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THE MULTIPLICITY OF NEUTRONS FROM THE SPONTANEOUS FISSION OF CALIFORNIUM-252

Donald A. Hicks, John Ise, Jr., and Robert V. Pyle

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THE 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.

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.† The 8,494 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.

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*This work was done under the auspices of the U. S. Atomic Energy Commission.

†The probable error quoted here differs slightly from that in the letter by Crane et al. because of further information from Mound Laboratory concerning the neutron standard used.

[1] C. L. Cowan, Jr., F. Reines, F. B. Harrison, E. C. Anderson, and F. N. Hayes, Phys. Rev. 90, 493 (1953).

[2] W. Crane, G. Higgins, and S. Thompson. Submitted to the Physical Review.

Table I

Number 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

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,[3] using equipment with a neutron detection efficiency of three percent.

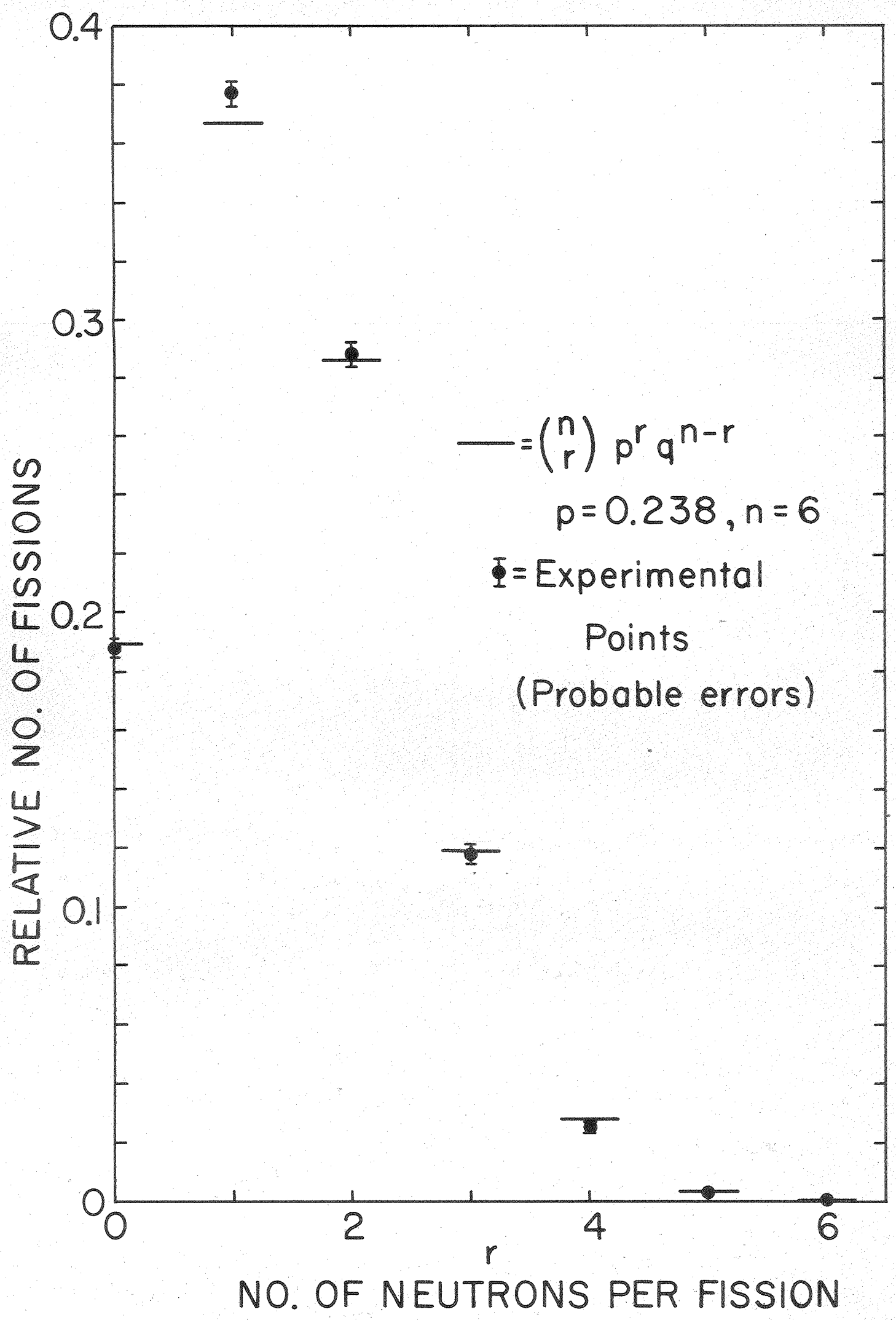
They were able to fit their data to a Poisson distribution, although other forms were not excluded. It can be shown that if the true distribution is binomial with a mean number of neutrons m, and the efficiency with which a single neutron is detected is e, then the observed distribution will also be of the binomial form $\binom{n}{r}p^r q^{n-r}$ with $p = \frac{em}{n}$. 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

[3] K. W. Geiger and D. C. Rose, Canadian Journal of Physics 32, 498 (1954).

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.


0.4
0.3
0.2
0.1
0
RELATIVE NO. OF FISSIONS
—— = $\binom{n}{r} p^r q^{n-r}$
p = 0.238, n = 6
= Experimental
Points
(Probable errors)
0
2
4
6
r
NO. OF NEUTRONS PER FISSION

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