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ENDF/B Neutron Cross-section Data for Natural Helium (ENDF-125)

by

E. M. Pennington

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for Natural Helium
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E. M. Pennington

Reactor Physics Division

October 1968

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ENDF/B Neutron Cross-section Data for Natural Helium (ENDF-125)

by

E. M. Pennington

ABSTRACT

This report describes the compilation of neutron cross-section data for natural helium. The elastic scattering cross section, $\bar{\mu}_L$, ξ , γ , and elastic scattering Legendre coefficients are included for ^4He . Since ^3He has a natural abundance of merely 0.00013%, only its (n,p) cross section, which is large at low energies, is considered. A listing of the data in the ENDF/B format is presented, as are graphs of much of the data.

I. INTRODUCTION

Since natural helium is a possible coolant for fast breeder reactors, the present helium cross-section data were compiled. The data will be distributed with ENDF/B identification number MAT = 1088.

The composition of natural helium is 99.99987% ^4He and 0.00013% ^3He . Because of the low abundance of ^3He , only its (n,p) cross section, which is large at low energies, need be considered. Elastic scattering is the only possible reaction for neutrons incident on ^4He at energies below 15 MeV. Thus the elastic scattering cross section and values of $\bar{\mu}_L$, ξ , and γ are included in the compilation, as well as elastic scattering Legendre coefficients. Here $\bar{\mu}_L$ is the average cosine of the angle of elastic scattering in the laboratory system, ξ is the average logarithmic energy decrement in an elastic collision, and γ , the Greuling-Goertzel parameter, is the average of the square of the logarithmic energy decrement divided by twice the average logarithmic energy decrement. Parameters for a free-gas thermal scattering law are also included.

II. DATA SOURCES AND CALCULATIONAL METHODS

The elastic scattering cross section and Legendre expansion coefficients were calculated from s-, p-, and d-wave phase shifts using a FORTRAN program written for the purpose. Appendix A presents the equations involved in this program. The phase shifts were read from smooth

curves based on Table I of Ref. 1. At energies below the 300-keV lower limit of this table, each of the two p-wave phase shifts was obtained by using a functional form based on the low-energy limit for a single p-wave resonance, with parameters determined from fitting the low-energy phase shifts of the table. Appendix B presents the equations connected with the low-energy phase shifts, and the parameters obtained by the fitting procedure. The s-wave phase shift below 300 keV was calculated using hard-sphere scattering and a nuclear radius of $a = 2.4$ F. This yields a thermal scattering cross section of $4\pi a^2 = 0.7238$ barn, in agreement with the experimental value² of 0.73 ± 0.05 barn. The low-energy s-wave phase shifts of Ref. 1 are consistent with a nuclear radius of about 2.48 F and so would yield a somewhat high thermal cross section.

Table I lists the phase shifts used in the calculations at energies above 10 keV.

TABLE I. Helium Phase Shifts Used in Calculations of Elastic Scattering Cross Sections and Legendre Expansion Coefficients

