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LETTERS TO THE EDITORS

The Age of Polonium-Boron Neutrons in Water

As a part of a continuing effort[1] to investigate the adequacy of the medium energy cross sections used in reactor calculations, a series of measurements of the age to indium resonance of Po-B neutrons in metal-water lattices has been performed. Results have been obtained of the age in pure water and a comparison has been made with theory. Inasmuch as the effect on the age of the approximations used in the theoretical solution of the problem is smaller than the experimental errors, the disagreement between calculated and measured results could be attributed to errors in the input spectrum or cross sections used in the calculations.

Unfortunately, the status of spectral measurements of Po-B is not very good at the present time. Three different measurements of the spectrum were used as part of the input data in the calculations. Perlman, Richards, and Speck used a photographic emulsion technique (*1*). They did not draw the curve of $N(E)dE$ *vs* E, but showed only the experimental points with the probable errors. Since drawing a curve becomes rather arbitrary and the age is very sensitive to the position of the peak and the average energy, four spectra from this one set of measured points have been extracted in the following manner:

a. Curve followed the lower parts of the probable error. Peak at about 2.4 Mev.
b. Curve followed the upper parts of the probable errors. Peak at about 2.6 Mev.
c. Curve followed the lower parts of the probable errors on the low-energy side and the upper parts on the high-energy side. Peak at about 3.2 Mev.
d. Curve followed the upper parts of the probable errors on the low-energy side and the lower parts on the high-energy side. Peak at about 2.0 Mev.

Curves c and d are obviously extremes. Staub (*2*) measured the spectrum using a proton recoil ionization chamber. His data goes from about 0.6 Mev to a little over 4 Mev and is peaked at about 3 Mev, but drops very rapidly to slightly more than $\frac{1}{8}$ of its value at 4 Mev. More recently Cochran and Henry (*3*) used a proton recoil spectrometer operating as a proportional counter. Their data extends from about 1 Mev to about 5 Mev with peak at about 2.7 Mev. The distribution decreases much more slowly than the Staub spectrum beyond the peak. In all cases the inferred spectrum is extrapolated smoothly from the last measured points so as to vanish at about 6 Mev.

The second moment of the spatial distribution, r^2, can be computed rigorously from the transport equation using a code commonly used in reactor design work at Bettis (*4*). Since r^2 to a particular energy is defined as

$$\int_0^\infty \phi r^2\, dV \Big/ \int_0^\infty \phi\, dV, \quad \text{which becomes} \quad \int_0^\infty A(r) r^4\, dr \Big/ \int_0^\infty A(r) r^2\, dr$$

[1] An extensive set of measurements and theoretical calculations of the age of polonium-beryllium neutrons in metal-water lattices will be submitted for publication in the near future. A detailed description of the experimental procedures and calculations will be found in this article.

TABLE I

COMPARISON BETWEEN MEASURED AND CALCULATED AGE OF PO-B NEUTRONS IN WATER

Spectrum	Age (in cm²)
Perlman *et al.*, Curve a	31.7
Curve b	33.7
Curve c	35.5
Curve d	29.9
Staub	29.7
Cochran-Henry	32.2
Measured	39.7 ± 1.2

if spherical symmetry is realized, the problem is reduced experimentally to measuring the saturated activity of cadmium-covered indium foils as a function of the distance from a point source of Po-B neutrons. A comparison between the calculated and measured age ($\bar{r}^2/6$) for water is shown in Table I.

It is significant that the highest calculated value corresponding to a weighting of the Perlman spectrum at the high energy side is lower than the measured value. Since the average energy of a Po-B spectrum is not substantially different from that of a fission spectrum, it is noteworthy that the discrepancy in the age between the calculations and measurements for the Po-B and the fission source is in the same direction. Since agreement between theory and experiment has previously been shown for 1-Mev neutrons (5) and Po-Be neutrons (see footnote) which have an average energy of about 5 Mev, it is believed that the results reported in this letter give further evidence for errors in the oxygen differential elastic cross sections between 1 and 3 Mev.

Although a complete report will be written when a more extensive set of calculations has been made for comparison with the metal-water data, it was felt that because of the long-standing disagreement between experiment and theory on the age of fission neutrons in pure water, a brief letter at an interim stage of the calculations was warranted.

It is a pleasure to acknowledge the assistance of Mr. Edgar Hooper in taking data.

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[2] Operated for the U. S. Atomic Energy Commission.