The Velocities of Slow Neutrons

Further experiments with a mechanical velocity selector[1] have been made on slow neutrons from sources at room and liquid-air temperatures. Fig. 1 shows the averaged results of the runs at room temperature. The limits of probable error are indicated by the vertical lines of lengths inversely proportional to the square root of the number of counts. The curve shows the experimental results that would be expected if the slow neutrons operated upon by the selector system have a Maxwellian distribution of velocities resulting from thermal equilibrium with the paraffin at its temperature of 300°K. The experimental points agree fairly well, for this type of measurement, with the calculated curve, although they would fit better a curve with a velocity maximum about 10 percent lower. If this shift is significant, then one factor which might account for this would be that the maximum of the Li detection region is somewhat below the most probable neutron velocity at 300°K. However, considering the poor resolution of the present selector with one to one ratio of slit width to width of Cd selector and the limited statistical accuracy on account of the small number of slow neutrons passing through the selector in comparison with the background effect of the fast neutrons, all that can be claimed is that the neutrons readily stopped by Cd and detected by Li have a maximum intensity in velocity distribution close (within ±250 meters/sec.) to the maximum in a Maxwellian distribution at 300°K (about 2500 meters/sec.).

Experiments in which the source of slow neutrons was a paraffin cylinder as before, except that a hole 3 cm in diameter was made in the paraffin extending axially 12 cm to the Rn-Be neutron source, also showed approximate thermal equilibrium in spite of the lack of paraffin in the direct beam. A measurement was made of the absorption in Cd of neutrons selected from the higher and lower velocity portions of the distribution curve. The mean velocities of the one group was estimated to differ from that of the other by about 10 percent, or 250 meters/sec. No difference in absorption by Cd was found, the probable error being ±3 percent, which is in accord with other observations as to the nonsensitiveness of Cd absorption to neutron velocity change.

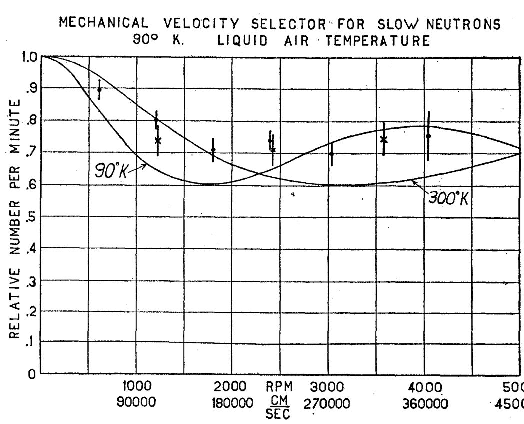

FIG. 1. Average results for the velocity distribution of slow neutrons from source at room temperature (300°K).

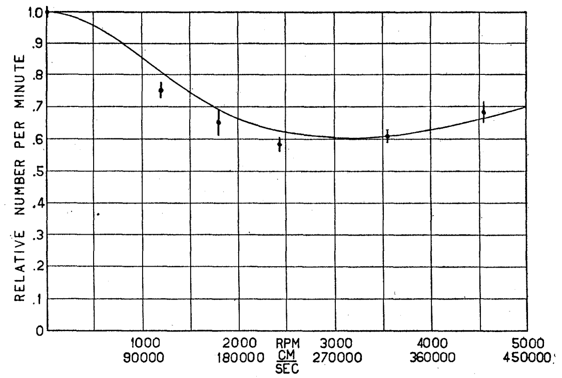

FIG. 2. Average results for the velocity distribution of slow neutrons from source at liquid-air temperature (90°K).

The experimental results with neutrons emerging from a soft glass Dewar flask containing about 2000 cc of paraffin at about 90°K are shown in Fig. 2 by the small circles, and the results of another group of runs with the source arranged to use only the neutrons emerging from a layer of cold paraffin 8 to 10 mm thick are indicated by the crosses. The theoretical curves to be expected at 90°K and at 300°K are also shown. The results are not very precise, but they do not appear to show complete thermal equilibrium in either case. The points seem to lie more between the two curves, while the maximum is not as well defined as at 300°K, and although it is probably shifted toward lower velocities, it is not shifted as far as would be expected for 90°K.

While the attempts to show temperature effects with artificial radioactive detectors[2,3] have indicated that thin cold layers of paraffin are more effective than thick cold paraffin layers, possibly due to increased probability of capture in the cold paraffin of neutrons on the slow side of the velocity distribution, under our conditions the results with Li detection and Cd absorption do not show any significant differences between thick and thin layers. It is possible that Li detection and Cd absorption are not as effective with the very slow neutrons as with those further up in the velocity distribution. If so, this might explain the failure to observe a velocity distribution appropriate to 90°K. The number of disintegrations of Li and the absorption of Cd show no changes larger than ±3 percent with the source at 90°K compared to the same source at 300°K.

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[1] Dunning, Pegram, Fink, Mitchell and Segrè, Phys. Rev. **48**, 704 (1935).
[2] Moon and Tillman, Nature **135**, 904 (1935).
[3] Lukirsky and Zarewa, Nature **136**, 682 (1935).