$E_{\text{lab}}, \text{ MeV}$	δ_0^+	δ_1^+	δ_1^-	δ_2^+	δ_2^-	$E_{\text{lab}}, \text{ MeV}$	δ_0^+	δ_1^+	δ_1^-	δ_2^+	δ_2^-
0.02	3.08203	0.00092	0.00022			2.9	2.4155	2.1660	0.4782	0.0030	0.0021
0.03	3.06865	0.00171	0.00040			3.0	2.4051	2.1677	0.5009	0.0031	0.0023
0.05	3.04742	0.00373	0.00086			3.2	2.3806	2.1712	0.5428	0.0037	0.0026
0.07	3.03017	0.00629	0.00143			3.4	2.3579	2.1729	0.5847	0.0042	0.0031
0.10	3.00842	0.0110	0.00246			3.6	2.3370	2.1694	0.6248	0.0049	0.0035
0.15	2.97849	0.0212	0.00457			3.8	2.3178	2.1625	0.6667	0.0054	0.0038
0.20	2.95326	0.0343	0.00711			4.0	2.2986	2.1537	0.7086	0.0061	0.0044
0.25	2.93103	0.0504	0.0100			4.2	2.2794	2.1468	0.7435	0.0070	0.0049
0.30	2.9025	0.0698	0.0133			4.4	2.2602	2.1398	0.7767	0.0077	0.0054
0.35	2.8833	0.0930	0.0170			4.6	2.2427	2.1328	0.8081	0.0084	0.0059
0.40	2.8658	0.1204	0.0209			4.8	2.2253	2.1258	0.8360	0.0093	0.0065
0.45	2.8466	0.1536	0.0252			5.0	2.2078	2.1171	0.8622	0.0101	0.0070
0.50	2.8292	0.1920	0.0299			5.2	2.1904	2.1084	0.8849	0.0110	0.0075
0.55	2.8152	0.2356	0.0348			5.4	2.1747	2.0996	0.9058	0.0120	0.0082
0.60	2.8047	0.2845	0.0401			5.6	2.1590	2.0892	0.9250	0.0131	0.0087
0.65	2.7908	0.3421	0.0454			5.8	2.1450	2.0804	0.9442	0.0141	0.0094
0.70	2.7786	0.4067	0.0524			6.0	2.1293	2.0717	0.9617	0.0152	0.0103
0.75	2.7646	0.4800	0.0576			6.2	2.1153	2.0630	0.9774	0.0162	0.0108
0.80	2.7524	0.5725	0.0646			6.4	2.1014	2.0543	0.9896	0.0175	0.0115
0.85	2.7402	0.6615	0.0698			6.6	2.0857	2.0438	1.0001	0.0185	0.0124
0.90	2.7297	0.7662	0.0768			6.8	2.0717	2.0351	1.0105	0.0197	0.0133
0.95	2.7175	0.8779	0.0838			7.0	2.0577	2.0263	1.0210	0.0209	0.0140
1.00	2.7070	0.9983	0.0908			7.2	2.0455	2.0176	1.0280	0.0222	0.0145
1.05	2.6965	1.1170	0.0977			7.4	2.0316	2.0089	1.0350	0.0236	0.0152
1.10	2.6861	1.2235	0.1065			7.6	2.0193	2.0001	1.0420	0.0248	0.0159
1.13	2.6791	1.2881	0.1100			7.8	2.0054	1.9914	1.0472	0.0262	0.0166
1.15	2.6756	1.3299	0.1134			8.0	1.9932	1.9827	1.0507	0.0279	0.0175
1.17	2.6721	1.3701	0.1169			8.2	1.9809	1.9740	1.0559	0.0297	0.0183
1.20	2.6669	1.4312	0.1222			8.4	1.9705	1.9652	1.0594	0.0314	0.0190
1.25	2.6564	1.5202	0.1292			8.6	1.9583	1.9565	1.0612	0.0332	0.0197
1.30	2.6477	1.5970	0.1379			8.8	1.9478	1.9478	1.0629	0.0349	0.0206
1.35	2.6389	1.6668	0.1466			9.0	1.9356	1.9391	1.0647	0.0367	0.0215
1.40	2.6302	1.7296	0.1553			9.2	1.9234	1.9321	1.0647	0.0384	0.0223
1.45	2.6215	1.7802	0.1641			9.4	1.9129	1.9234	1.0647	0.0401	0.0234
1.5	2.6128	1.8239	0.1745			9.6	1.9007	1.9146	1.0647	0.0419	0.0243
1.6	2.5953	1.9059	0.1937			9.8	1.8902	1.9059	1.0629	0.0436	0.0253
1.7	2.5796	1.9652	0.2129			10.0	1.8780	1.8972	1.0629	0.0454	0.0262
1.8	2.5639	2.0106	0.2321			10.5	1.8535	1.8780	1.0612	0.0506	0.0288
1.9	2.5482	2.0438	0.2531			11.0	1.8291	1.8570	1.0577	0.0541	0.0314
2.0	2.5342	2.0752	0.2758	0.0012	0.0009	11.5	1.8047	1.8378	1.0507	0.0593	0.0340
2.1	2.5203	2.0961	0.2967	0.0012	0.0009	12.0	1.7802	1.8169	1.0402	0.0646	0.0367
2.2	2.5063	2.1153	0.3194	0.0014	0.0010	12.5	1.7593	1.7994	1.0297	0.0698	0.0384
2.3	2.4923	2.1293	0.3403	0.0016	0.0012	13.0	1.7383	1.7820	1.0193	0.0750	0.0419
2.4	2.4784	2.1398	0.3630	0.0017	0.0012	13.5	1.7174	1.7628	1.0071	0.0803	0.0436
2.5	2.4644	2.1468	0.3857	0.0019	0.0014	14.0	1.6965	1.7453	0.9966	0.0855	0.0454
2.6	2.4522	2.1537	0.4084	0.0021	0.0016	14.5	1.6755	1.7279	0.9861	0.0908	0.0471
2.7	2.4400	2.1590	0.4328	0.0024	0.0017	15.0	1.6546	1.7104	0.9756	0.0960	0.0489
2.8	2.4278	2.1642	0.4555	0.0026	0.0019						

Values of $\bar{\mu}_L$, ξ , and γ were calculated from the Legendre coefficients using a FORTRAN program, MUXIGA. This program is based on the equations derived in Refs. 3-5. These equations are summarized in Appendix C.

