Letters to the Editor

Comment on the Elastic Slowing Down of Neutrons in Fast Systems

In a recent publication Segev[1] considers the problem of fast neutron systems with constant scattering ratio and assumes for the collision density a solution of the form

$$F(u) = C \exp(-\nu u) \tag{1}$$

with the following equation for ν:

$$\frac{1 - S}{S} = \sum_{l=1}^{\infty} \xi^{(l)} \nu^l \quad . \tag{2}$$

However, it is interesting to point out that there is another way of considering the problem which yields for ν a more easily solvable equation than Eq. (2); for the case of isotropic scattering in the center of mass system, the balance equation to be solved is

$$F(E) = \sum_{i=1}^{N} \frac{1}{(1 - \alpha_i)} \int_E^{E/\alpha_i} S_i(E') F(E') \frac{dE'}{E'} \tag{3}$$

(the notation being the same as in the reference mentioned).

Assuming the same type of solution as in Ref. (1),

$$F(E) = C\, E^{-n} \quad \text{where} \quad n = 1 - \nu \quad ,$$

we obtain for n the following transcendental equation:

$$n = \sum_{i=1}^{N} \langle S_i \rangle \frac{(1 - \alpha_i^n)}{(1 - \alpha_i)} \quad , \tag{4}$$

where the average is defined by the following expression:

$$\langle S_i \rangle = \frac{n \cdot E^n}{(1 - \alpha_i^n)} \int_E^{E/\alpha_i} \frac{\Sigma_{S_i}(E')}{\Sigma_T(E')} E'^{-(n+1)} dE' \quad . \tag{5}$$

For the case of constant scattering ratio [i.e., the case of Eq. (2)] this average is directly

$$\langle S_i \rangle = S_i \quad ;$$

then,

$$n = \sum_{i=1}^{N} S_i \frac{(1 - \alpha_i^n)}{(1 - \alpha_i)} \quad .$$

We have applied Eq. (4) to the case of slowly varying scattering ratio, and we approximated the mean value given by Eq. (5) by the arithmetic average. Results obtained so far are encouraging.

For a rapidly varying scattering ratio it could be interesting to solve Eqs. (4) and (5) by an iterative procedure to find n; the substitution of the mean value [Eq. (5)] by the arithmetic average being a poor approximation in this case.

R. Paviotti Corcuera

Centre d'Etudes Nucléaires de Cadarache
13 - Saint Paul lez Durance
France

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[1] M. Segev, *Nucl. Sci. Eng.*, **36**, 59 (1969).

Reply to Comment on the Elastic Slowing Down of Neutrons in Fast Systems

I would like to put in context Corcuera's[1] findings in the preceding letter about constant cross sections. His Eq. (4) is Placzek's[2] Eq. (67), generalized to a mixture. Placzek also indicated a general scheme for solving the equation. First, it obtains the form of a series expansion for s in powers of n; this is Placzek's[2] Eq. (68). The generalization of the latter equation to mixtures and anisotropic scattering is Segev's[3] Eq. (17) [Eq. (2) in Corcuera's[1] letter]. The series is then inverted, yielding a series expansion for n in powers of $(1 - s)/s$. The first few terms of the latter series are given in Placzek's[2] Eq. (69).

Given a finite, relatively narrow range in which to look for their solution, transcendental equations are easy to solve on the computer. It has been my experience that two successive truncations of the above-mentioned power series for n bracket n. The larger the number of terms included in the truncated series, the narrower becomes the bracket for n. With the aid of (the inversion of) Eq. (2), Eq. (4) (Ref. 1) is indeed "easily solvable."

As for variable cross sections, attempting $F(E) = CE^{-n}$, n constant, as an approximate solution is interesting. If there are many, not extremely high, resonances in the range $[E, E/\alpha i]$, then the collision density, in a limited energy range, indeed deviates from an E^{-n} variation only by small wiggles. The condition for $F(E) \approx CE^{-n}$ is, in Corcuera's terms

$$\langle S_i \rangle (E,n) = \langle S_i \rangle \quad ,$$

where $\langle S_i \rangle (E,n)$ are defined in Eq. (5) of Ref. (1). It will be of interest to know what Corcuera finds out about the classes of cross sections that permit the above approximation.

M. Segev

Soreq Nuclear Research Center
Yavne, Israel

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[1] R. Paviatti Corcuera, *Nucl. Sci. Eng.*, **46**, 168 (1971).
[2] G. Placzek, *Phys. Rev.*, **69**, 423 (1946).
[3] M. Segev, *Nucl. Sci. Eng.*, **36**, 59 (1969).