$$\beta(\theta) = \frac{\sqrt{N-1}}{\sqrt{N}+\sqrt{3}\cos\theta} \tag{7-18}$$

This is inconsistent with the first result at $\theta = 0$, only because this solution allows for the fact that although $\theta = 0$ for the incident neutrons, they are not restricted to move along the x axis in the medium. The effect of allowing motion at angles to the x axis is to allow longer paths and hence more chance for absorption. This makes β slightly smaller.

Suppose we wish to measure the albedo for slow neutrons on paraffin. A direct measurement would be difficult, for even if a collimated slow neutron beam can be made to impinge on some paraffin, neutrons would be coming off at all angles from all over the surface of the paraffin, and their detection would not be easy. A much simpler way to find the albedo is the following. Place a thin-foil* slow neutron detector (Figure 46) somewhere in the middle of a mass of paraffin whose boundaries are far enough away from the foil that the paraffin can be considered infinite in extent. By means of some neutron source, we induce an activity in the foil. Call this activity A. Next back the foil on one side with some cadmium, enough that the cadmium will absorb practically all the slow neutrons hitting it but not enough to distort the neutron flux field appreciably. Measure the new activity in the detector foil. Call this activity B. Now the ratio (A/B) bears a simple relation to the albedo. To understand this, consider the number of neutrons ν hitting the foil each second in situation B. It is clear that for a uniform distribution of slow neutrons, the foil in case A would have ν neutrons per second hitting it from each side and would have at least 2ν slow neutrons hitting it per second. Actually, more than 2ν slow neutrons will hit the foil in case A, for some of the neutrons passing through the foil can return and pass through it again, there being no cadmium about to prevent this (see Figure 47). In fact, we can calculate the average number of times a neutron about to hit the foil will pass through it before it is eventually absorbed in the paraffin. Certainly the probability that this neutron will return through the foil is β, the albedo of the paraffin for slow neutrons. The probability that it will make at least two trips is $\beta \times \beta$ or β^2, and so on. Thus the total number of passages through the foil for a neutron about to hit it is on the average:

$$1 + \beta + \beta^2 + \ldots = \frac{1}{1-\beta}$$

Hence, there would be $2\nu/(1-\beta)$ slow neutrons hitting the foil each second, rather than simply 2ν neutrons. From this it follows that:

$$\frac{A}{B} = \frac{2\nu/(1-\beta)}{\nu} = \frac{2}{1-\beta}; \quad \beta = 1-2(B/A) \tag{7-19}$$

In this manner a measurement of the two activities A and B suffices to determine the albedo. For paraffin, A/B is 11. From equation (7-19), it follows that the albedo for paraffin is $\beta = 0.82$. This type of measurement would not be feasible with poor absorbers of neutrons, for it has to be assumed that the diffusion length in the medium is small compared to the foil size, i.e., that most of the "reflection" takes place close to the foil. Further, if the detector is not thin, it acts as its own cadmium, so to speak, and a correction must be made for the absorption in the foil.

*By a thin foil is meant one where there is little modification of the neutron distribution due to the presence of the foil, i.e., one for which $\sigma_{tot} n \delta \ll 1$, where σ_{tot} is the total cross section, n the number of atoms per cm^3, and δ the foil thickness.

a-93-84