The Absorption Cross Section of Gold for Neutrons of Energies from 0.01 to 0.3 Ev*

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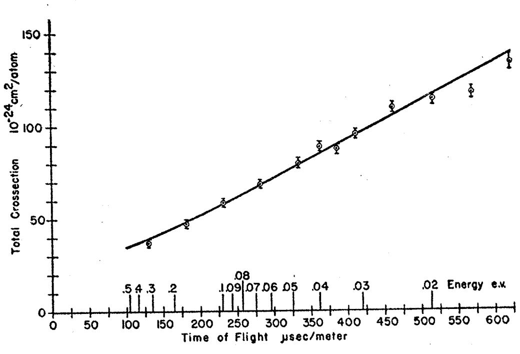
THE neutron transmission of a gold sheet, 3.01 g/cm^2 thick, has been measured for neutron energies from 0.01 to 0.3 ev. Neutrons of high energy were produced by bombardment of a Be target with deuterons from the 42-inch Los Alamos cyclotron. The neutrons were slowed down in a moderating medium near the cyclotron chamber. The moderator consisted of a 5-cm thickness of a solution of 7 g of B_2O_3 per liter of water, boron being used to shorten the mean life of the source. Neutron energies were determined by measuring their time of flight over a 7.6-meter path from the moderator to a BF_3-ion chamber. The time of flight was measured by means of the Cornell neutron velocity spectrometer.[5] Corrections, which amounted to less than 3 percent of the time of flight, were made to take account of the 68-microsecond mean life of the moderator.

Figure 1 shows the total cross section, obtained from the transmission data, plotted as a function of the neutron time of flight expressed in microseconds per meter. A corresponding scale of neutron energies is also included for comparison. It can be seen that the relation between cross section and time of flight is approximately linear. However, because of the resonance in gold, which is located at about[6] 4.8 ev, the cross-section dependence on time of flight is expected to depart slightly from a linear relation. One may assume that the Breit-Wigner one-level formula describes the variation of the cross section from 4.8 ev down to zero energy and that contributions from higher resonances are not significant. Under this assumption, the total cross section in the region investigated is expected to follow the approximate relation given below.

$$\sigma_T \doteq \alpha(E_r/E)^{\frac{1}{2}}(1+2E/E_r)+\sigma_s,$$

σ_T = total cross section, E = neutron energy, E_r = resonance energy = 4.8 ev.

The scattering cross section σ_s is assumed to be approximately constant, while α is a constant depending on the Breit-Wigner parameters of the 4.8-ev resonance as is given below.



Total cross section of gold as a function of neutron time of flight. Corresponding energy scale also given on the abscissa.

$$\alpha = \sigma_0\Gamma^2/4E_r^2,$$

σ_0 = cross section at resonance, and Γ = resonance width.

The curve in Fig. 1 is drawn in accordance with the approximate relation given above, and uses a choice of the constants which provides a good fit to the data. The values of α and σ_s which were chosen are 6.80 and 9.0 barns, respectively (one barn equals 10^{-24} cm^2/atom). Substitution of these values in the equation above yields the following expression for σ_T when the neutron energy is expressed in ev:

$$\sigma_T = \{(14.9\pm0.3)E^{-\frac{1}{2}}(1+0.42E)+(9.0\pm2)\} \quad \text{barns}.$$

The corresponding value of $\sigma_0\Gamma^2$ is 625 barns-ev^2, in agreement with that given by Havens.[6] The value of the total cross section observed at 0.025 ev is (104±2) barns.

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5 B. D. McDaniel, Phys. Rev. 70, 832 (1946).
6 Havens, Wu, Rainwater, and Meaker, Phys. Rev. 71, 166 (1947).

Gamma-Rays from Cu^{64}, Annihilation of Swift Positrons, and Experiments on Orbital-Electron Capture

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BRADT, *et al*[1] have reported that Cu^{64} emits one gamma-ray of 1.2 Mev for every ten positrons emitted. About a year ago, before the Swiss work came to our attention, we observed a feeble hard radiation from Cu^{64} and believed it to be due to the annihilation of moving positrons. According to Heitler,[2] about three percent of the positrons should be annihilated before stopping, and somewhat more than half of the resulting continuous gamma-ray spectrum should be above 0.51 Mev, with an end point of about 1.35 Mev. The existence of nuclear gamma-rays of the energy and abundance reported by the Zurich group would be of importance to our understanding of the orbital-electron capture process, since the results of Good, Peaslee, and Deutsch,[3] which showed excellent agreement with the theory for allowed transitions, in several cases were based on the use of Cu^{64} as a source of pure annihilation radiation.

The gamma-rays from a sample of copper obtained from Oak Ridge were therefore investigated in the magnetic lens spectrometer. Secondary electrons caused by a feeble 1.35-Mev gamma-ray were found and decayed with the half-life of Cu^{64}. The K-photoelectron line was slightly more than 0.005 times as intense as the K-line caused by the annihilation radiation, as shown in Fig. 1. Evaluation of relative gamma-ray intensities from this ratio is not too easy, because of the relatively thick radiator (50 mg/cm^2) used. A gamma-ray spectrum of Na^{22} was there-