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GOLD CROSS SECTION FOR NEUTRONS FROM 0.01 TO 0.3 EV

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Physics - Nuclear Reactions, etc

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ABSTRACT

The cross-section of gold has been measured by a transmission experiment using the time of flight method. If the scattering cross-section is constant, the absorption cross-section follows the $1/v$ law between .01 ev and .3 ev. The total cross-section at .0250 ev is 104 ± 2 barns. Using the extrapolated value of 10 barns for the scattering cross-section, one finds that the absorption cross-section at .0250 ev is 94 barns.

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GOLD CROSS-SECTION FOR NEUTRONS FROM 0.01 TO 0.3 EV

The total cross-section of gold as a function of neutron energy has been measured by a transmission experiment using the time of flight method. The measurements were in the range from .01 ev to .3 ev. It was expected that the absorption cross-section would follow the 1/v law in this region.

APPARATUS

The cyclotron modulated with the slow-modulation equipment was the primary source of neutrons. These neutrons were thermalized in a 5 cm thick tank containing a boron solution of 7 grams of B_2O_3 per liter. This tank then, served as the source of neutrons, whose time of flight was to be measured.

The 12 inch I.D. paraffin and boron carbide collimator[1] was used; one end of this collimator was closed by the boron "source" and a BF_3 ionization chamber was placed in the collimator 7.6 meters away from the source. In addition the BF_3 detector was surrounded by a smaller boron carbide collimator of surface density 1.0 gm/cm^2, which extended 75 cm from the front of the chamber. The aperture was 2 inches in diameter, and the gold sample was placed over this aperture[2].

The gold sample consisted of four sheets each 3 inches square. Their combined average surface density was 3.01 gm/cm^2.

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1) Anderson, Lavatelli, McDaniel and Sutton, LA-91

2) Anderson, Lavatelli, McDaniel and Sutton, LA-82

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PROCEDURE

The procedure is essentially the same as that described in the appendix of LA-91. The arc repetition rate was 100 cps and the arc and detector "on-times" were 200 μsec. The data were subject to the usual background corrections.

The timed observations were made alternately with the absorber in place and with no absorber, a total of four such sequences being taken.

The total transmission was determined using an unmodulated beam, by comparing the counts per neutron monitor count, with the absorber in place, with the same quantity without the absorber. The mean deviation of the repeated runs provides a measure of the accuracy of the total transmission determination.

The mean life of the boron source was measured with a normal (unenriched) tuballoy fission chamber placed with its center 10 cm from the source. Using the modulation equipment, 25 fission counts were recorded as a function of time from 40 μsec to 460 μsec after the pulse arrived at the target. The mean life of the source was measured to be 68 μsec.

The effect of the mean life is to distort the resolution of the equipment and also to shift to a later time the time average of the pulse leaving the source. This delay can be shown to be approximately the mean life, and as a consequence the time of flight associated with each timed counter must be decreased by 68 μsec, which is 9 μsec/m in this experiment.

This correction applies to neutrons of thermal energies; for energies above 0.5 ev (100 μsec/m) there is no significant mean life correction. For energies less than .06 ev (300 μsec/m) the correction is 3 percent or less,

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so small that it is assumed constant and equal to 9 μsec/m. In the intermediate interval the correction is assumed to vary linearly with the time of flight.

RESULTS AND DISCUSSION

The total transmission is .514 with a probable error of about 1 percent.

The absolute transmission as a function of time of flight for the gold sample is shown in Fig. 1, and the attached probable errors are the statistical errors associated with each point and do not include the error in the total transmission. The time of flight for each counter has been corrected for the effect of mean life discussed in the previous section.

The transmission is

$$T = \exp\left[-\left(\sigma_s + \sigma_a(v)\right)n\right] = \exp(-\sigma_T n)$$

where σ_s is the scattering cross-section per atom (assumed constant)

$\sigma_a(v)$ is the absorption cross-section per atom

n is the number of atoms per cm^2

σ_T is the total cross-section $= \sigma_s + \sigma_a(v)$

In Fig. 2 is shown the total cross-section as a function of the time of flight, τ. A straight line has been drawn through the points as a consequence of the following considerations. If $\sigma_a(v) = k/v = k\tau$, then $\sigma_T(\tau) = \sigma_s + k\tau$, which corresponds to a straight line in the σ-τ plane. The intercept when $\tau = 0$ is $\sigma_s = \sigma(0) = 10$ barns. (1 barn = 10^{-24} cm^2.)

