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ELASTIC NEUTRON SCATTERING FROM DISTRIBUTED
FUSION NEUTRONS, DEUTERIUM, TRITIUM, AND LITHIUM

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ABSTRACT

Rate coefficients and normalized differential scattering rate distributions for (n-n), (n-d), (n-t), and (n-^{6}Li) elastic reactions for radially translating Maxwellian distributed targets are tabulated for energy and temperature ranges related to fusion energies. For these reactions, both asymptotically constant cross sections and cross sections decaying inversely as the relative speed are treated. For the (n-d), (n-t), and (n-^{6}Li) cases, actual multigroup cross sections are employed in the energy range, 0-17 MeV, while the (n-n) interaction is treated in the hard sphere limit. Results are tabulated for incident neutron energies in the range 2-14 MeV, final neutron energies in the range 2-28 MeV, given target temperatures and translational energies of 2, 6, 10, and 14 MeV. With minor modification, these results can be incorporated into multigroup neutron transport codes.

I. INTRODUCTION

Possible measurements of neutrons with energies in the 20-30 MeV range in a recent test raise questions of origins of these fast neutrons. Neutrons below 14 MeV are to be expected from (d-t) and (d-d) fusion reactions. Simple (or multiple) upscatter collisions of neutrons with other neutrons, deuterons, tritons, or heavier nuclei are a possible explanation for the origin of the higher energy neutrons. In this analysis, we examine the spectrum of outgoing neutrons from (n-n), (n-d), (n-t), and (n-^{6}Li) collisions off a moving Maxwellian target assembly, isotropically centered about various energies and temperatures. Rate coefficients are also computed using actual multigroup (n-d), (n-t), and (n-^{6}Li) cross sections and hard sphere (n-n) cross sections, enjoined to both asymptotically decaying and constant high energy tails. Transport reaction theory forms the basis of approach and representation.

Our primary interest here is an examination of the rate coefficients and scattering distributions for neutrons off radially translating Maxwellian-like target distributions of other neutrons, deuterons, tritons, and lithium. Deuterium and tritium will fuse the reactions,

$$d + d \rightarrow \underset{(0.82\text{ MeV})}{{}^{3}\text{He}} + \underset{(2.45\text{ MeV})}{n}$$

$$d + d \rightarrow \underset{(1.01\text{ MeV})}{t} + \underset{(3.02\text{ MeV})}{p}$$

$$d + t \rightarrow \underset{(3.5\text{ MeV})}{{}^{3}\text{He}} + \underset{(14.1\text{ MeV})}{n} \quad ,$$

with the (d-t) reaction rates generally predominating. Neutrons of 14 MeV from the (d-t) reaction could scatter from other neutrons of 14 MeV, producing some neutrons with upper limit energy of 28 MeV. Correspondingly, if deuterium, tritium, and lithium possessed energies of sufficient magnitude (somewhere in 6-14 MeV range), upscatter of 14-MeV neutrons into the 20-MeV and above range is conceivable. Depending on the target energy spectrum, elastic cross sections, and overall energy-momentum constraints a continuous distribution of scattered neutrons is expected, which, when integrated over all energies, yields the total scattering rate.

II. REPRESENTATION AND DISTRIBUTIONS

Consider the elastic scattering of a neutron of initial energy ε, velocity $\vec{v}$, and mass m, off a distribution of target nuclei of mass Am and velocity distribution function $F(\vec{V})$ into the final energy ε' and velocity $\vec{v}'$. The effective cross section $\bar{\sigma}$ takes the form,[1-4]

$$v\bar{\sigma} = \int \sigma q F(\vec{V}) d^3V, \tag{1}$$

with initial and final relative velocities

$$\vec{q} = \vec{v} - \vec{V}$$
$$\vec{q}' = \vec{v}' - \vec{V}' \tag{2}$$

for $\vec{V}$, $\vec{V}'$ the initial and final target nuclei velocities,

$$\int F(\vec{V})d^3V = 1 \ , \tag{3}$$

and the microscopic cross sections assumed as functions of the relative collision velocities,

$$\begin{aligned} \sigma &= \sigma(\vec{q}) \\ \sigma' &= \sigma(\vec{q}\,') \ . \end{aligned} \tag{4}$$

The effective differential scattering function $\overline{\overline{\sigma f}}$ is written

$$v\overline{\overline{\sigma f}} = \int \sigma f q F(\vec{V}) d^3V, \tag{5}$$

with the differential probability function f given by

$$f(\vec{v},\vec{v}\,') = \left(\frac{A+1}{A}\right)^3 \left(\frac{1}{4\pi}\right)\left(\frac{1}{q'}\right)^2 \delta(q-q') \tag{6}$$

for

$$\int f(\vec{v},\vec{v}\,')d^3v' = 1 \ . \tag{7}$$

Equations (1) and (5) are related, of course, in that

$$\int \sigma f q F(\vec{V}) d^3V d^3v' = \int v\overline{\overline{\sigma f}} d^3v' = v\bar{\sigma} \ . \tag{8}$$

The quantities $v\bar{\sigma}$ and $v\overline{\overline{\sigma f}}$ are the total and differential rate coefficients so that multiplying by the incident neutron and target nuclei densities n and N, respectively, yields the differential and total reaction rates,

$$\begin{aligned} nN\frac{d\gamma}{d^3v'} &= nNv\overline{\overline{\sigma f}} \\ nN\gamma &= nNv\bar{\sigma} \ . \end{aligned} \tag{9}$$

The target distribution, $F(\vec{V})$, appearing in the above equations may encompass more than one degree of distributional freedom. It may be the end result of folding any number of degrees of freedom over one another. In this analysis, our concern will focus on a Maxwellian target population isotropically centered about some mean energy. Suppose these targets are given a Maxwellian velocity distribution, $M(\vec{h}')$, and are also assigned a translational probability $N(\vec{h}'')$, where

$$\vec{V} = \vec{h}' + \vec{h}'', \tag{10}$$

and

$$M(\vec{h}') = \left(\frac{Am}{2\pi kT}\right)^{3/2} e^{-\frac{Amh'^2}{2kT}} , \tag{11}$$

$$N(\vec{h}'') = \left(\frac{1}{4\pi h''^2}\right) \delta(h''-V_o) , \tag{12}$$

with k Boltzmann's constant, T absolute temperature, and V_o the translational speed. The effective target distribution function can be written as the compound probability integral,

$$F(\vec{V}) = \int N(\vec{h}'')M(\vec{V}-\vec{h}'')d^3h'' , \tag{13}$$

which, for Eqs. (11) and (12), physically describes an isotropic Maxwellian assembly spherically moving with energy $\frac{1}{2}AmV_o^2$. Employing

$$h'^2 = V^2 + h''^2 - 2Vh'' \cos \alpha'' , \tag{14}$$

and integrating Eq. (13), one obtains the desired target distribution function

$$F(\vec{V}) = \left(\frac{Am}{8\pi^3 kT}\right)^{\frac{1}{2}} \left(\frac{1}{VV_o}\right) e^{-\frac{Am(V^2+V_o^2)}{2kT}} \sinh\left(\frac{AmVV_o}{kT}\right) . \tag{15}$$

