the source is proportional to erf $[(E/kT_S)^{1/2}]$ where kT_S = 0.117 ev.

To test the sensitivity to the source term, infinite medium spectra have been obtained using the free proton model as such, the Nelkin model as such, and the Nelkin kernel with the free proton source. The compositions treated correspond to the measured spectra of Beyster *et al.* (*3*). Table I shows macroscopic absorption cross sections averaged over the spectrum for each composition for the three models used. The percentage differences of values for the free proton model and for the Nelkin kernel with free proton source from values for the Nelkin kernel are indicated. The absorbers and absorption cross section at 2200 m/sec are shown in the first column of the table.

The differences between the Nelkin kernel values for the two sources are significant. Moreover, it is especially noteworthy that for the non $1/v$ cross sections, the major part of the difference between the free proton model values and the Nelkin model values is associated with the source term.

The Nelkin model is based on the short collision time approximation (*6*) which improves in accuracy with the incident neutron energy. This is supported by some comparisons of theoretical and experimental values of the scattering law for particular values of the energy and momentum transfer (*7*). Of the three models in Table I, the values obtained from the Nelkin model are almost certainly the most accurate.

However, the significant point of Table I is that the spectra for non $1/v$ cross sections are sensitive to the source term. On this ground, experimental investigation of the kernel for energies above 0.625 ev would be of interest.

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The Time Scale of Neutron Slowing Down in Water

Measurements on the time behavior of neutrons during the slowing down process have started at the 5.5 Mev van de Graaff accelerator at Studsvik, Sweden. The neutrons are generated in bursts by the Li (p, n) reaction in a target inserted in a large volume of water. A small amount of a neutron absorber can be placed at a chosen position in the moderator. The rate of neutron capture in the absorber is dependent on the flux spectrum and the capture cross section of the absorber. The capture gamma rays are detected by a fast scintillation counter, the pulses from which are fed to a multichannel time analyzer.

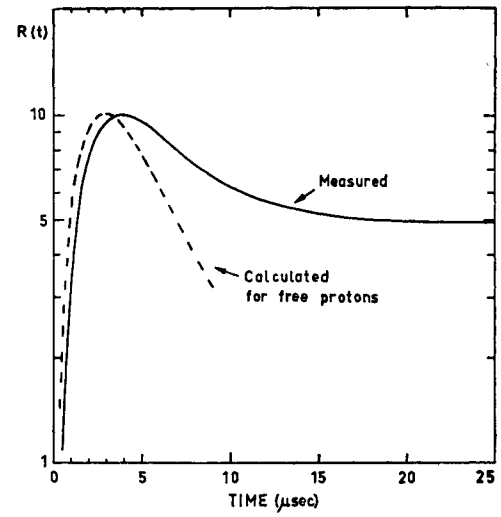

FIG. 1. Reaction rate $R(t)$ (arbitrary units) between the slowing down flux and cadmium as a function of time.

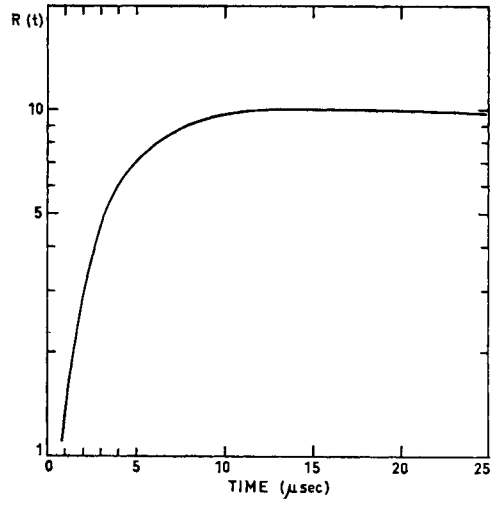

FIG. 2. Reaction rate $R(t)$ (arbitrary units) between the slowing down flux and gadolinium as a function of time.

In the first experiments very dilute solutions of cadmium and gadolinium salts, contained in 250 cm³ plastic bottles, were used. The time resolution was about 0.2 μsec. The source neutrons had a mean energy of 0.5 Mev. Figure 1 and 2 show the observed capture rate as a function of time for the cadmium and gadolinium experiments respectively. The center of the absorber was 9.5 cm from the target. The curves are corrected for overlap and dead-time, and the contribution from neutron capture in water is subtracted.

In Fig. 1 the capture rate increases to a maximum at 3.8 μsec, corresponding to the slowing down into the cadmium resonance region. From the shape of the cadmium cross

section and assuming that the flux tends towards a Maxwell distribution the mean neutron energy may be estimated as about 0.1 ev at this time. Later, from 7 μsec, the decay can be described as a sum of two exponentials with time constants of about 4 and 200 μsec respectively. The first is ascribed to the thermalization process and the second to the decay through absorption of thermal neutrons by the water. The thermalization time constant, 4 μsec, is somewhat shorter than expected (*1*, *2*).

The capture rate predicted for neutrons from a homogeneous source and moderated by free protons is also shown in Fig. 1. It was obtained from the cadmium cross section and the time dependent neutron velocity spectrum $vt^2/l^2 \exp(-vt/l)$, where l is the mean free path, assumed to be 0.75 cm (*1*, *3*). The two curves differ already in their rise; the theoretical one reaching its maximum at 3 μsec. The difference is mainly due to the effect of chemical binding, but the different source conditions may also have some influence. However, the binding effects during the slowing down to the cadmium resonance are not so large as was indicated by an earlier experiment (*4*, *5*).

The gadolinium curve, Fig. 2, has quite a different look because of the deviation of the cross section from the $1/v$ law in the opposite direction compared to cadmium. Here the last part of the curve can be described as a sum of a positive slow exponential and a negative fast exponential with approximately the same time constants as for cadmium. This supports the validity of the thermalization time concept as defined by Purohit (*2*).

Further experimental and theoretical work is under way. Among other things it is important to study the influence of the change in the spatial distribution of the neutrons during the time of measurement.

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