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CONCLUSION

The value of σ as determined by Fermi and Marshall[3] for 2200 m/sec or 454.5 μsec/m or .0253 ev is 101 barns. This value compares favorably with 103.5 $\pm$ 2 barns as determined from Fig. 2. At 0.0250 ev, σ is found to be 104 barns.

The reasonable assumption that the scattering cross-section is constant leads to the conclusion that the absorption cross-section of gold follows the 1/v law in the thermal region of neutron energies within the error of the experiment, and exhibits no significant deviation in this range.

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3) Fermi and Marshall, CP-1255.

Fig. 1

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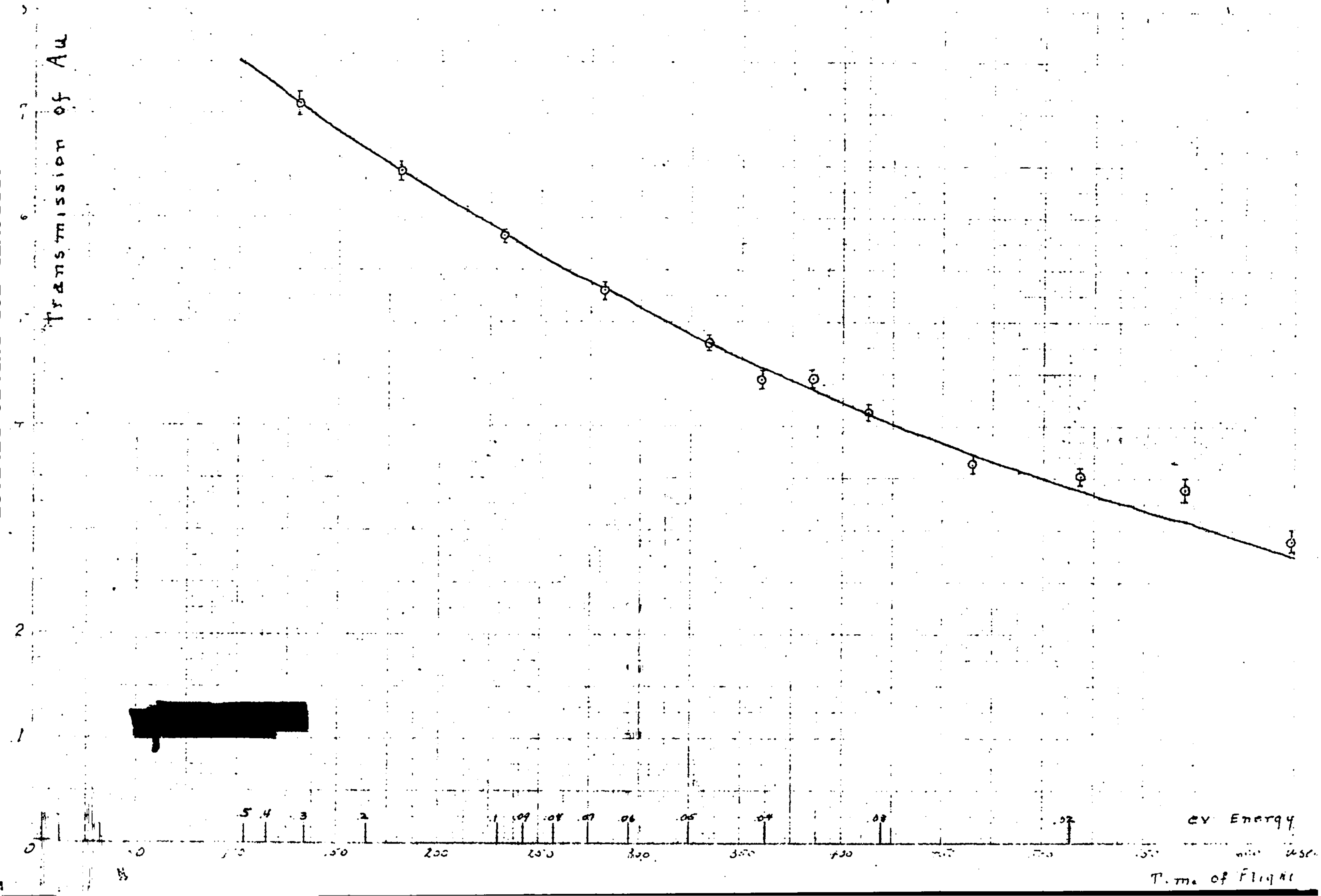