Correspondingly, from Eqs. (1), (5), and (6), and using the relationship,

$$\int f(\vec{v},\vec{v}')d\Omega' = \left(\frac{A+1}{2A}\right)\left(\frac{1}{qcv'}\right) \quad , \tag{16}$$

it follows that

$$\frac{d\gamma}{dv'} = (2\pi)\left(\frac{Am}{8\pi^3 kT}\right)^{\frac{1}{2}}\int\left(\frac{V}{V_o}\right)\sigma(\vec{q})\left(\frac{v'}{c}\right) e^{-\frac{Am(V^2+V_o^2)}{2kT}} \sinh\left(\frac{AmVV_o}{kT}\right) dVd\mu \tag{17}$$

and,

$$\gamma = (2\pi)\left(\frac{Am}{8\pi^3 kT}\right)^{\frac{1}{2}}\int\left(\frac{V}{V_o}\right) q\sigma(q)\, e^{-\frac{Am(V^2+V_o^2)}{2kT}} \sinh\left(\frac{AmVV_o}{kT}\right) dVd\mu \ , \tag{18}$$

with center of mass velocity, $\vec{c}$, given by

$$(A+1)\vec{c} = \vec{v} + A\vec{V}, \tag{19}$$

and v, v', V, and μ constrained by the limits[5]

$$\left|\left(\frac{A}{A+1}\right)q - c\right| \le v' \le \left|\left(\frac{A}{A+1}\right)q + c\right| \quad , \tag{20}$$

where

$$\mu = \frac{\vec{v}\cdot\vec{V}}{vV} \quad . \tag{21}$$

For a quasi-Maxwellian target distribution radially translating with energy E_o, one might expect the average energy <E> to approximate E_o,

$$\langle E\rangle \sim kT \sim E_o + \Delta \ , \tag{22}$$

with, for the cases at hand, $0 \le E_o \le 14$ MeV and Δ a factor accounting for the energy spread about E_o (probably somewhere in the 10- to 1 000-keV range). For actual calculations, we will take Δ = 0. We do not propose characteristic times nor mechanisms for formation of the quasi-Maxwellian target assembly. Additional study of the dynamics of the target assembly is warranted, but we will content ourselves in this analysis with assemblies of equal temperature and translational energies for gross estimates of γ and $\gamma^{-1}d\gamma/d\varepsilon'$.

III. CROSS SECTIONS

Cross sections for deuterons, tritons, and lithium are available from experimental data. Neutron cross sections have not been measured, but have been estimated from (n-p) elastic data,[6] assuming isotopic spin invariance of the nucleon-nucleon interaction. Another alternative is to treat the neutron-neutron interaction as hard-core spheres and employ the phase shift expansion of the cross section

$$\sigma_n(\vec{q}) = \left(\frac{4\pi}{q^2}\right) \sum_{\ell=0}^{\infty} (2\ell+1) \sin^2 \delta_\ell \tag{23}$$

with δ_ℓ obtained from solution of the hard core wave equation. In the low-energy limit $q \to 0$ the phase shifts δ_ℓ are given in terms of the scattering length, a,

$$\lim_{q\to o} \delta_\ell \sim \tan^{-1} \left[\frac{(qa)^{2\ell+1}}{(2\ell-1)!^2}\right] , \tag{24}$$

resulting in a constant neutron-neutron cross section

$$\sigma_n(\vec{q}) = \sigma_n^o = 4\pi a^2 . \tag{25}$$

Numerically, we take $\sigma_n^o \simeq 0.25$ barns.

The experimental multigroup deuteron, triton, and lithium cross sections, σ_d, σ_t, σ_{Li}, are listed in Table I.[8] The energy values listed in column 2 are the lower boundaries. The upper boundary for the first group is 17 MeV. The entries for the last group represent a simple average over eight lower energy group cross sections.

Realistically, one expects the cross sections to fall off with increasing energy. In the following numerical rate compilation, we therefore treat both constant and decaying cross sections. Asymptotically, we assign both a q^{-1} dependence and constant behavior to the cross sections of Table I for relative

TABLE I

ELASTIC GROUP CROSS SECTIONS FOR NEUTRONS (HARD SPHERE), DEUTERONS, TRITONS, AND LITHIUM (ENDF/B-IV EVALUATIONS)

Group	Energy (MeV)	σ_n (barns)	MAT = 1120 σ_d (barns)	MAT = 1169 σ_t (barns)	MAT = 1271 σ_{Li} (barns)
1	15.0	0.250 00	0.531 80	0.821 28	0.824 26
2	13.5	0.250 00	0.611 25	0.916 78	0.877 01
3	12.0	0.250 00	0.679 56	0.995 13	0.919 43
4	10.0	0.250 00	0.814 30	1.172 06	0.993 72
5	7.79	0.250 00	1.029 75	1.492 79	1.098 75
6	6.07	0.250 00	1.276 04	1.856 64	1.204 47
7	3.68	0.250 00	1.714 09	2.312 04	1.347 98
8	2.865	0.250 00	2.055 13	2.414 91	1.433 00
9	2.232	0.250 00	2.281 52	2.289 60	1.320 32
10	1.738	0.250 00	2.480 85	2.102 88	1.119 58
11	1.353	0.250 00	2.653 98	1.912 28	0.972 98
12	0.823	0.250 00	2.856 2	1.721 59	1.019 38
13	0.50	0.250 00	2.990 5	1.535 12	1.252 53
14	0.303	0.250 00	3.083 85	1.398 84	2.297 63
15	0.184	0.250 00	3.167 93	1.325 57	5.368 16
16	0.067 6	0.250 00	3.249 71	1.301 00	1.038 41
17	0.024 8	0.250 00	3.347 06	1.300 00	0.718 15

energies in excess of 17 MeV, with the value at 17 MeV serving as pivot point for the assumed decaying or constant behavior. That is, defining the relative kinetic energy ω in terms of the reduced neutron-target mass ρ,

$$\rho = \frac{Am}{A+1} \quad , \tag{26}$$

and relative velocity q,

$$\omega = \frac{1}{2}\rho q^2 \quad , \tag{27}$$

we have for asymptotically constant energy cross section,

$$\sigma_j(\omega) = \sigma_j(17), \quad 17 \text{ MeV} \le \omega \tag{28}$$

while, for the asymptotically decaying energy cross section,

$$\sigma_j(\omega) = \sigma_j(17)\left(\frac{17}{\omega}\right)^{1/2}, \quad 17 \text{ MeV} \le \omega \tag{29}$$

with j = n, t, d, or Li.

IV. RESULTS AND CONCLUSIONS

Tables IIa-Vj summarize predictions of γ and $\gamma^{-1}d\gamma/d\varepsilon'$ from Eqs. (17), (18), and (20) for neutrons, deuterons, tritons, and lithium. Tables IIa-IIj treat neutron-neutron scattering rates. Tables IIIa-IIIj treat neutron-deuteron scattering rates. Tables IVa-IVj treat neutron-triton scattering rates, and Tables Va-Vj deal with neutron-lithium scattering rates. Tables IIa, IIb, IIIa, IIIb, IVa, IVb, Va, and Vb give predictions of γ while the remaining tables list normalized predictions of $\gamma^{-1}d\gamma/d\varepsilon'$. Incident neutron energies ε are chosen in 2-MeV increments such that 2 MeV $\le \varepsilon \le$ 14 MeV, with 2 MeV $\le E_o \le$ 14 MeV in increments of 4 MeV. Normalized scattering rates into $d\varepsilon'$ for 0 MeV $\le \varepsilon' \le$ 28 MeV are also computed for 4 MeV bin sizes centered at the midpoints of the seven energy regions spanning 28 MeV.

