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The Age of U^{233} Fission Neutrons in Water

The age to indium resonance energy (1.4 ev) of U^{233} fission neutrons slowing down in water has been calculated with the SLAG code (*1*) on the University of Michigan IBM-650. The fission spectrum used was measured at Oak Ridge (*2*) with the low energy portion ($E < 1.3$ Mev) taken to be the (U^{235}) Watt spectrum (*3*). This spectrum, and the Watt spectrum, both normalized to unit area, are given in Fig. I as a function of $u = \ln(10^7/E)$ where E is in electron-volts. The crosses indicate the experimental points, and the smooth curve has been drawn by eye.

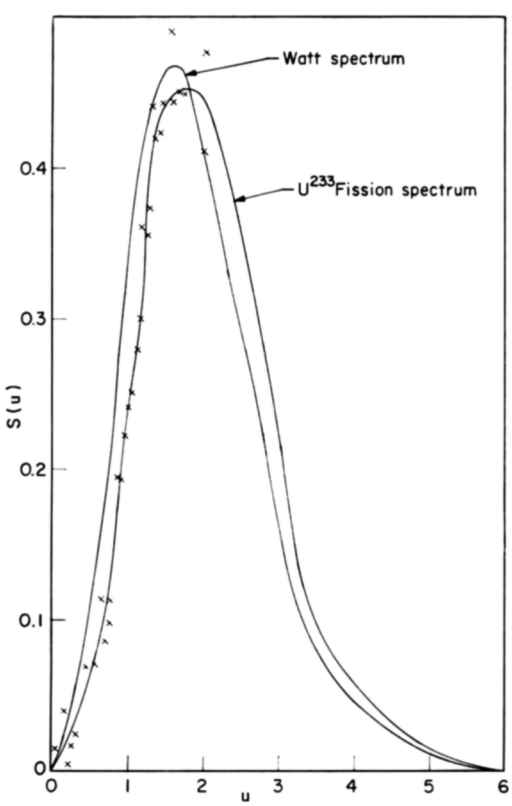

Fig. I. Fission neutron spectrum of U^{233} and U^{235}. The U^{235} spectrum is the Watt spectrum given by $\chi(E) = 0.484\, e^{-E} \sinh \sqrt{2E}$.

The result for τ (1.4 ev) is 23.0 ± 3 cm² compared to a value of 25.3 cm² from the Watt spectrum. The error limits were obtained from calculations for curves passing through the maximum and minimum error points of the measured spectrum. In order to test the sensitivity to the fit to the experimental points, a calculation was made for a curve generated by connecting adjacent experimental points, with no change being observed in the age. Finally, a calculation was made for the measured fission spectrum of U^{235} reported in reference *1*, which differs slightly from the Watt spectrum, in order to test the possibility of consistent errors in the fission spectrum measurements. However, this spectrum led to a value of τ identical with that given by the Watt spectrum.

The results of these calculations indicate that the age of U^{233} fission neutrons is probably about 8 or 9 per cent lower than the age of U^{235} fission neutrons, a fact which has important implications in the measurement of η of U^{233} by critical experimental techniques, such as are now being used at ORNL (*4*). In addition, it indicates that the losses to fast leakage from a U^{233} system will be somewhat less than those from a U^{235} system, which improves the possibility of breeding. It is clear, however, that an age experiment with U^{233} fission neutrons must be performed because of the fairly large error limits on the measured spectrum which lead to the error limits of ± 3 cm² in the age.

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Note on Position-Dependent Spectra

Near boundaries between dissimilar media (A, B, etc.), the spatial behavior of the thermal neutron flux is predicted incorrectly by normal diffusion theory, in which energy averages of the constants are taken over the asymptotic spectra of A, B, etc. To some extent transport corrections are necessary but the predominant effect is that due to a continuous change of spectrum with position in going from one medium to another.

In particular, the observed peaking from a slab water gap immersed in a multiplying medium is always higher than that predicted by normal diffusion theory. On the other hand, the first correction term arising from a one-