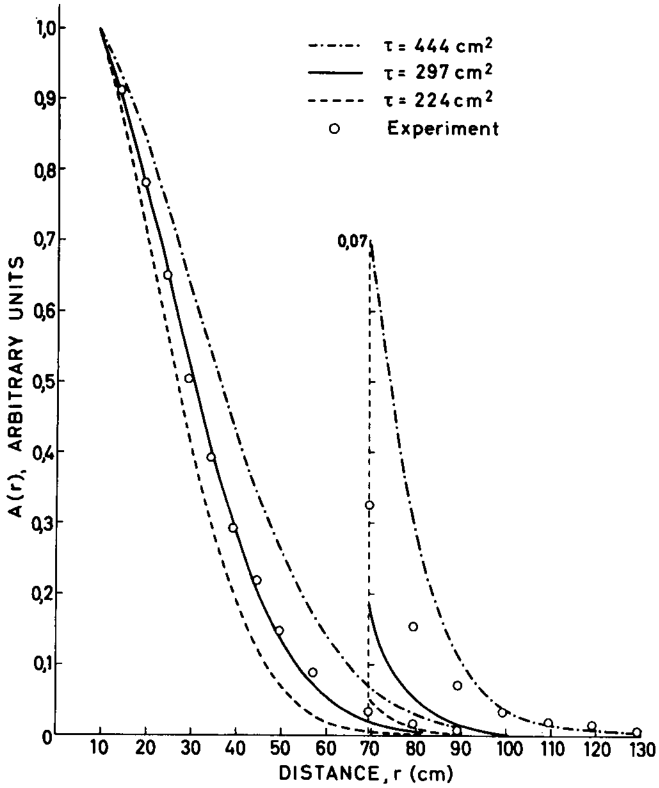

Fig. 3. Fermi age distribution, $C \cdot \exp(-r^2/4\tau)$ for $\tau = 224$ cm², $\tau = 297$ cm² and $\tau = 444$ cm².

In water the difference amounts to about 19%, in heavy water to about 8%. The difference between the neutron age in concrete for (D, D) neutrons measured in the 90° direction and fission neutrons could hardly exceed the 19% met with in water, and most probably it is smaller.

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Relation of the Neutron Diffusion Length to Neutron-Pulse Parameters in H_2O*

The well known expression[1,2,3] for the behavior of the time constant ω of a thermal-neutron pulse

$$\omega = \omega_0 + DB^2 - CB^4 + \ldots , \qquad (1)$$

can be inverted for $\omega = 0$ and $B^2 = -L^{-2}$ to give the neutron diffusion length L,

$$L^2 \cong (D/\omega_0)\left\{1 + C\omega_0/D^2\right\} , \qquad (2)$$

provided $4\omega_0 C \ll D^2$.

This has been used (e.g. Reference (4)) to determine the diffusion length from measured pulse parameters.

The fractional correction $C\omega_0/D^2$ for H_2O has been calculated for the Nelkin model[5] from the values given[3]. This is given as a function of temperature in Table I. For room temperature $C\omega_0/D^2$ is 1.1%. However, Kerr[6] has calculated the same correction for the Nelkin model by means of a ten-group eigenvalue calculation and obtained a value of 3.4%.

To resolve this discrepancy, eigenvalue calculations have been carried out using the method of Reference (3) and a group structure with 39 groups. Specifically, that value of $B^2 = -L^{-2}$ has been found which implies $\omega = 0$. In Table I are compared values of L^2 obtained from Equation 2 and those obtained from the eigenvalue calculation as a function

TABLE I. Correction Term and Diffusion Lengths for the Nelkin Model for H_2O

t(°C)	$C\omega_0/D^2$	$(D/\omega_0)\{1 + C\omega_0/D^2\}$	L^2(eigenvalue)
23	.0114	7.878	7.875
50	.0098	8.544	8.545
100	.0082	10.222	10.223
140	.0072	11.886	11.889
180	.0065	13.982	13.990
220	.0060	16.796	16.804
260	.0055	20.632	20.648
300	.0051	26.067	26.110

ω_0 is based on an absorption of 0.3322 barns per H atom in H_2O at 2200 m/s.

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of temperature. The two sets of values agree very well, within 1 part in 3000 for room temperature. These eigenvalue calculations thus confirm the correction of 1.1% given by $C\omega_0/D^2$ rather than Kerr's value of 3.4%.

The small differences that remain between the last two columns of Table I are believed due to the least-squares fitting process used in Reference 3 to obtain the values of D, since the magnitude of these differences is correlated in detail with the uncertainty determined in this process. It thus appears that within the accuracy of the pulse parameters used, there is agreement between values from Equation 2 and those obtained from an eigenvalue calculation.

Kerr's different result may be associated with the coarser group structure used in her calculations, or with the spectrum used to obtain group constants.

TABLE II. Hardening of Diffusion Length Eigenvalue Scalar Flux Relative to Maxwell Distribution

Energy (eV)	Eigenvalue Flux (23 C)[a]	Maxwell Dist. (23 C)[a]	Eigenvalue Flux (300 C)[a]	Maxwell Dist. (300 C)[a]
.001	.1420 + 01	.1478 + 01	.3932 + 00	.4014 + 00
.009	.9456 + 01	.9723 + 01	.3020 + 01	.3072 + 01
.025	.1425 + 02	.1442 + 02	.6098 + 01	.6172 + 01
.049	.1110 + 02	.1103 + 02	.7398 + 01	.7440 + 01
.081	.5263 + 01	.5197 + 01	.6426 + 01	.6433 + 01
.121	.1659 + 01	.1617 + 01	.4294 + 01	.4275 + 01
.169	.3556 + 00	.3439 + 00	.2280 + 01	.2259 + 01
.225	.5320 - 01	.5093 - 01	.9820 + 00	.9675 + 00
.400	.1014 - 03	.9472 - 04	.5113 - 01	.4971 - 01
.625	.2387 - 07	.2179 - 07	.8493 - 03	.8154 - 03

[a] Normalization is such that $\int_0^{.625\,\mathrm{eV}} \phi(E)dE = 1$.

TABLE III. Macroscopic Absorption Cross Sections Averaged Over the Diffusion Length Eigenvalue Spectrum and a Maxwell Distribution

t(°C)	Σ_A(eigenvalue)	Σ_A(Maxwell)
23	.0194188	.0195552
50	.0184244	.0185396
100	.0166424	.0167318
140	.0152944	.0153690
180	.0139800	.0140430
220	.0126553	.0127086
260	.0113298	.0113748
300	.0100031	.0100408

The spectra associated with the eigenvalue problems are of interest; the approach to an asymptotic spectrum as the distance from the source is increased has been pointed out by Gelbard and Pearson[7]. The asymptotic spectrum is similar to a Maxwell distribution at the same temperature[a]. However, the scalar flux is not exactly a Maxwell distribution; the differences are shown quantitatively in Table II for the ends of the temperature range considered. The effect on the average absorption cross section of these differences is shown in Table III. The eigenvalue spectrum is slightly hardened relative to the Maxwell distribution and has a correspondingly smaller average cross section. However, the differences in cross sections are small, ranging from 0.7% at room temperature to 0.4% at 300 C.

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[a] The results of Reference 3 indicate that a diffusion approximation is reasonably accurate in this application. If the diffusion coefficient had exactly the same energy dependence as the absorption cross section, the scalar flux would be a Maxwell distribution[6]. However, the actual diffusion coefficient for H_2O increases rather than decreases with energy.

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