TABLE IIa

NEUTRON RATE COEFFICIENTS ($\gamma cm^3/sec \times 10^{-14}$)

FOR ASYMPTOTICALLY DECAYING CROSS SECTIONS

	E_o = 2 MeV	E_o = 6 MeV	E_o = 10 MeV	E_o = 14 MeV
ε = 2 MeV	0.083	0.129	0.153	0.167
ε = 4 MeV	0.094	0.135	0.156	0.169
ε = 6 MeV	0.104	0.140	0.159	0.170
ε = 8 MeV	0.114	0.145	0.162	0.172
ε = 10 MeV	0.123	0.150	0.164	0.173
ε = 12 MeV	0.131	0.154	0.167	0.175
ε = 14 MeV	0.139	0.158	0.169	0.176

TABLE IIb

NEUTRON RATE COEFFICIENTS ($\gamma cm^3/sec \times 10^{-14}$)

FOR ASYMPTOTICALLY CONSTANT CROSS SECTIONS

	E_o = 2 MeV	E_o = 6 MeV	E_o = 10 MeV	E_o = 14 MeV
ε = 2 MeV	0.083	0.132	0.166	0.194
ε = 4 MeV	0.094	0.139	0.172	0.199
ε = 6 MeV	0.105	0.146	0.178	0.204
ε = 8 MeV	0.114	0.153	0.184	0.209
ε = 10 MeV	0.123	0.160	0.189	0.214
ε = 12 MeV	0.132	0.166	0.194	0.218
ε = 14 MeV	0.140	0.173	0.200	0.223

TABLE IIc

NEUTRON SCATTERING RATE DISTRIBUTION ($\gamma^{-1} d\gamma/d\epsilon'$ MeV^{-1}) FOR

E_o = kT = 2 MeV AND ASYMPTOTICALLY DECAYING CROSS SECTIONS

	ε' = 2 MeV	ε' = 6 MeV	ε' = 10 MeV	ε' = 14 MeV	ε' = 18 MeV	ε' = 22 MeV	ε' = 26 MeV
ε = 2 MeV	0.53	0.34	0.10	0.02	0.01	0.00	0.00
ε = 4 MeV	0.39	0.42	0.14	0.04	0.01	0.00	0.00
ε = 6 MeV	0.22	0.47	0.22	0.06	0.02	0.01	0.00
ε = 8 MeV	0.17	0.35	0.34	0.10	0.03	0.01	0.00
ε = 10 MeV	0.14	0.26	0.37	0.16	0.05	0.01	0.01
ε = 12 MeV	0.11	0.20	0.30	0.27	0.08	0.02	0.02
ε = 14 MeV	0.09	0.17	0.25	0.31	0.14	0.04	0.00

TABLE IId

NEUTRON SCATTERING RATE DISTRIBUTION ($\gamma^{-1} d\gamma/d\epsilon'$ MeV^{-1}) FOR

E_o = kT = 2 MeV AND ASYMPTOTICALLY CONSTANT CROSS SECTIONS

	ε' = 2 MeV	ε' = 6 MeV	ε' = 10 MeV	ε' = 14 MeV	ε' = 18 MeV	ε' = 22 Mev	ε' = 26 MeV
ε = 2 MeV	0.54	0.32	0.10	0.03	0.01	0.00	0.00
ε = 4 MeV	0.40	0.39	0.14	0.05	0.01	0.01	0.00
ε = 6 MeV	0.28	0.43	0.20	0.07	0.01	0.01	0.00
ε = 8 MeV	0.22	0.36	0.29	0.10	0.02	0.01	0.00
ε = 10 MeV	0.17	0.28	0.33	0.16	0.05	0.01	0.00
ε = 12 MeV	0.14	0.23	0.28	0.24	0.08	0.02	0.01
ε = 14 MeV	0.12	0.20	0.24	0.26	0.13	0.04	0.01

TABLE IIe

NEUTRON SCATTERING RATE DISTRIBUTION ($\gamma^{-1} d\gamma/d\varepsilon'$ MeV^{-1}) FOR

E_o = kT = 6 MeV AND ASYMPTOTICALLY DECAYING CROSS SECTIONS

	ε' = 2 MeV	ε' = 6 MeV	ε' = 10 MeV	ε' = 14 MeV	ε' = 18 Mev	ε' = 22 MeV	ε' = 26 MeV
ε = 2 MeV	0.23	0.26	0.19	0.13	0.09	0.06	0.04
ε = 4 MeV	0.18	0.26	0.20	0.14	0.10	0.07	0.05
ε = 6 MeV	0.13	0.26	0.22	0.16	0.11	0.08	0.04
ε = 8 MeV	0.10	0.21	0.26	0.17	0.13	0.09	0.04
ε = 10 MeV	0.09	0.17	0.24	0.19	0.14	0.10	0.07
ε = 12 MeV	0.07	0.14	0.21	0.23	0.16	0.11	0.08
ε = 14 MeV	0.07	0.12	0.18	0.23	0.18	0.13	0.09

TABLE IIf

NEUTRON SCATTERING RATE DISTRIBUTION ($\gamma^{-1} d\gamma/d\varepsilon'$ MeV^{-1}) FOR

E_o = kT = 6 MeV AND ASYMPTOTICALLY CONSTANT CROSS SECTIONS

	ε' = 2 MeV	ε' = 6 MeV	ε' = 10 MeV	ε' = 14 MeV	ε' = 18 MeV	ε' = 22 MeV	ε' = 26 MeV
ε = 2 MeV	0.21	0.23	0.19	0.14	0.10	0.07	0.06
ε = 4 MeV	0.18	0.24	0.19	0.15	0.11	0.08	0.05
ε = 6 MeV	0.14	0.23	0.20	0.16	0.12	0.09	0.06
ε = 8 MeV	0.12	0.20	0.22	0.17	0.13	0.09	0.07
ε = 10 MeV	0.10	0.17	0.23	0.18	0.14	0.10	0.08
ε = 12 MeV	0.09	0.15	0.21	0.20	0.15	0.11	0.09
ε = 14 MeV	0.08	0.14	0.18	0.21	0.17	0.13	0.09

TABLE IIg

NEUTRON SCATTERING RATE DISTRIBUTION ($\gamma^{-1} d\gamma/d\varepsilon'$ MeV^{-1}) FOR

E_o = kT = 10 MeV AND ASYMPTOTICALLY DECAYING CROSS SECTIONS

	ε' = 2 MeV	ε' = 6 MeV	ε' = 10 MeV	ε' = 14 MeV	ε' = 18 MeV	ε' = 22 MeV	ε' = 26 MeV
ε = 2 MeV	0.15	0.20	0.18	0.15	0.13	0.10	0.09
ε = 4 MeV	0.13	0.20	0.19	0.16	0.13	0.11	0.08
ε = 6 MeV	0.10	0.20	0.19	0.17	0.14	0.11	0.09
ε = 8 MeV	0.09	0.17	0.21	0.17	0.15	0.12	0.10
ε = 10 MeV	0.07	0.14	0.20	0.18	0.16	0.13	0.12
ε = 12 MeV	0.06	0.12	0.18	0.20	0.17	0.14	0.13
ε = 14 MeV	0.06	0.11	0.16	0.21	0.18	0.15	0.13

