gold at 1 Mev is estimated to be about 1.8 barns. The 1-Mev data were compared with the inelastic cross sections obtained by Walt and Barschall.[7] For the majority of the elements, the agreement is within the experimental errors.

The cross sections given for 4.0- and 4.5-Mev neutron energies were obtained with the scintillation detector biased at 3.4 and 3.8 Mev respectively. The values do not change rapidly with the energy threshold of the detector. These data agree very well with inelastic collision cross sections recently determined at 4.1-Mev neutron energy in the elastic scattering angular distribution experiments.[8]

A more extensive report on the experimental procedure, numerical analysis, and results is being prepared.

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Multiplicity of Neutrons from the Spontaneous Fission of Californium-252*

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THE neutron number distributions from the spontaneous fission of some of the transuranic elements are being measured with a neutron detector of high efficiency. The first data to be analyzed are from a sample of Cf^{252} with about 300 spontaneous fissions per minute.

The material was mounted in a fission chamber placed at the center of a cylindrical tank of cadmium-loaded liquid scintillator. The dimensions and construction of this detector are nearly identical with the design of the Los Alamos group.[1] A pulse from the fission chamber triggered the sweep of an oscilloscope. The fission neutrons were moderated in the toluene and captured in the cadmium with a mean lifetime of 20 microseconds, and some of the resulting γ rays produced pulses in the scintillator which were displayed on the scope trace and photographically recorded.

Table I. Observed and calculated neutron multiplicities from the spontaneous fission of Cf^{252}.

No. of neutrons	0	1	2	3	4	5	6	7
Observed distribution	1596	3200	2445	1001	214	33	5	0
True distribution	−65 ±100	+999 ±340	+1407 ±770	+2970 ±950	+2763 ±1150	−107 ±600	+528 ±250	0

The numbers of fissions with 0, 1, 2, etc., *detected* neutrons are given in Table I. A correction has been made for a background of 0.75 percent. The average number of neutrons per spontaneous fission of this nucleus has been measured by Crane *et al.*[2] to be 3.10 ± 0.18.[3] The 8494 fissions reported here gave an average of 1.43 neutrons, from which we conclude that our detection efficiency was 46.0 ± 2.8 percent (probable error) for this measurement. A Monte Carlo calculation made at the Livermore laboratory indicates that this efficiency is constant over the energy interval in which nearly all the fission neutrons are expected to lie. Using this value of the efficiency we calculated the number of fissions *vs* the *true* numbers of neutrons per fission; the results are given in Table I.

It is seen that there is a large probability that all Cf^{252} fissions emit at least one neutron, and the fraction of spontaneous fissions giving seven or more neutrons is certainly less than one percent.

The multiplicities of neutron production by spontaneous fission of natural uranium have been measured by Geiger and Rose,[4] using equipment with a neutron detection efficiency of three percent.

They were able to fit their data to a Poisson distribution, although other forms were not excluded. It can be shown that if the true distribution is binomial with a mean number of neutrons m, and the efficiency with which a single neutron is detected is e, then the observed

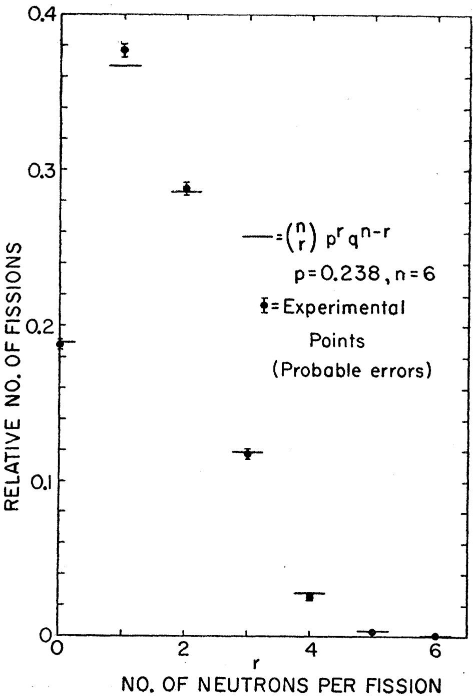

Fig. 1. Observed neutron number distribution arising from the spontaneous fission of Cf^{252}.

distribution will also be of the binomial form $\binom{n}{r}p^rq^{n-r}$, with $p=em/n$. If we take $n=6$, then $p=0.238$. It is seen from Fig. 1 that the experimental points agree well with this description. The observed points will also fit the expansion with $n=7$. Conversely, if the observed distribution is binomial, the true distribution is also binomial. Because of the magnitude and probable error of the detection efficiency, we are not able to state that the true distribution is binomial.