An elastic scattering Legendre-coefficient transformation matrix from the center-of-mass system to the laboratory system was computed using CHAD.⁶ A minor revision was made in the CHAD code to avoid elements of the matrix being set equal to zero if they were larger than elements closer to the diagonal.

The (n,p) cross section for ^3He is that recommended in the ^3He evaluation by J. Als-Nielsen.⁷ Extension from 10 to 15 MeV was made using linear extrapolation on a $\log \sigma$ versus $\log E$ scale.

The total cross section is the sum of the elastic scattering and (n,p) cross sections.

The free-gas thermal scattering law involves a value of 0.7238 barn for the free-atom scattering cross section.

III. GRAPHS AND LISTING

Figures 1-8 are graphs of the ENDF/B File 3 data.⁸ The File 3 data are represented by a series of pairs of x and y values with an interpolation rule applying between successive pairs. The interpolation rule might specify, for example, that $\log y$ is linear in $\log x$ between successive (x,y) pairs. In Figs. 1-8 the axis types have been chosen to correspond to the interpolation rule. Thus in Figs. 1 and 2 a linear axis is used for the total cross section and a logarithmic axis is used for the energy, because linear y versus $\log x$ interpolation is specified for this cross section. The total cross section

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Fig. 1. Helium Total Cross Section,
10⁻⁵ eV to 1 keV

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Fig. 2. Helium Total Cross Section,
1 keV to 15 MeV

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Fig. 3. Helium Elastic Scattering Cross Section

113-686

Fig. 4. Helium (n,p) Cross Section, 10^{-5} eV to 1 keV

113-685

Fig. 5. Helium (n,p) Cross Section, 1 keV to 15 MeV

113-696

Fig. 6. Helium Average Elastic Scattering Cosine, $\bar{\mu}_L$

113-698

Fig. 7. Helium Average Logarithmic Energy Decrement, ξ

113-680

Fig. 8. Helium Greuling-Goertzel Parameter, γ

and the (n,p) cross section have been plotted in two energy ranges in Figs. 1 and 2 and Figs 4 and 5, respectively, in order to display the data better. The data in Figs. 3, 6, 7, and 8 for the elastic scattering cross section, $\bar{\mu}_L$, ξ , and γ are not plotted below 1 keV because the values are almost constant at low energies. Not all data points are plotted, especially at high energies, to avoid clutter on the graphs.

Figures 9-12 display the Legendre coefficients for elastic scattering angular distributions in the center-of-mass system, f_1 through f_4 . The elastic scattering angular distribution, $d\sigma(E)/d\Omega$, is given by⁸

$$\frac{d\sigma(E)}{d\Omega} = \frac{\sigma_s(E)}{4\pi} \sum_{\ell=0} (2\ell+1) f_{\ell}(E) P_{\ell}(\mu), \quad (1)$$

where the elastic scattering cross section $\sigma_s(E)$ is tabulated in ENDF/B File 3, and the expansion coefficients $f_{\ell}(E)$ are presented at a series of

113-694

Fig. 9. Helium Elastic Scattering
Legendre Coefficient f_1

113-688

Fig. 10. Helium Elastic Scattering
Legendre Coefficient f_2

113-702

Fig. 11. Helium Elastic Scattering
Legendre Coefficient f_3

113-674

Fig. 12. Helium Elastic Scattering
Legendre Coefficient f_4

energies in File 4. In Figs. 13-31 the angular distributions have been calculated from Eq. 1 at a representative sequence of 19 energies. Note that the angular distributions at the energies shown below 1.2 MeV are peaked in the backward direction, as is typical on the low-energy side of a p-wave resonance. All graphs were drawn with the aid of the CDC-3600 computer and the Calcomp 580 plotter.

The helium data in the ENDF/B format are listed in Appendix D. The listing will not be explained here since all information necessary for understanding the formats involved is in Ref. 8.

113-701

Fig. 13

113-678

Fig. 14

113-700

Fig. 15

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Fig. 16

113-703

Fig. 17

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Fig. 18

Figs. 13-18. Helium Elastic Scattering Angular Distributions

113-677

Fig. 19

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Fig. 20

113-699

Fig. 21

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Fig. 22

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Fig. 23

113-692

Fig. 24

Figs. 19-24. Helium Elastic Scattering Angular Distributions

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Fig. 25

113-675

Fig. 26

113-690

Fig. 27

113-679

Fig. 28

113-687

Fig. 29

113-704

Fig. 30

113-689

Fig. 31

Figs. 25-31

Helium Elastic Scattering Angular Distributions

IV. DISCUSSION

The phase shifts of Ref. 1, which were used in the compilation, are optical-model phase shifts chosen to fit both angular-distribution and polarization data at many energies. The total cross section is also fit within the scatter of the experimental points. Because Ref. 1 is recent and considers the experimental data comprehensively, the data calculated from the phase shifts should be reliable. Another recent set of phase shifts⁹ is not very different from that of Ref. 1 and could also have been used in the present work.