TABLE IIh

NEUTRON SCATTERING RATE DISTRIBUTION ($\gamma^{-1}d\gamma/d\varepsilon'$ MeV^{-1}) FOR

E_o = kT = 10 MeV AND ASYMPTOTICALLY CONSTANT CROSS SECTIONS

	ε' = 2 MeV	ε' = 6 MeV	ε' = 10 MeV	ε' = 14 MeV	ε' = 18 MeV	ε' = 22 MeV	ε' = 26 MeV
ε = 2 MeV	0.13	0.17	0.17	0.16	0.14	0.12	0.11
ε = 4 MeV	0.12	0.18	0.17	0.16	0.14	0.12	0.11
ε = 6 MeV	0.11	0.18	0.18	0.16	0.14	0.12	0.11
ε = 8 MeV	0.09	0.17	0.19	0.17	0.15	0.12	0.11
ε = 10 MeV	0.08	0.15	0.19	0.17	0.16	0.14	0.11
ε = 12 MeV	0.07	0.13	0.18	0.19	0.16	0.14	0.13
ε = 14 MeV	0.07	0.12	0.16	0.19	0.17	0.15	0.14

TABLE IIi

NEUTRON SCATTERING RATE DISTRIBUTION ($\gamma^{-1}d\gamma/d\varepsilon'$ MeV^{-1}) FOR

E_o = kT = 14 MeV AND ASYMPTOTICALLY DECAYING CROSS SECTIONS

	ε' = 2 MeV	ε' = 6 MeV	ε' = 10 MeV	ε' = 14 MeV	ε' = 18 MeV	ε' = 22 MeV	ε' = 26 MeV
ε = 2 MeV	0.12	0.17	0.17	0.16	0.14	0.13	0.11
ε = 4 MeV	0.11	0.18	0.17	0.16	0.14	0.13	0.11
ε = 6 MeV	0.09	0.17	0.18	0.17	0.15	0.13	0.11
ε = 8 MeV	0.08	0.15	0.19	0.17	0.16	0.14	0.11
ε = 10 MeV	0.07	0.13	0.19	0.18	0.16	0.15	0.12
ε = 12 MeV	0.06	0.12	0.17	0.19	0.17	0.15	0.14
ε = 14 MeV	0.05	0.10	0.16	0.21	0.18	0.16	0.14

TABLE IIj

NEUTRON SCATTERING RATE DISTRIBUTION ($\gamma^{-1}d\gamma/d\varepsilon'$ MeV^{-1}) FOR

E_o = kT = 14 MeV AND ASYMPTOTICALLY CONSTANT CROSS SECTIONS

	ε' = 2 MeV	ε' = 6 MeV	ε' = 10 MeV	ε' = 14 MeV	ε' = 18 MeV	ε' = 22 MeV	ε' = 26 MeV
ε = 2 MeV	0.10	0.15	0.16	0.16	0.15	0.15	0.13
ε = 4 MeV	0.10	0.16	0.16	0.16	0.15	0.14	0.13
ε = 6 MeV	0.09	0.16	0.17	0.16	0.15	0.14	0.13
ε = 8 MeV	0.08	0.15	0.18	0.16	0.16	0.14	0.13
ε = 10 MeV	0.07	0.13	0.18	0.17	0.16	0.15	0.14
ε = 12 MeV	0.06	0.11	0.15	0.19	0.17	0.16	0.14
ε = 14 MeV	0.06	0.11	0.15	0.19	0.17	0.16	0.14

TABLE IIIa

DEUTERON RATE COEFFICIENTS ($\gamma cm^3/sec \times 10^{-14}$)

FOR ASYMPTOTICALLY DECAYING CROSS SECTIONS

	E_o = 2 MeV	E_o = 6 MeV	E_o = 10 MeV	E_o = 14 MeV
ε = 2 MeV	1.152	1.117	1.036	0.971
ε = 4 MeV	1.160	1.072	1.000	0.947
ε = 6 MeV	1.137	1.035	0.972	0.926
ε = 8 MeV	1.090	0.994	0.941	0.904
ε = 10 MeV	1.042	0.957	0.914	0.885
ε = 12 MeV	0.996	0.938	0.899	0.873
ε = 14 MeV	0.940	0.904	0.875	0.855

TABLE IIIb

DEUTERON RATE COEFFICIENTS ($\gamma cm^3/sec \times 10^{-14}$)

FOR ASYMPTOTICALLY CONSTANT CROSS SECTIONS

	E_o = 2 MeV	E_o = 6 MeV	E_o = 10 MeV	E_o = 14 Mev
ε = 2 MeV	1.152	1.120	1.053	1.013
ε = 4 MeV	1.160	1.077	1.026	1.002
ε = 6 MeV	1.137	1.046	1.008	0.995
ε = 8 MeV	1.091	1.011	0.989	0.988
ε = 10 MeV	1.043	0.981	0.974	0.983
ε = 12 MeV	0.998	0.971	0.972	0.986
ε = 14 MeV	0.945	0.948	0.962	0.984

TABLE IIIc

DEUTERON SCATTERING RATE DISTRIBUTION ($\gamma^{-1} d\gamma/d\varepsilon'$ MeV^{-1}) FOR

E_o = kT = 2 MeV AND ASYMPTOTICALLY DECAYING CROSS SECTIONS

	ε' = 2 MeV	ε' = 6 MeV	ε' = 10 MeV	ε' = 14 MeV	ε' = 18 MeV	ε' = 22 MeV	ε' = 26 MeV
ε = 2 MeV	0.59	0.30	0.08	0.02	0.01	0.00	0.00
ε = 4 MeV	0.40	0.42	0.14	0.03	0.01	0.00	0.00
ε = 6 MeV	0.26	0.46	0.21	0.06	0.01	0.00	0.00
ε = 8 MeV	0.19	0.37	0.31	0.10	0.02	0.01	0.00
ε = 10 MeV	0.14	0.27	0.37	0.16	0.04	0.01	0.01
ε = 12 MeV	0.11	0.22	0.32	0.25	0.07	0.02	0.01
ε = 14 MeV	0.09	0.18	0.26	0.30	0.13	0.03	0.01

TABLE IIId

DEUTERON SCATTERING RATE DISTRIBUTION ($\gamma^{-1}d\gamma/d\varepsilon'$ MeV^{-1}) FOR E_o = kT = 2 MeV AND ASYMPTOTICALLY CONSTANT CROSS SECTIONS

	ε' = 2 MeV	ε' = 6 MeV	ε' = 10 MeV	ε' = 14 MeV	ε' = 18 Mev	ε' = 22 MeV	ε' = 26 MeV
ε = 2 MeV	0.59	0.30	0.09	0.02	0.00	0.00	0.00
ε = 4 MeV	0.40	0.42	0.13	0.03	0.02	0.00	0.00
ε = 6 MeV	0.26	0.46	0.21	0.06	0.01	0.00	0.00
ε = 8 MeV	0.19	0.37	0.31	0.10	0.02	0.01	0.00
ε = 10 MeV	0.14	0.27	0.37	0.16	0.04	0.01	0.00
ε = 12 MeV	0.11	0.22	0.32	0.26	0.07	0.02	0.00
ε = 14 MeV	0.09	0.18	0.26	0.30	0.13	0.03	0.01

TABLE IIIe

DEUTERON SCATTERING RATE DISTRIBUTION ($\gamma^{-1}d\gamma/d\varepsilon'$ MeV^{-1}) FOR E_o = kT = 6 MeV AND ASYMPTOTICALLY DECAYING CROSS SECTIONS