We are in the process of improving the efficiency of the detector as well as the statistics of the experiment. A more detailed discussion of the method and results will be submitted shortly, along with data from other elements and isotopes.

The use of a large liquid scintillator tank as an efficient neutron moderator and detector was suggested to us by Walter E. Crandall. Discussions with George P. Millburn and R. L. Gluckstern concerning treatment of the data were very helpful. We are grateful to Stanley Thompson and Albert Ghiorso of this laboratory for supplying the sample, and wish to thank Edward Leshan for the Monte Carlo calculations, Frank Adelman for much preliminary work, and Stephen Kahn and Edith Goodwin for much of the processing and reading of the film. This work was done under the supervision of C. M. Van Atta.

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Evidence for a Second Naturally Occurring Isotope in Tantalum*

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A SMALL "resonance shaped" peak was observed at 0.433±0.004 ev during high-resolution tantalum total neutron cross section measurements with the Materials Testing Reactor crystal spectrometer. The data are presented in Fig. 1. Evidence for this peak is also to be found in Christensen's data.[1] The 240 planes of an NaCl monochromating crystal were used. The width at half-maximum of the spectrometer resolution function at 0.43 ev was 0.007 ev. A tantalum metal sample 0.505±0.001 cm thick was used. It was obtained from the Fansteel Metal Corporation, and had a stated purity greater than 99.9 percent. The measured density of the sample was 16.58±0.02 g/cm².

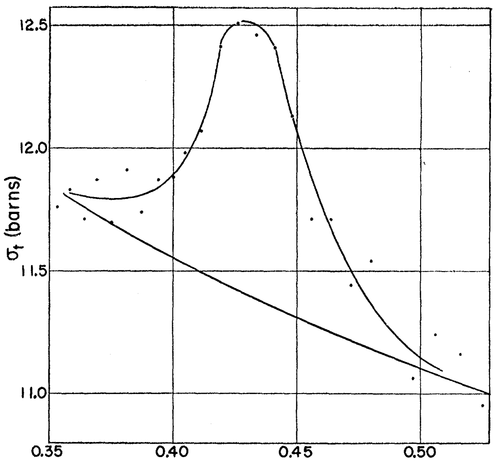

FIG. 1. The total neutron cross section of tantalum in the 0.43-ev region. The lower curve is a $1/v$ fit to the nonresonance data.

The resonance effect was isolated by plotting cross section values against $E^{-\frac{1}{2}}$ and subtracting values given by a visual straight-line fit of the nonresonance data from the experimental values. The resulting data are plotted in Fig. 2. The observed width of the peak at half-maximum is 0.048±0.005 ev and the observed height is 1.16±0.08 barns. The Breit-Wigner single-level formula, corrected for Doppler broadening by Sailor's variation of the trial and error method,[2] was used to obtain the solid curve in Fig. 2. After making a small instrument resolution correction (0.001 ev) on the width, the resonance parameters for the element are: $E_0=0.433\pm0.004$ ev, $\sigma_0=1.59\pm0.11$ barns, $\Gamma=0.030\pm0.005$ ev, and $g\Gamma_n=0.8\times10^{-8}$ ev. The location of the resonance is outside the recommended range of applica-

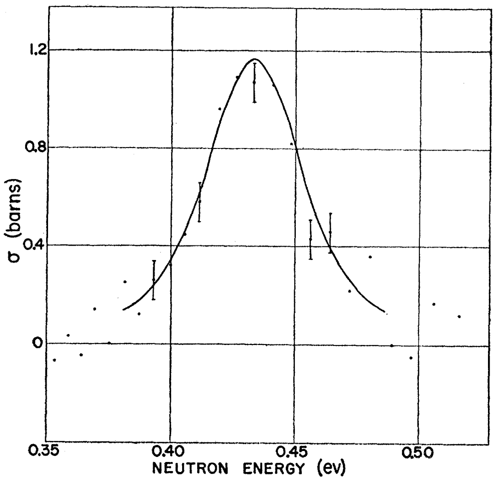

FIG. 2. A linear plot of the tantalum resonance data. The $1/v$ component has been subtracted from the total cross section data of Fig. 1. The solid curve is a calculated single level Breit-Wigner curve corrected for Doppler broadening. The parameters used are those given in the text for the element with natural isotopic abundance. The standard deviations indicated are those due to counting statistics.