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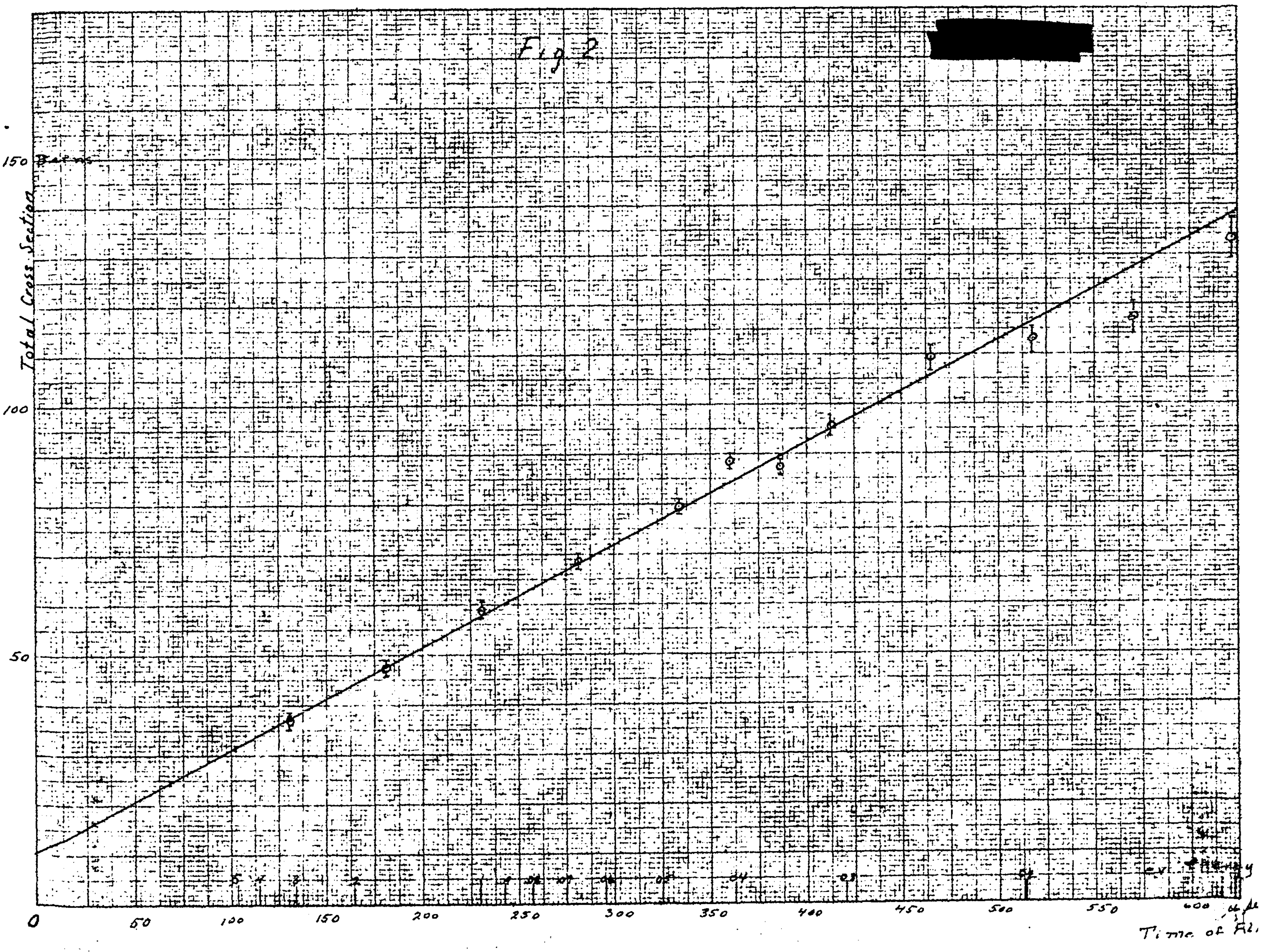

Fig 2
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150 Barns
Total Cross Section
100
50
0
50
100
150
200
250
300
350
400
450
500
550
600
Time of Fl.
ev Energy