	ε' = 2 MeV	ε' = 6 MeV	ε' = 10 MeV	ε' = 14 MeV	ε' = 18 MeV	ε' = 22 MeV	ε' = 26 MeV
ε = 2 MeV	0.25	0.26	0.19	0.13	0.09	0.05	0.03
ε = 4 MeV	0.20	0.29	0.20	0.14	0.09	0.05	0.03
ε = 6 MeV	0.15	0.28	0.23	0.16	0.09	0.06	0.03
ε = 8 MeV	0.12	0.24	0.25	0.17	0.11	0.07	0.04
ε = 10 MeV	0.09	0.18	0.26	0.21	0.13	0.08	0.05
ε = 12 MeV	0.07	0.15	0.22	0.24	0.16	0.10	0.06
ε = 14 MeV	0.06	0.13	0.19	0.24	0.18	0.12	0.08

TABLE IIIf

DEUTERON SCATTERING RATE DISTRIBUTION ($\gamma^{-1}d\gamma/d\varepsilon'$ MeV^{-1}) FOR E_o = kT = 6 MeV AND ASYMPTOTICALLY CONSTANT CROSS SECTIONS

	ε' = 2 MeV	ε' = 6 MeV	ε' = 10 MeV	ε' = 14 MeV	ε' = 18 MeV	ε' = 22 MeV	ε' = 26 MeV
ε = 2 MeV	0.25	0.26	0.19	0.13	0.09	0.05	0.03
ε = 4 MeV	0.20	0.29	0.20	0.14	0.09	0.05	0.03
ε = 6 MeV	0.15	0.28	0.23	0.16	0.09	0.06	0.03
ε = 8 MeV	0.12	0.24	0.25	0.18	0.11	0.07	0.03
ε = 10 MeV	0.09	0.19	0.26	0.21	0.13	0.08	0.04
ε = 12 MeV	0.07	0.15	0.23	0.24	0.16	0.10	0.05
ε = 14 MeV	0.06	0.13	0.19	0.24	0.18	0.11	0.09

TABLE IIIg

DEUTERON SCATTERING RATE DISTRIBUTION ($\gamma^{-1}d\gamma/d\epsilon'$ MeV^{-1}) FOR E_o = kT = 10 MeV AND ASYMPTOTICALLY DECAYING CROSS SECTIONS

	ε' = 2 MeV	ε' = 6 MeV	ε' = 10 MeV	ε' = 14 MeV	ε' = 18 MeV	ε' = 22 MeV	ε' = 26 MeV
ε = 2 MeV	0.18	0.22	0.19	0.15	0.12	0.09	0.05
ε = 4 MeV	0.15	0.23	0.19	0.15	0.12	0.09	0.07
ε = 6 MeV	0.12	0.22	0.21	0.17	0.12	0.09	0.07
ε = 8 MeV	0.09	0.19	0.22	0.18	0.14	0.10	0.08
ε = 10 MeV	0.08	0.16	0.22	0.20	0.15	0.11	0.08
ε = 12 MeV	0.06	0.13	0.20	0.21	0.17	0.12	0.11
ε = 14 MeV	0.06	0.12	0.17	0.22	0.18	0.14	0.11

TABLE IIIh

DEUTERON SCATTERING RATE DISTRIBUTION ($\gamma^{-1}d\gamma/d\epsilon'$ MeV^{-1}) FOR E_o = kT = 10 MeV AND ASYMPTOTICALLY CONSTANT CROSS SECTIONS

	ε' = 2 MeV	ε' = 6 MeV	ε' = 10 MeV	ε' = 14 MeV	ε' = 18 MeV	ε' = 22 MeV	ε' = 26 MeV
ε = 2 MeV	0.18	0.22	0.19	0.15	0.12	0.08	0.06
ε = 4 MeV	0.16	0.24	0.20	0.16	0.12	0.08	0.04
ε = 6 MeV	0.12	0.23	0.22	0.17	0.12	0.08	0.06
ε = 8 MeV	0.10	0.20	0.22	0.18	0.13	0.10	0.07
ε = 10 MeV	0.08	0.16	0.23	0.20	0.15	0.11	0.07
ε = 12 MeV	0.07	0.14	0.20	0.21	0.17	0.13	0.08
ε = 14 MeV	0.06	0.12	0.18	0.22	0.18	0.14	0.10

TABLE IIIi

DEUTERON SCATTERING RATE DISTRIBUTION ($\gamma^{-1}d\gamma/d\epsilon'$ MeV^{-1}) FOR E_o = kT = 14 MeV AND ASYMPTOTICALLY DECAYING CROSS SECTIONS

	ε' = 2 MeV	ε' = 6 MeV	ε' = 10 MeV	ε' = 14 MeV	ε' = 18 MeV	ε' = 22 MeV	ε' = 26 MeV
ε = 2 MeV	0.18	0.22	0.19	0.15	0.12	0.09	0.05
ε = 4 MeV	0.13	0.21	0.19	0.16	0.13	0.10	0.08
ε = 6 MeV	0.10	0.20	0.20	0.17	0.13	0.11	0.09
ε = 8 MeV	0.08	0.18	0.21	0.18	0.14	0.12	0.09
ε = 10 MeV	0.07	0.15	0.21	0.19	0.16	0.13	0.09
ε = 12 MeV	0.06	0.13	0.18	0.21	0.17	0.14	0.11
ε = 14 MeV	0.05	0.11	0.17	0.21	0.18	0.15	0.13

TABLE IIIj

DEUTERON SCATTERING RATE DISTRIBUTION ($\gamma^{-1} d\gamma/d\varepsilon'$ MeV^{-1}) FOR E_o = kT = 14 MeV AND ASYMPTOTICALLY CONSTANT CROSS SECTIONS

	ε' = 2 MeV	ε' = 6 MeV	ε' = 10 MeV	ε' = 14 MeV	ε' = 18 MeV	ε' = 22 MeV	ε' = 26 MeV
ε = 2 MeV	0.16	0.20	0.18	0.16	0.13	0.10	0.07
ε = 4 MeV	0.14	0.22	0.19	0.16	0.13	0.10	0.06
ε = 6 MeV	0.11	0.21	0.20	0.17	0.13	0.10	0.08
ε = 8 MeV	0.09	0.18	0.21	0.18	0.14	0.11	0.09
ε = 10 MeV	0.07	0.15	0.21	0.19	0.16	0.12	0.10
ε = 12 MeV	0.06	0.13	0.19	0.21	0.17	0.13	0.11
ε = 14 MeV	0.05	0.11	0.17	0.21	0.18	0.15	0.13

TABLE IVa

TRITON RATE COEFFICIENTS ($\gamma cm^3/sec \times 10^{-14}$) FOR ASYMPTOTICALLY DECAYING CROSS SECTIONS

	E_o = 2 MeV	E_o = 6 MeV	E_o = 10 MeV	E_o = 14 MeV
ε = 2 MeV	1.480	1.806	1.863	1.853
ε = 4 MeV	1.849	1.870	1.856	1.832
ε = 6 MeV	2.005	1.878	1.834	1.806
ε = 8 MeV	2.063	1.907	1.842	1.804
ε = 10 MeV	2.001	1.879	1.819	1.783
ε = 12 MeV	1.945	1.866	1.806	1.770
ε = 14 MeV	1.842	1.818	1.777	1.748