As discussed in Ref. 7, the ^3He (n,p) cross section is rather well known. Probably more error is introduced into the (n,p) cross section for natural helium by the uncertainty in the ^3He isotopic abundance than by the uncertainty in the ^3He (n,p) cross section itself.

Previous evaluations of natural helium for reactor calculations include those of Schmidt¹⁰ and of Buckingham *et al.*^{11,12} Schmidt's evaluation includes the (n,p) cross section for ^3He and σ_s , $\bar{\mu}_L$, and a set of phase shifts for ^4He . Buckingham *et al.* present separate compilations for ^3He and ^4He . For ^3He , elastic, (n,p), (n,d), and (n,2n) cross sections are given, as well as elastic angular distributions. The ^4He evaluation consists of σ_s and angular distributions.

The (n,p) cross section of ^3He , which was based on Ref. 7, is not very different from those of previous evaluations,^{10,12} as may be seen from Table 3 of Ref. 7.

The values of the elastic scattering cross section are in fairly good agreement with those in the other evaluations.^{10,11} Schmidt's values¹⁰ agree with those of the present evaluation at energies below the main resonance and are generally a little larger at higher energies, except for a range on the high-energy side of the main resonance. The English values¹¹ are higher than the present values at energies below about 1 MeV and lower at higher energies.

The present values of $\bar{\mu}_L$ are in rather good agreement with those shown on Fig. He-3 in Part I of KFK-120¹⁰ at energies above approximately 1 MeV, but do not agree well at lower energies.

APPENDIX A

Equations Relating the Elastic Scattering Cross Section and Legendre Expansion Coefficients to the s-, p-, and d-wave Phase Shifts

The elastic scattering angular distribution, $d\sigma/d\Omega$, in the center-of-mass system is given by¹³

$$\frac{d\sigma}{d\Omega} = \frac{1}{4k^2} (|a|^2 + |b|^2) = \sum_n C_n P_n(\mu), \quad (\text{A.1})$$

where

$$a = \sum_{\ell=0}^{\infty} \left[(\ell+1)(e^{2i\delta_{\ell}^+} - 1) + \ell(e^{2i\delta_{\ell}^-} - 1) \right] P_{\ell}(\mu), \quad (\text{A.2})$$

and

$$b = \sum_{\ell=0}^{\infty} \left(e^{2i\delta_{\ell}^+} - e^{2i\delta_{\ell}^-} \right) P_{\ell}^1(\mu). \quad (\text{A.3})$$

Here μ is the cosine of the center-of-mass scattering angle, $P_{\ell}(\mu)$ is the Legendre polynomial of order ℓ , and

$$P_{\ell}^1(\mu) = (1 - \mu^2)^{1/2} \frac{d}{d\mu} P_{\ell}(\mu).$$

The quantity $k = \sqrt{2mE/\hbar^2}$, where E is the energy of relative motion of neutron and nucleus in the center-of-mass system, and m is the reduced mass. The phase shifts δ_{ℓ}^+ and δ_{ℓ}^- refer to $j = \ell + 1/2$ and $j = \ell - 1/2$, respectively, where j is the angular momentum quantum number referring to the addition of the orbital and spin angular momenta.

On restricting the sums in Eqs. A.2 and A.3 by considering only s-, p-, and d-wave phase shifts, and using the explicit forms for the Legendre polynomials, we obtain

$$k^2 C_0 = \sin^2 \delta_0^+ + 2 \sin^2 \delta_1^+ + \sin^2 \delta_1^- + 3 \sin^2 \delta_2^+ + 2 \sin^2 \delta_2^-, \quad (\text{A.4})$$

$$\begin{aligned} k^2 C_1 = & 3 \sin^2 \delta_0^+ + 6 \sin^2 \delta_1^+ + 3 \sin^2 \delta_1^- + \frac{18}{5} \sin^2 \delta_2^+ + \frac{12}{5} \sin^2 \delta_2^- \\ & - 2 \sin^2 (\delta_0^+ - \delta_1^+) - \sin^2 (\delta_0^+ - \delta_1^-) - \frac{18}{5} \sin^2 (\delta_1^+ - \delta_2^+) \\ & - 2 \sin^2 (\delta_1^- - \delta_2^-) - \frac{2}{5} \sin^2 (\delta_1^+ - \delta_2^-), \end{aligned} \quad (\text{A.5})$$

