LETTERS TO THE EDITORS

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Measurements on the Neutron Multiplication in a System of Uranium Rods and Ordinary Water

In order to determine the multiplication constant of a system of uranium rods and ordinary water we have made two different experiments with a radium–beryllium source.

A total of 129 uranium rods, 30 mm. in diameter and about 2 m. long, were suspended in a hexagonal lattice in a tank with distilled water. The lattice constant was varied from 40 mm. to 65 mm. in steps of 5 mm. The uranium rods were encased in aluminium tubes, 0·3 mm. thick. The tank had a diameter of 1·2 m. and a height of 2 m. Since the diameter of the uranium core was always less than 0·8 m., the water reflector could in all cases be considered infinitely thick. As detectors, we used boron trifluoride chambers.

(1) Some ordinary exponential experiments[1] were carried out. From these measurements we can calculate the material buckling or 'Laplacian', B_m^2, and obtain the infinite multiplication constant, k, from the formula

$$B_m^2 = (k - 1)/M^2, \qquad (1)$$

where M^2 is the migration area for fission neutrons.

Due to the presence of the water reflector, the radial part α^2 of the buckling cannot be calculated from the extrapolated radius. We have instead calculated it from measurements near the centre of the core, where the influence of the reflector is small. If, in this region, the neutron density can be expanded in a power series,

$$n(r) = A - B r^2 + C r^4 - \ldots, \qquad (2)$$

it is easy to show that the radial part of the buckling at the centre is

$$\alpha^2 = 4B/A. \qquad (3)$$

For the tightest lattices, irregular fluctuations in the measured distribution prevented the determination of the radial buckling.

Far away from the source the neutron density decays exponentially in the axial direction, and a relaxation-length $1/\gamma$ is measured. For intensity reasons the higher harmonics were not negligible, where the radial distribution was measured, and therefore corrections have to be applied to the axial buckling, $-\gamma^2$, valid for exponential distribution.

For M^2 we have used the value 45 cm.^{2}, which is probably accurate to 10 per cent.

(2) We have also used an integrating method due to Heisenberg and Wirtz[2]. In this case the source was placed in the middle of the core, and the total number of neutrons in the core (N_c) and in the reflector (N_r) were determined by integration. The strength of the source was calibrated by measuring the total number of neutrons (N_0) with uranium rods removed. From these data the multiplication constant can be calculated by means of the formula:

$$k - 1 = \frac{\Sigma_0(N_r - N_0)}{\Sigma_c N_c}, \qquad (4)$$

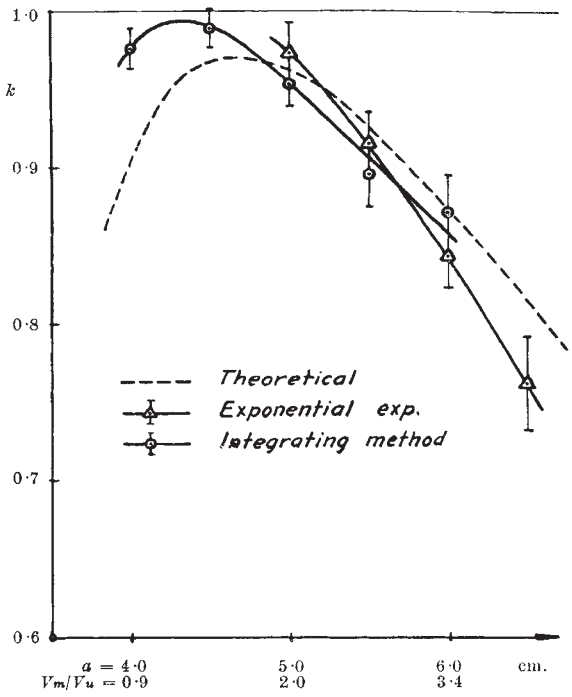

Fig. 1

where Σ_0 and Σ_c are the macroscopic absorption cross-sections of the water and the core respectively. We have, however, to apply some corrections to this formula. On account of the fast fission effect in uranium-238, the number of source neutrons will increase before they reach thermal equilibrium. Therefore, the quantity N_0 must be multiplied by a factor larger than unity. Further, N_c must be divided by the resonance escape probability.

The two experimental curves of the multiplication constant as a function of lattice spacing are compared in Fig. 1 and are seen to be in good agreement with each other. Also shown in this diagram is a theoretical curve[1]. In calculating this curve account has been taken of fissions produced by fast neutrons from one rod in the adjoining rods as well.

Further information about this experiment will be published elsewhere.

Rolf Persson

Department of Physics,
AB Atomenergi,
Stockholm.
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[1] Glasstone, S., and Edlund, M. C., "The Elements of Nuclear Reactor Theory", chapter 9 (D. Van Nostrand Co., New York, 1952).
[2] "The Fiat Review of German Science 1939–1946". Nuclear Physics and Cosmic Radiation, 2, 143–165.

Spontaneous Fission Properties of Elements 97, 98, 99 and 100

Isotopes of several heavy elements (Z = 94–100) have recently been produced in the Materials Testing Reactor (MTR) in Arco, Idaho. It has thus been possible to extend the data on partial spontaneous fission half-lives to isotopes of berkelium, californium, element 99 and element 100 [1–5]. Table 1