TABLE IVb

TRITON RATE COEFFICIENTS ($\gamma cm^3/sec \times 10^{-14}$) FOR ASYMPTOTICALLY CONSTANT CROSS SECTIONS

	E_o = 2 MeV	E_o = 6 MeV	E_o = 10 MeV	E_o = 14 MeV
ε = 2 MeV	1.480	1.807	1.877	1.895
ε = 4 MeV	1.849	1.875	1.885	1.899
ε = 6 MeV	2.005	1.890	1.881	1.900
ε = 8 MeV	2.063	1.929	1.911	1.929
ε = 10 MeV	2.002	1.916	1.914	1.941
ε = 12 MeV	1.950	1.923	1.931	1.962
ε = 14 MeV	1.853	1.899	1.933	1.976

TABLE IVc

TRITON SCATTERING RATE DISTRIBUTION ($\gamma^{-1} d\gamma/d\varepsilon'$ MeV^{-1}) FOR

E_o = kT = 2 MeV AND ASYMPTOTICALLY DECAYING CROSS SECTIONS

	ε' = 2 MeV	ε' = 6 MeV	ε' = 10 MeV	ε' = 14 MeV	ε' = 18 MeV	ε' = 22 MeV	ε' = 26 MeV
ε = 2 MeV	0.52	0.34	0.10	0.02	0.01	0.01	0.00
ε = 4 MeV	0.41	0.42	0.13	0.03	0.01	0.00	0.00
ε = 6 MeV	0.28	0.45	0.20	0.05	0.01	0.01	0.00
ε = 8 MeV	0.20	0.38	0.31	0.08	0.02	0.01	0.00
ε = 10 MeV	0.14	0.28	0.38	0.15	0.04	0.01	0.00
ε = 12 MeV	0.12	0.23	0.31	0.25	0.07	0.02	0.00
ε = 14 MeV	0.09	0.18	0.25	0.31	0.13	0.03	0.01

TABLE IVd

TRITON SCATTERING RATE DISTRIBUTION ($\gamma^{-1} d\gamma/d\varepsilon'$ MeV^{-1}) FOR

E_o = kT = 2 MeV AND ASYMPTOTICALLY CONSTANT CROSS SECTIONS

	ε' = 2 MeV	ε' = 6 MeV	ε' = 10 MeV	ε' = 14 MeV	ε' = 18 MeV	ε' = 22 MeV	ε' = 26 MeV
ε = 2 MeV	0.52	0.34	0.10	0.02	0.01	0.01	0.00
ε = 4 MeV	0.41	0.42	0.13	0.03	0.01	0.00	0.00
ε = 6 MeV	0.28	0.45	0.20	0.06	0.01	0.00	0.00
ε = 8 MeV	0.20	0.38	0.31	0.08	0.02	0.01	0.00
ε = 10 MeV	0.14	0.28	0.38	0.15	0.04	0.01	0.00
ε = 12 MeV	0.12	0.23	0.31	0.25	0.07	0.02	0.00
ε = 14 MeV	0.08	0.18	0.26	0.31	0.13	0.03	0.01

TABLE IVe

TRITON SCATTERING RATE DISTRIBUTION ($\gamma^{-1} d\gamma/d\varepsilon'$ MeV^{-1}) FOR

E_o = kT = 6 MeV AND ASYMPTOTICALLY DECAYING CROSS SECTIONS

	ε' = 2 MeV	ε' = 6 MeV	ε' = 10 MeV	ε' = 14 MeV	ε' = 18 MeV	ε' = 22 MeV	ε' = 26 MeV
ε = 2 MeV	0.25	0.30	0.21	0.12	0.08	0.03	0.01
ε = 4 MeV	0.22	0.31	0.21	0.13	0.07	0.04	0.02
ε = 6 MeV	0.17	0.30	0.23	0.14	0.09	0.04	0.03
ε = 8 MeV	0.13	0.26	0.27	0.16	0.10	0.06	0.02
ε = 10 MeV	0.10	0.20	0.28	0.20	0.12	0.07	0.03
ε = 12 MeV	0.08	0.16	0.23	0.23	0.15	0.09	0.06
ε = 14 MeV	0.06	0.14	0.19	0.24	0.18	0.12	0.07

TABLE IVf

TRITON SCATTERING RATE DISTRIBUTION ($\gamma^{-1} d\gamma/d\varepsilon'$ MeV^{-1}) FOR

E_o = kT = 6 MeV AND ASYMPTOTICALLY CONSTANT CROSS SECTIONS

	ε' = 2 MeV	ε' = 6 MeV	ε' = 10 MeV	ε' = 14 MeV	ε' = 18 MeV	ε' = 22 MeV	ε' = 26 MeV
ε = 2 MeV	0.26	0.30	0.21	0.12	0.08	0.03	0.00
ε = 4 MeV	0.22	0.31	0.21	0.13	0.07	0.04	0.02
ε = 6 MeV	0.17	0.31	0.23	0.15	0.08	0.04	0.02
ε = 8 MeV	0.13	0.26	0.27	0.16	0.09	0.06	0.03
ε = 10 MeV	0.10	0.20	0.28	0.21	0.12	0.06	0.03
ε = 12 MeV	0.08	0.17	0.23	0.23	0.15	0.09	0.05
ε = 14 MeV	0.07	0.14	0.20	0.25	0.18	0.11	0.05

TABLE IVg

TRITON SCATTERING RATE DISTRIBUTION ($\gamma^{-1} d\gamma/d\varepsilon'$ MeV^{-1}) FOR

E_o = kT = 10 MeV AND ASYMPTOTICALLY DECAYING CROSS SECTIONS

	ε' = 2 MeV	ε' = 6 MeV	ε' = 10 MeV	ε' = 14 MeV	ε' = 18 MeV	ε' = 22 MeV	ε' = 26 MeV
ε = 2 MeV	0.19	0.26	0.22	0.14	0.11	0.05	0.03
ε = 4 MeV	0.18	0.27	0.21	0.15	0.10	0.06	0.03
ε = 6 MeV	0.14	0.26	0.22	0.16	0.11	0.07	0.04
ε = 8 MeV	0.11	0.22	0.24	0.17	0.12	0.09	0.05
ε = 10 MeV	0.08	0.17	0.24	0.20	0.14	0.10	0.07
ε = 12 MeV	0.07	0.14	0.20	0.22	0.16	0.12	0.09
ε = 14 MeV	0.06	0.12	0.18	0.22	0.18	0.14	0.10

TABLE IVh

TRITON SCATTERING RATE DISTRIBUTION ($\gamma^{-1} d\gamma/d\varepsilon'$ MeV^{-1}) FOR

E_o = kT = 10 MeV AND ASYMPTOTICALLY CONSTANT CROSS SECTIONS

	ε' = 2 MeV	ε' = 6 MeV	ε' = 10 MeV	ε' = 14 MeV	ε' = 18 MeV	ε' = 22 MeV	ε' = 26 MeV
ε = 2 MeV	0.19	0.26	0.22	0.14	0.11	0.05	0.03
ε = 4 MeV	0.18	0.27	0.21	0.15	0.10	0.06	0.03
ε = 6 MeV	0.14	0.26	0.22	0.16	0.11	0.07	0.04
ε = 8 MeV	0.11	0.22	0.25	0.17	0.12	0.08	0.05
ε = 10 MeV	0.08	0.18	0.25	0.20	0.13	0.09	0.07
ε = 12 MeV	0.07	0.15	0.21	0.22	0.16	0.11	0.08
ε = 14 MeV	0.06	0.13	0.18	0.22	0.18	0.13	0.10