$$\begin{aligned}
k^2 C_2 = & 5 \sin^2 \delta_0^+ + 4 \sin^2 \delta_1^+ + 2 \sin^2 \delta_1^- + \frac{51}{7} \sin^2 \delta_2^+ + \frac{34}{7} \sin^2 \delta_2^- \\
& - 2 \sin^2 (\delta_1^+ - \delta_1^-) - \frac{6}{7} \sin^2 (\delta_2^+ - \delta_2^-) - 3 \sin^2 (\delta_0^+ - \delta_2^+) \\
& - 2 \sin^2 (\delta_0^+ - \delta_2^-), \quad (A.6)
\end{aligned}$$

$$\begin{aligned}
k^2 C_3 = & 6 \sin^2 \delta_1^+ + 3 \sin^2 \delta_1^- + \frac{27}{5} \sin^2 \delta_2^+ + \frac{18}{5} \sin^2 \delta_2^- \\
& - \frac{12}{5} \sin^2 (\delta_1^+ - \delta_2^+) - \frac{18}{5} \sin^2 (\delta_1^+ - \delta_2^-) - 3 \sin^2 (\delta_1^- - \delta_2^+), \quad (A.7)
\end{aligned}$$

and

$$k^2 C_4 = \frac{54}{7} \sin^2 \delta_2^+ + \frac{36}{7} \sin^2 \delta_2^- - \frac{36}{7} \sin^2 (\delta_2^+ - \delta_2^-). \quad (A.8)$$

Equation 1 gives the angular distribution in the ENDF/B normalization. Thus the elastic scattering cross section is $\sigma_s = 4\pi C_0$, and the Legendre coefficients are given by

$$f_\ell = \frac{C_\ell}{(2\ell+1) C_0}.$$

APPENDIX B

Low-energy Phase Shifts from Resonance Parameters

The phase shift, $\delta_{\ell J}$, near an isolated purely scattering resonance with orbital angular momentum ℓ and total angular momentum J is¹⁴

$$\delta_{\ell J} = \tan^{-1} \left(\frac{R_{\ell J} P_{\ell}}{1 - R_{\ell J} \hat{S}_{\ell}} \right) - \phi_{\ell}, \quad (\text{B.1})$$

where

$$\phi_{\ell} = \tan^{-1} \left(\frac{F_{\ell}}{G_{\ell}} \right) \quad (\text{B.2})$$

with

$$F_{\ell} = \rho j_{\ell}(\rho) \quad (\text{B.3})$$

and

$$G_{\ell} = -\rho n_{\ell}(\rho). \quad (\text{B.4})$$

The functions $j_{\ell}(\rho)$ and $n_{\ell}(\rho)$ are spherical Bessel functions.¹⁵ The quantity ρ is defined by

$$\rho = ka = a \sqrt{2mE/\hbar^2} = a \sqrt{\frac{2m}{\hbar^2} \frac{A}{A+1} E_{\text{lab}}} = C \sqrt{E_{\text{lab}}},$$

where E is the energy of the relative motion of neutron and target in the center-of-mass system, E_{lab} is the neutron energy in the laboratory system, $m = m_n A/(1+A)$, with A being the ratio of the target mass to the neutron mass, m_n , and a is the nuclear radius. The penetration and shift factors are

$$P_{\ell} = \frac{\rho}{F_{\ell}^2 + G_{\ell}^2} \quad (\text{B.5})$$

and

$$S_{\ell} = \frac{\rho(F_{\ell}' F_{\ell}' + G_{\ell}' G_{\ell}')}{F_{\ell}^2 + G_{\ell}^2} \quad (\text{B.6})$$

where the prime signifies differentiation with respect to ρ . The $\hat{S}_{\ell}$ in Eq. B.1 is related to S_{ℓ} by $\hat{S}_{\ell} = S_{\ell} - B_{\ell J}$, where $B_{\ell J}$ is a boundary-condition constant.¹⁴ The function $R_{\ell J}$ is

$$R_{\ell J} = \frac{\gamma_{\lambda \ell J}^2}{E_{\lambda \ell J} - E}, \quad (\text{B.7})$$

where $\gamma_{\lambda \ell J}^2$ is the reduced width of the resonance, and $E_{\lambda \ell J}$ is the associated energy eigenvalue.

