Slow Neutrons

Following our earlier experiments[1] we have investigated further the production of slow neutrons from fast neutrons through collisions with H nuclei. A 500 mc Rn-Be neutron source bulb, with about 0.75 mm lead foil around it, was suspended about 65 cm from a Li lined ionization chamber connected to an amplifier-thyratron recording system. The source was then successively surrounded by paraffin spheres from 0 to 23 cm radius, and the number of slow neutrons which were capable of disintegrating Li, and being anomalously absorbed by Cd, was observed by taking readings with and without Cd interposed, in order to separate out the slow and fast neutrons. Cd shields protected the chamber from slow neutrons scattered back from the room.

In Fig. 1, the upper solid curve shows the readings without Cd, and the lower solid curve the readings with Cd interposed (neutrons outside the Cd absorption region), the dashed intermediate curve being the difference between the two, or the slow neutron component only. The lowest dotted curve shows the decrease in fast neutrons detected through projected protons from previous data[2] for comparison. The number of slow neutrons present in the original source is apparently zero, but since the mean free path of fast neutrons in paraffin is of the order of 4–5 cm, in order to account for the production of some slow neutrons with near thermal velocities with only about 3 cm of paraffin, it seems necessary to conclude that there are a large number of neutrons in the original source which are already below the ordinary fast neutron limits, i.e., probably below 100,000 e.v., where the M.F.P. is already smaller. This is consistent with other evidence.[3] The decrease observed after the maximum may be due to some absorption process, such as with H to form deuterium, or possibly with C. Since the slow neutron M.F.P. in paraffin is of the order of 2 mm, the actual number of collisions in the large spheres is enormous, so the probability of capture per collision does not need to be large. The behavior of water was practically the same as paraffin at the points tested.[4] The slight rise in the lower solid curve with Cd interposed implies that Li detects some neutrons above the Cd absorption region, in the intermediate range between fast and slow.

Measurements of slow neutron-nucleus collision cross sections have now been made over a wider range of elements, and under more refined conditions. The slow neutron-proton cross section is revised upward to about 31×10^{-24} cm^2, and that of the neutron-deuteron is about 5.3×10^{-24} cm^2, compared to about 1.6×10^{-24} cm^2 for both with fast neutrons. Al and S cross sections with slow neutrons are probably less than for fast neutrons. Samarium and terbium, from some rare earth samples kindly supplied by Dr. A. F. Daggett, show the highest absorption coefficients yet measured, even larger than Cd, with cross sections of about 5000×10^{-24} cm^2, when measured with a reasonably parallel beam of slow neutrons. It does not seem likely that the presence of impurities of unknown cross section could cause any large part of the effect. Cd shows a nearly exponential absorption curve for an approximately parallel slow neutron beam, and gives a neutron-nucleus cross section of about 3300×10^{-24} cm^2.

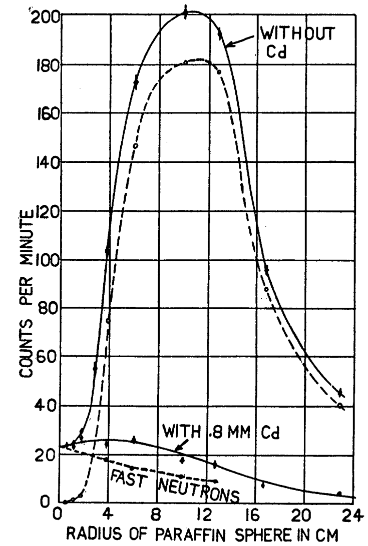

FIG. 1.

Previous attempts to measure elastic scattering of slow neutrons from Cd have shown it to be so small that introduction of a Cd scattering cylinder actually decreased the observed number of neutrons, since it shielded the chamber from neutrons scattered back from the room somewhat, although such materials as Cu, MgO or $CaCO_3$ showed large scattering. A new experiment to eliminate room scattering, was performed by placing the source (paraffin sphere) and Li chamber at opposite ends of a tight cylindrical enclosure made of Cd. The direct beam of slow neutrons was eliminated by interposing a Cd disk between the source and chamber. The presence of any slow neutrons scattered from the walls of the Cd cylinder was tested by measuring the effect of placing a Cd sheet before the ionization chamber. Less than one neutron per minute was scattered from the Cd (which might be due to the air rather than Cd), whereas with Cu or Mg under similar conditions more than 100 per minute would be observed. The large stopping power of Cd for slow neutrons (0.005 cm is sufficient to absorb about one-half) is then due almost entirely to capture and absorption, and not to elastic scattering. Rough experiments indicate that this is also true for the other highly absorbing elements.

J. R. DUNNING
G. B. PEGRAM
G. A. FINK
D. P. MITCHELL

Pupin Physics Laboratories,
Columbia University,
June 3, 1935.

[1] J. R. Dunning and G. B. Pegram, Phys. Rev. **47**, 640 (1935).
[2] J. R. Dunning, G. B. Pegram and G. A. Fink, Phys. Rev. **47**, 325 (1935).
[3] J. R. Dunning, Phys. Rev. **45**, 586 (1934).
[4] Westcott and Bjerge, Proc. Camb. Phil. Soc. 145 (1935).