulties due to the small yield of the (γ, d) reaction and due to the lack of a sufficiently trustworthy method of distinguishing between singly charged particles of low energy. The investigations of the relative yields of photodeuterons have led to rather conflicting results which also are sometimes difficult to compare.

In the present work the ratio of the yield of photodeuterons and photoprotons was measured for Al^{27} irradiated with bremsstrahlung of $E_{\gamma max} = 35$ Mev. The charged particles were identified by the radius of curvature of their trajectory in a magnetic field and by their range in a nuclear emulsion.[3] Compared to the more frequently used method of grain counting in the residual range this method is less cumbersome to apply and more sensitive in distinguishing between singly charged particles.

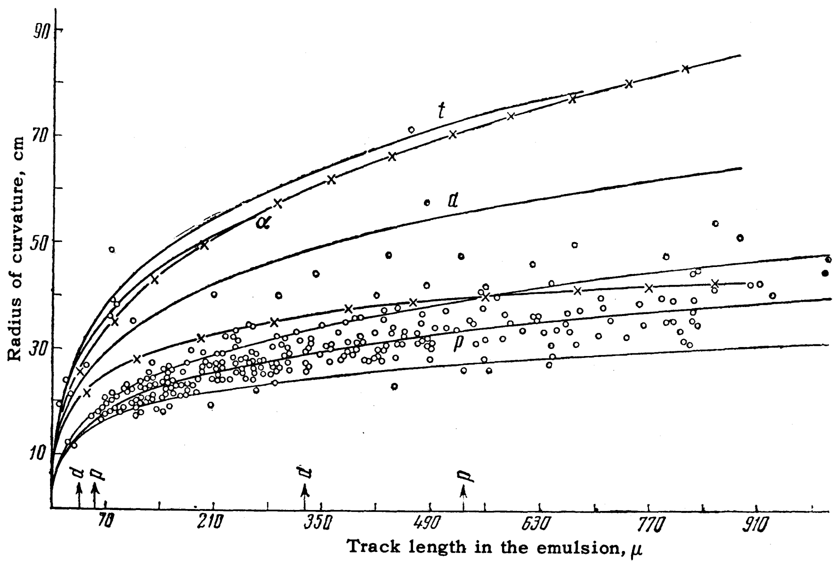
The target was an aluminum foil of 7 mg/cm^2 thickness. Together with the nuclear emulsion it was placed inside a vacuum chamber in a transverse constant magnetic field with H = 13 500 oe. The nuclear emulsions, type NIKFI-Ya2 400 μ thick, were distributed in the interval 50° to 120° with respect to the photon beam. In addition to the range of the particles, the orientations of their tracks were measured in order to determine the radius of curvature of their trajectories in the magnetic field. The irradiation dose was measured with a quantometer.[4] The background due to (n, p) reactions in the vacuum chamber and due to (γ, p) reaction in the aluminum foil windows was determined in a run with the target foil removed from the chamber. A correction for the background was applied to the results.

The distribution of the radii of curvature as a function of the range is given in the figure. The solid curves give the calculated dependence $\rho(R)$ for protons, deuterons, α particles and tritons. The "range of errors" also is indicated: for the protons by solid lines, for the deuterons by lines with crosses. The corresponding curves for tritons and α particles are not given. The measured events are indicated by open circles.

From the analysis of the data we obtain for the ratio of the yield of photodeuterons of energy 2.9 to 10 Mev to the yield of photoprotons of the same energies, $Y(\gamma, d)/Y(\gamma, p) = 0.009 \pm 0.007$. Thus the deuteron yield is less than two percent of the proton yield. Recently Forkman[5] has used a method analogous to ours to measure the yield of photodeuterons from S, Co and Cu. His results agree in the order of magnitude with the results of the present paper.

According to the evaporation model the yield of photodeuterons from light and medium nuclei (at $E_{\gamma max} = 30$ Mev) is also a fraction of a percent of the photoproton yield. However, despite the agreement of the experimental data with the results obtained from the evaporation model the question of the mechanism of the production of photodeuterons remains open so long as the angular and energy distributions are unknown. Another probable process along with evaporation of deuterons is one in which a deuteron is emitted when an evaporated proton picks up a neutron while leaving the nucleus. Byerly and Stephens[6] point out that this process is more probable than simple evaporation. However, at present one can only confirm that if such a process of production of low energy photodeuterons exists its probability is of the same order of magnitude as the probability of the evaporation process.

In the earlier paper[3] somewhat too large val-



Dependence of the radius of curvature on the track length of the particles in the emulsion. The arrows on the abscissa indicate the limits of the range of the particles corresponding to the energy interval 2.9 to 10 Mev.

ues were given for the ratio $Y(\gamma, d)/Y(\gamma, p)$ for copper at $E_{\gamma max} = 70$ Mev. When the data are more correctly analyzed with account of the background, we obtain for particles with energies in the range 4 to 10 Mev $Y(\gamma, d)/Y(\gamma, p) = 0.04 \pm 0.01$ and for the range 3 to 10 Mev $Y(\gamma, d)/Y(\gamma, p) = 0.05 \pm 0.01$.

Chizhov and Kul'chitskii [1] have shown that the yield ratio for particles of a given energy interval increases with increasing bremsstrahlung energy. Such a tendency has been confirmed by our experiments. The observed rather sharp increase of the yield ratio is obviously due not to evaporation but to a different process of deuteron production.

In the present work we also have estimated the ratio of the yield of photoalphas to the yield of photoprotons from Al^{27}. Neglecting a possible contribution from phototritons we obtain for particle energies 8.8 to 14 Mev $Y(\gamma, \alpha)/Y(\gamma, p) = 0.023 \pm 0.019$. This relative yield of α particles is not in contradiction with the available experimental information for light and medium nuclei.

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