For $\ell = 1$, the explicit forms of F_ℓ and G_ℓ are

$$F_1 = \frac{\sin \rho - \rho \cos \rho}{\rho} \quad (\text{B.8})$$

and

$$G_1 = \frac{\cos \rho + \rho \sin \rho}{\rho}. \quad (\text{B.9})$$

Using Eqs. B.5-B.9 in conjunction with Eq. B.1 and the boundary condition $B_{\ell J} = 0$ results in

$$\delta_{1J} + \phi_1 = \tan^{-1} \left(\frac{\alpha \rho^3}{1 + \beta \rho^2 + (\alpha + \beta - 1) \rho^4} \right) \approx \frac{\alpha \rho^3}{1 + \beta \rho^2 + (\alpha + \beta - 1) \rho^4}, \quad (\text{B.10})$$

where

$$\alpha = \frac{\gamma_{\lambda 1J}^2}{E_{\lambda 1J} + \gamma_{\lambda 1J}^2} \quad (\text{B.11})$$

and

$$\beta = \frac{E_{\lambda 1J} - \frac{A}{A+1} \frac{1}{C^2}}{E_{\lambda 1J} + \gamma_{\lambda 1J}^2} \quad (\text{B.12})$$

The parameters α and β were determined by fitting the low-energy p-wave phase shifts of Table I of Ref. 1 using Eq. B.10 and $a = 3.0 \times 10^{-13}$ cm. The phase shifts at 0.3 and

TABLE II. Low-energy Parameters for p-wave Phase Shifts

J	α	β
3/2	2.528	-2.534
1/2	0.857	-0.204

0.4 MeV were fit for $J = 3/2$; those at 0.4 and 0.6 MeV were fit for $J = 1/2$. This procedure gives two linear equations in α and β for both $J = 3/2$ and $J = 1/2$. Table II presents the solutions of the equations.

APPENDIX C

Equations for Calculation of $\bar{\mu}_L$, ξ , and γ

Equation 1 gives the angular distribution in the center-of-mass system for elastic scattering. The equations for $\bar{\mu}_L$, ξ , and γ , in terms of the f_ℓ expansion coefficients, derived in Refs. 3-5 and used in FORTRAN program MUXIGA, are given below.

The average cosine of the angle of elastic scattering in the laboratory system is

$$\bar{\mu}_L = \sum_{\ell=0}^{\infty} T_{1\ell} f_\ell, \quad (C.1)$$

where

$$T_{1\ell} = \frac{\ell}{2\ell-1} \left(\frac{-1}{A}\right)^{\ell-1} - \frac{\ell+2}{2\ell+3} \left(\frac{-1}{A}\right)^{\ell+1}, \quad (C.2)$$

A being the ratio of the mass of the scatterer to the neutron mass.

The average logarithmic energy decrement in elastic scattering is

$$\xi = \sum_{\ell=0}^{\infty} \sum_{p=\ell+\delta_{\ell 0}}^{\infty} (1-\alpha)^p A_{p\ell} f_\ell, \quad (C.3)$$

where

$$A_{p\ell} = \frac{(-1)^\ell (2\ell+1) p! p!}{p(p-\ell)! (p+\ell+1)!} \quad (C.4)$$

and

$$\alpha = \left(\frac{A-1}{A+1}\right)^2.$$

The Greuling-Goertzel parameter, γ , is given by

$$2\xi\gamma = \sum_{\ell=0}^{\infty} \sum_{p=\ell+\delta_{\ell 1}+\frac{1}{2}\delta_{\ell 0}}^{\infty} (1-\alpha)^p A_{p\ell} C_{p\ell} f_\ell, \quad (C.5)$$

where

$$C_p = 2 \sum_{q=1}^{p-1} \frac{1}{q}. \quad (C.6)$$

The $\delta_{\ell 0}$ and $\delta_{\ell 1}$ in Eqs. C.3 and C.5 are Kronecker δ symbols; that is, $\delta_{\ell \ell'} = 0$ for $\ell \neq \ell'$ and $\delta_{\ell \ell'} = 1$ for $\ell = \ell'$.