TABLE IVi

TRITON SCATTERING RATE DISTRIBUTION ($\gamma^{-1}d\gamma/d\varepsilon'$ MeV^{-1}) FOR

E_o = kT = 14 MeV AND ASYMPTOTICALLY DECAYING CROSS SECTIONS

	ε' = 2 MeV	ε' = 6 MeV	ε' = 10 MeV	ε' = 14 MeV	ε' = 18 MeV	ε' = 22 MeV	ε' = 26 MeV
ε = 2 MeV	0.17	0.24	0.21	0.15	0.12	0.06	0.05
ε = 4 MeV	0.16	0.25	0.20	0.16	0.11	0.07	0.05
ε = 6 MeV	0.13	0.23	0.21	0.16	0.12	0.08	0.07
ε = 8 MeV	0.10	0.20	0.23	0.17	0.13	0.10	0.07
ε = 10 MeV	0.08	0.16	0.23	0.20	0.15	0.11	0.07
ε = 12 MeV	0.07	0.13	0.19	0.21	0.17	0.13	0.10
ε = 14 MeV	0.05	0.12	0.17	0.21	0.19	0.15	0.11

TABLE IVj

TRITON SCATTERING RATE DISTRIBUTION ($\gamma^{-1}d\gamma/d\varepsilon'$ MeV^{-1}) FOR

E_o = kT = 14 MeV AND ASYMPTOTICALLY CONSTANT CROSS SECTIONS

	ε' = 2 MeV	ε' = 6 MeV	ε' = 10 MeV	ε' = 14 MeV	ε' = 18 MeV	ε' = 22 MeV	ε' = 26 MeV
ε = 2 MeV	0.17	0.24	0.21	0.15	0.12	0.06	0.05
ε = 4 MeV	0.16	0.25	0.21	0.16	0.11	0.07	0.04
ε = 6 MeV	0.13	0.24	0.21	0.17	0.12	0.08	0.05
ε = 8 MeV	0.10	0.20	0.24	0.17	0.13	0.10	0.06
ε = 10 MeV	0.08	0.16	0.23	0.20	0.14	0.10	0.09
ε = 12 MeV	0.07	0.14	0.20	0.21	0.17	0.13	0.08
ε = 14 MeV	0.06	0.12	0.17	0.22	0.18	0.14	0.11

TABLE Va

LITHIUM RATE COEFFICIENTS ($\gamma cm^3/sec \times 10^{-14}$)

FOR ASYMPTOTICALLY DECAYING CROSS SECTIONS

	E_o = 2 MeV	E_o = 6 MeV	E_o = 10 MeV	E_o = 14 MeV
ε = 2 MeV	1.667	2.045	2.268	2.414
ε = 4 MeV	2.224	2.383	2.479	2.555
ε = 6 MeV	2.575	2.605	2.633	2.665
ε = 8 MeV	2.735	2.745	2.744	2.751
ε = 10 MeV	2.807	2.845	2.837	2.829
ε = 12 MeV	2.864	2.896	2.883	2.869
ε = 14 MeV	2.876	2.932	2.923	2.905

TABLE Vb

LITHIUM RATE COEFFICIENTS ($\gamma cm^3/sec \times 10^{-14}$)

FOR ASYMPTOTICALLY CONSTANT CROSS SECTIONS

	E_o = 2 MeV	E_o = 6 MeV	E_o = 10 MeV	E_o = 14 MeV
ε = 2 MeV	1.667	2.045	2.270	2.426
ε = 4 MeV	2.244	2.384	2.489	2.586
ε = 6 MeV	2.575	2.609	2.658	2.726
ε = 8 MeV	2.735	2.758	2.795	2.853
ε = 10 MeV	2.808	2.875	2.924	2.981
ε = 12 MeV	2.867	2.955	3.018	3.081
ε = 14 MeV	2.890	3.034	3.116	3.186

TABLE Vc

LITHIUM SCATTERING RATE DISTRIBUTION ($\gamma^{-1} d\gamma/d\varepsilon'$ MeV^{-1}) FOR

E_o = kT = 2 MeV AND ASYMPTOTICALLY DECAYING CROSS SECTIONS

	ε' = 2 MeV	ε' = 6 MeV	ε' = 10 MeV	ε' = 14 MeV	ε' = 18 MeV	ε' = 22 MeV	ε' = 26 MeV
ε = 2 MeV	0.85	0.15	0.00	0.00	0.00	0.00	0.00
ε = 4 MeV	0.49	0.44	0.06	0.01	0.00	0.00	0.00
ε = 6 MeV	0.31	0.49	0.17	0.03	0.00	0.00	0.00
ε = 8 MeV	0.21	0.41	0.31	0.06	0.01	0.00	0.00
ε = 10 MeV	0.16	0.30	0.38	0.13	0.03	0.00	0.00
ε = 12 MeV	0.13	0.24	0.32	0.24	0.06	0.01	0.00
ε = 14 MeV	0.10	0.19	0.26	0.30	0.11	0.03	0.01

TABLE Vd

LITHIUM SCATTERING RATE DISTRIBUTION ($\gamma^{-1} d\gamma/d\varepsilon'$ MeV^{-1}) FOR

E_o = kT = 2 MeV AND ASYMPTOTICALLY CONSTANT CROSS SECTIONS

	ε' = 2 MeV	ε' = 6 MeV	ε' = 10 MeV	ε' = 14 MeV	ε' = 18 MeV	ε' = 22 MeV	ε' = 26 MeV
ε = 2 MeV	0.85	0.15	0.00	0.00	0.00	0.00	0.00
ε = 4 MeV	0.49	0.44	0.06	0.01	0.00	0.00	0.00
ε = 6 MeV	0.31	0.49	0.17	0.03	0.00	0.00	0.00
ε = 8 MeV	0.21	0.41	0.31	0.06	0.01	0.00	0.00
ε = 10 MeV	0.16	0.30	0.38	0.13	0.03	0.00	0.00
ε = 12 MeV	0.13	0.25	0.32	0.23	0.06	0.01	0.00
ε = 14 MeV	0.11	0.19	0.26	0.30	0.11	0.02	0.01

TABLE Ve

LITHIUM SCATTERING RATE DISTRIBUTION ($\gamma^{-1}d\gamma/d\epsilon'$ MeV^{-1}) FOR E_o = kT = 6 MeV AND ASYMPTOTICALLY DECAYING CROSS SECTIONS

	ε' = 2 MeV	ε' = 6 MeV	ε' = 10 MeV	ε' = 14 MeV	ε' = 18 MeV	ε' = 22 MeV	ε' = 26 MeV
ε = 2 MeV	0.80	0.20	0.00	0.00	0.00	0.00	0.00
ε = 4 MeV	0.41	0.45	0.13	0.01	0.00	0.00	0.00
ε = 6 MeV	0.23	0.41	0.24	0.10	0.02	0.00	0.00
ε = 8 MeV	0.15	0.32	0.31	0.14	0.06	0.02	0.00
ε = 10 MeV	0.12	0.23	0.31	0.19	0.09	0.04	0.02
ε = 12 MeV	0.09	0.19	0.25	0.24	0.13	0.06	0.04
ε = 14 MeV	0.08	0.15	0.21	0.25	0.17	0.09	0.05

