LABORATORY DEMONSTRATION OF THE NUCLEAR PHOTOEFFECT

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The cross-sections for this effect are extremely small, so it is difficult to observe with ordinary equipment and (especially) to demonstrate it at lectures; no such experiments are described in books on laboratory and lecture demonstrations, although the effect is of some importance in nuclear physics.

Counting equipment is now widely available [1], as is a centralized supply of heavy water at a reasonable price [2], so such experiments can be made available in technical colleges. Heavy water is the most convenient substance for the purpose, because the binding energy is only 2.18 MeV [3], so the effect can be demonstrated without resort to accelerators by using the γ-rays from radiothorium (or thorium ore), some of which are of energy 2.6 MeV [3, 4]. An SCh-3 scaler system with an SNM-5 counter [1] allows one to demonstrate the effect on a very small amount of water with weak γ-ray sources; for instance, it is detectable with 5 g of heavy water used with four of the thorium preparations employed in school-type Wilson chambers (made by Glavuchtekhprom, usually supplied by the local Fizpribor branch) even when the geometry is poor (preparations left in chambers, which are surrounded with water as the moderator for the counter). The counter is here about 6 cm from the water, which is 5-8 cm from the sources. Each preparation emits about 2×10^6 photons per minute (various energies), which gives a dose far below the daily tolerance even when the apparatus is used for several hours.

The effect is clearly detectable (some 15 counts) in measurements lasting 1-1.5 hr with the counter surrounded by the γ-ray sources but with the heavy water first present and then absent. The discriminator of the SCh-3 is set at 75-100 to minimize the background. The number of 2.6 MeV photons is known, but the fluctuations in the background and neutron counts are such that the result gives only the order of magnitude (about 10^{-27} cm^2) of the cross-section of ${}_1D^2 + \gamma \rightarrow {}_1H^1 + {}_0n^1$. A complete ampule of heavy water of the minimum size supplied by Izotop (50 g) will give a detectable effect from 1-2 min readings if the best geometry is employed (i.e., in a lecture demonstration); an accurate value for the cross-section is obtained when the readings are taken over the period of a laboratory practical [5]. The angular variation in the neutron flux may be traced if several rather larger γ-ray sources are available; this gives the ratio of the photomagnetic effect to the photoelectric one [5].

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DERIVATION OF WIEN'S FORMULA

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Wien's thermodynamic formula for the spectral density of equilibrium electromagnetic radiation

$$du(\nu) = \nu^3 f(\nu/T)\, d\nu \qquad (1)$$

is of great importance because it implies the Stefan-Boltzmann law and the shift in the peak. Most textbooks omit the derivation of this formula on account of its length. Formula (1) may be shown to be correct by comparing it with Planck's formula for $u(\nu)$.