APPENDIX D
 ENDF/B Listing of Helium

2000.0	3.96822	0	0	0	01088 1451	1
0.0	0.0	0	0	74	01088 1451	2
HELIUM CROSS SECTIONS MATERIAL 1088						3
COMPILED BY ED PENNINGTON, ARGONNE NATIONAL LAB., IN JUNE 1968.						4
NATURAL HELIUM CONSISTS OF 0.00013 PER CENT HE-3 AND 99.99987 PER						5
CENT HE-4.						6
BECAUSE OF THE LOW ABUNDANCE OF HE-3, ONLY ITS (N,P) CROSS						7
SECTION, WHICH IS VERY LARGE AT LOW ENERGIES, NEED BE CONSIDERED.						8
ELASTIC SCATTERING IS THE ONLY POSSIBLE REACTION FOR NEUTRONS						9
INCIDENT ON HE-4 AT ENERGIES BELOW 15 MEV. THUS THE ELASTIC						10
SCATTERING CROSS SECTION AND VALUES OF MU BAR(LAB), XI, AND GAMMA						11
ARE GIVEN IN FILE 3, AND ELASTIC SCATTERING LEGENDRE COEFFICIENTS						12
ARE GIVEN IN FILE 4. PARAMETERS FOR A FREE GAS THERMAL SCATTERING						13
LAW ARE IN FILE 7.						14
THE ELASTIC SCATTERING CROSS SECTION AND THE LEGENDRE EXPANSION						15
COEFFICIENTS WERE CALCULATED FROM S-, P-, AND D-WAVE PHASE SHIFTS						16
USING A FORTRAN PROGRAM WRITTEN FOR THE PURPOSE, THE PHASE SHIFTS						17
WERE READ FROM SMOOTH CURVES BASED ON TABLE I OF REF.1, AT						18
ENERGIES BELOW THE 300 KEV, LOWER LIMIT OF TABLE I, EACH OF THE						19
TWO P-WAVE PHASE SHIFTS WAS OBTAINED BY ASSUMING A FUNCTIONAL						20
FORM BASED ON THE LOW ENERGY LIMIT FOR A SINGLE P-WAVE RESONANCE,						21
WITH PARAMETERS DETERMINED FROM FITTING THE LOW ENERGY PHASE						22
SHIFTS OF TABLE I, THE S-WAVE PHASE SHIFT BELOW 300 KEV, WAS						23
CALCULATED USING HARD SPHERE SCATTERING AND A NUCLEAR RADIUS, A =						24
2.4 FERMI, THIS YIELDS THE THERMAL SCATTERING CROSS SECTION =						25
4. *PI * A ** 2 = 0.7238 BARNS IN AGREEMENT WITH THE EXPERIMENTAL VALUE						26
OF 0.73 +- 0.05 BARNS (REF.2). THE LOW ENERGY S-WAVE PHASE SHIFTS						27
OF REF.1 ARE CONSISTENT WITH A NUCLEAR RADIUS OF ABOUT 2.48						28
FERMI, AND SO WOULD YIELD A SOMEWHAT HIGH THERMAL CROSS SECTION.						29
VALUES OF MU BAR(LAB), XI, AND GAMMA WERE CALCULATED FROM THE						30
LEGENDRE COEFFICIENTS USING A FORTRAN PROGRAM, MUXIGA, THIS						31
PROGRAM USES THE EQUATIONS OF REF.3-5.						32
AN ELASTIC SCATTERING TRANSFORMATION MATRIX FROM THE CENTER-OF-						33
MASS TO THE LABORATORY SYSTEM WAS COMPUTED USING CHAD (REF.6),						34
THE (N,P) CROSS SECTION FOR HE-3 IS THAT RECOMMENDED IN THE						35
EVALUATION OF HE-3 BY J. ALS-NIELSEN GIVEN IN REF.7, EXTENSION						36
FROM 10 TO 15 MEV. WAS MADE USING LINEAR EXTRAPOLATION ON A						37
LOG SIGMA- LOG E SCALE.						38
THE TOTAL CROSS SECTION IS THE SUM OF THE ELASTIC SCATTERING AND						39
(N,P) CROSS SECTIONS.						40
COMMENTS.						41
THE PHASE SHIFTS OF REF.1 ARE OPTICAL MODEL PHASE SHIFTS CHOSEN						42
TO FIT BOTH ANGULAR DISTRIBUTION AND POLARIZATION DATA AT MANY						43
ENERGIES. THE TOTAL SCATTERING CROSS SECTION IS ALSO FIT WITHIN						44
THE SCATTER OF THE EXPERIMENTAL POINTS. ANOTHER RECENT SET OF						45
PHASE SHIFTS (REF.8) IS NOT VERY DIFFERENT FROM THOSE USED HERE,						46
AND COULD ALSO HAVE BEEN USED IN THE PRESENT WORK, THERE SHOULD						47
BE NO SERIOUS DISAGREEMENTS WITH EXPERIMENTAL VALUES IN THE HE-4						48
DATA CALCULATED FROM THE PHASE SHIFTS.						49
AS DISCUSSED IN REF.7, THE HE-3 (N,P) CROSS SECTION IS RATHER						50
WELL KNOWN. PROBABLY MORE ERROR IS INTRODUCED INTO THE (N,P)						51
CROSS SECTION FOR NATURAL HELIUM BY THE UNCERTAINTY IN THE HE-3						52
ISOTOPIC ABUNDANCE THAN BY THE UNCERTAINTY IN THE HE-3 (N,P)						53
CROSS SECTION ITSELF.						54
PREVIOUS EVALUATIONS OF HELIUM FOR REACTOR CALCULATIONS INCLUDE						55
THOSE OF J.J.SCHMIDT (REF.9) AND B.R.S.BUCKINGHAM ET AL (REF.10).						56
SCHMIDT-S EVALUATION INCLUDES THE (N,P) CROSS SECTION FOR HE-3,						57
AND SIGMA ELASTIC, MU BAR(LAB), AND A SET OF PHASE SHIFTS FOR						58
HE-4. BUCKINGHAM ET AL GIVE SEPARATE EVALUATIONS FOR HE-3 AND						59
HE-4, FOR HE-3 ELASTIC, (N,P), (N,D), AND (N,2N) CROSS SECTIONS						60
ARE GIVEN, AS WELL AS ELASTIC ANGULAR DISTRIBUTIONS. THE HE-4						61
EVALUATION GIVES THE ELASTIC CROSS SECTION AND ANGULAR						62