TABLE Vf

LITHIUM SCATTERING RATE DISTRIBUTION ($\gamma^{-1}d\gamma/d\epsilon'$ MeV^{-1}) FOR E_o = kT = 6 MeV AND ASYMPTOTICALLY CONSTANT CROSS SECTIONS

	ε' = 2 MeV	ε' = 6 MeV	ε' = 10 MeV	ε' = 14 MeV	ε' = 18 MeV	ε' = 22 MeV	ε' = 26 MeV
ε = 2 MeV	0.80	0.20	0.00	0.00	0.00	0.00	0.00
ε = 4 MeV	0.41	0.45	0.13	0.01	0.00	0.00	0.00
ε = 6 MeV	0.23	0.41	0.24	0.10	0.02	0.00	0.00
ε = 8 MeV	0.15	0.32	0.31	0.14	0.06	0.02	0.00
ε = 10 MeV	0.12	0.24	0.31	0.19	0.09	0.03	0.02
ε = 12 MeV	0.09	0.19	0.26	0.24	0.12	0.06	0.04
ε = 14 MeV	0.08	0.16	0.22	0.26	0.16	0.08	0.04

TABLE Vg

LITHIUM SCATTERING RATE DISTRIBUTION ($\gamma^{-1}d\gamma/d\epsilon'$ MeV^{-1}) FOR E_o = kT = 10 MeV AND ASYMPTOTICALLY DECAYING CROSS SECTIONS

	ε' = 2 MeV	ε' = 6 MeV	ε' = 10 MeV	ε' = 14 MeV	ε' = 18 MeV	ε' = 22 MeV	ε' = 26 MeV
ε = 2 MeV	0.79	0.21	0.00	0.00	0.00	0.00	0.00
ε = 4 MeV	0.39	0.45	0.15	0.01	0.00	0.00	0.00
ε = 6 MeV	0.22	0.39	0.24	0.11	0.04	0.00	0.00
ε = 8 MeV	0.14	0.30	0.30	0.15	0.07	0.03	0.01
ε = 10 MeV	0.11	0.21	0.30	0.20	0.11	0.06	0.01
ε = 12 MeV	0.08	0.17	0.24	0.23	0.14	0.08	0.06
ε = 14 MeV	0.07	0.14	0.20	0.24	0.18	0.11	0.06

TABLE Vh

LITHIUM SCATTERING RATE DISTRIBUTION ($\gamma^{-1} d\gamma/d\varepsilon'$ MeV^{-1}) FOR

E_o = kT = 10 MeV AND ASYMPTOTICALLY CONSTANT CROSS SECTIONS

	ε' = 2 MeV	ε' = 6 MeV	ε' = 10 MeV	ε' = 14 MeV	ε' = 18 MeV	ε' = 22 MeV	ε' = 26 MeV
ε = 2 MeV	0.79	0.21	0.00	0.00	0.00	0.00	0.00
ε = 4 MeV	0.39	0.45	0.15	0.01	0.00	0.00	0.00
ε = 6 MeV	0.22	0.39	0.24	0.11	0.03	0.01	0.00
ε = 8 MeV	0.14	0.30	0.30	0.15	0.07	0.03	0.01
ε = 10 MeV	0.11	0.22	0.30	0.20	0.10	0.05	0.02
ε = 12 MeV	0.09	0.18	0.24	0.24	0.14	0.08	0.03
ε = 14 MeV	0.07	0.14	0.20	0.24	0.17	0.10	0.08

TABLE Vi

LITHIUM SCATTERING RATE DISTRIBUTION ($\gamma^{-1} d\gamma/d\varepsilon'$ MeV^{-1}) FOR

E_o = kT = 14 MeV AND ASYMPTOTICALLY DECAYING CROSS SECTIONS

	ε' = 2 MeV	ε' = 6 MeV	ε' = 10 MeV	ε' = 14 MeV	ε' = 18 MeV	ε' = 22 MeV	ε' = 26 MeV
ε = 2 MeV	0.78	0.22	0.00	0.00	0.00	0.00	0.00
ε = 4 MeV	0.38	0.45	0.15	0.02	0.00	0.00	0.00
ε = 6 MeV	0.21	0.38	0.25	0.12	0.04	0.00	0.00
ε = 8 MeV	0.14	0.29	0.30	0.16	0.08	0.03	0.00
ε = 10 MeV	0.10	0.21	0.28	0.20	0.11	0.07	0.03
ε = 12 MeV	0.08	0.17	0.23	0.23	0.15	0.09	0.05
ε = 14 MeV	0.07	0.13	0.19	0.23	0.18	0.12	0.08

TABLE Vj

LITHIUM SCATTERING RATE DISTRIBUTION ($\gamma^{-1} d\gamma/d\varepsilon'$ MeV^{-1}) FOR

E_o = kT = 14 MeV AND ASYMPTOTICALLY CONSTANT CROSS SECTIONS

	ε' = 2 MeV	ε' = 6 MeV	ε' = 10 MeV	ε' = 14 MeV	ε' = 18 MeV	ε' = 22 MeV	ε' = 26 MeV
ε = 2 MeV	0.78	0.22	0.00	0.00	0.00	0.00	0.00
ε = 4 MeV	0.38	0.46	0.15	0.01	0.00	0.00	0.00
ε = 6 MeV	0.21	0.38	0.25	0.12	0.04	0.00	0.00
ε = 8 MeV	0.14	0.29	0.30	0.16	0.08	0.03	0.00
ε = 10 MeV	0.10	0.21	0.29	0.20	0.11	0.06	0.03
ε = 12 MeV	0.08	0.17	0.24	0.23	0.14	0.08	0.06
ε = 14 MeV	0.07	0.14	0.20	0.24	0.18	0.11	0.06

A number of anticipated features emerge from Tables IIa-Vj. The rate coefficients γ are increasing functions of both target mass and temperature, though fluctuations in cross sections produce small variations. Rate coefficients for asymptotically constant cross sections exceed those for asymptotically decaying cross sections, with the largest differences occurring at higher temperatures and lighter target nuclei. The maximum difference occurs in the neutron-neutron rate coefficient at $E_o = kT = 14$ MeV and $\varepsilon = 14$ MeV (26%). The greatest percentages of neutron scatter into the 20-28 MeV region occur for the lighter target nuclei at highest temperatures and incident neutron energy. The scattering rate distributions, $\gamma^{-1} d\gamma/d\varepsilon'$ are typically peaked at final neutron energies about equal to the incident neutron energies, that is, the zero energy transfer region. Increasing target temperatures (and thus translational energies) tend to flatten, but spread the final neutron energy spectrum. The greatest percentage scatter into the 20- to 28-MeV region occurs for neutron-neutron scattering at $E_o = kT = 14$ MeV and $\varepsilon = 14$ MeV (about 30%). Lighter targets are more effective in scattering neutrons into the higher energy regions because larger energy transfers can be effected within energy-momentum constraints.

It is hoped that the foregoing analysis gives some comparative estimates of neutron scattering rates and distributions for spherically translating Maxwellian target assemblies. Reaction rates for use in transport calculations can be obtained by multiplying γ and $d\gamma/d\varepsilon'$ by the neutron and target particle densities, as indicated in Eq. (9).

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