DISTRIBUTIONS.						1088	1451	63.
THE PRESENT COMPILATION WILL BE DESCRIBED IN DETAIL IN REF.11.						1088	1451	64
REFERENCES-						1088	1451	65
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0.0	0.0	0	0	0	0	01088	1	0 77
0.0	0.0	0	0	0	0	01088	0	0 78
2000.0	3,96822	0	0	0	0	01088	3	1 79
0.0	0.0	0	0	1	1	1421088	3	1 80
142	3					1088	3	1 81
1.00E-05	1.0721E+00	2.00E-05	0.9701E+00	3.00E-05	0.9249E+00	1088	3	1 82
5.00E-05	0.8796E+00	7.00E-05	0.8555E+00	1.00E-04	0.8339E+00	1088	3	1 83
2.00E-04	0.8017E+00	3.00E-04	0.7874E+00	5.00E-04	0.7731E+00	1088	3	1 84
7.00E-04	0.7654E+00	1.00E-03	0.7586E+00	2.00E-03	0.7484E+00	1088	3	1 85
3.00E-03	0.7439E+00	5.00E-03	0.7394E+00	7.00E-03	0.7370E+00	1088	3	1 86
1.00E-02	0.7348E+00	2.00E-02	0.7316E+00	2.53E-02	0.7307E+00	1088	3	1 87
3.00E-02	0.7302E+00	5.00E-02	0.7287E+00	7.00E-02	0.7280E+00	1088	3	1 88
1.00E-01	0.7273E+00	2.00E-01	0.7263E+00	3.00E-01	0.7258E+00	1088	3	1 89
5.00E-01	0.7254E+00	7.00E-01	0.7251E+00	1.00E+00	0.7249E+00	1088	3	1 90
2.00E+00	0.7246E+00	3.00E+00	0.7244E+00	5.00E+00	0.7243E+00	1088	3	1 91
7.00E+00	0.7242E+00	1.00E+01	0.7241E+00	2.00E+01	0.7240E+00	1088	3	1 92
3.00E+01	0.7240E+00	5.00E+01	0.7240E+00	7.00E+01	0.7239E+00	1088	3	1 93
1.00E+02	0.7239E+00	2.00E+02	0.7239E+00	3.00E+02	0.7239E+00	1088	3	1 94
5.00E+02	0.7238E+00	7.00E+02	0.7238E+00	1.00E+03	0.7238E+00	1088	3	1 95
2.00E+03	0.7237E+00	3.00E+03	0.7237E+00	5.00E+03	0.7236E+00	1088	3	1 96
7.00E+03	0.7236E+00	1.00E+04	0.7235E+00	2.00E+04	0.7235E+00	1088	3	1 97
3.00E+04	0.7234E+00	5.00E+04	0.7241E+00	7.00E+04	0.7256E+00	1088	3	1 98
1.00E+05	0.7297E+00	1.50E+05	0.7425E+00	2.00E+05	0.7644E+00	1088	3	1 99
2.50E+05	0.7977E+00	3.00E+05	0.8978E+00	3.50E+05	0.9654E+00	1088	3	1 100
4.00E+05	0.1056E+01	4.50E+05	0.1197E+01	5.00E+05	0.1373E+01	1088	3	1 101
5.50E+05	0.1581E+01	6.00E+05	0.1826E+01	6.50E+05	0.2168E+01	1088	3	1 102
7.00E+05	0.2576E+01	7.50E+05	0.3076E+01	8.00E+05	0.3750E+01	1088	3	1 103
8.50E+05	0.4380E+01	9.00E+05	0.5114E+01	9.50E+05	0.5844E+01	1088	3	1 104
1.00E+06	0.6525E+01	1.05E+06	0.7038E+01	1.10E+06	0.7321E+01	1088	3	1 105
1.13E+06	0.7424E+01	1.15E+06	0.7456E+01	1.17E+06	0.7461E+01	1088	3	1 106
1.20E+06	0.7432E+01	1.25E+06	0.7278E+01	1.30E+06	0.7040E+01	1088	3	1 107
1.35E+06	0.6757E+01	1.40E+06	0.6453E+01	1.45E+06	0.6157E+01	1088	3	1 108
1.50E+06	0.5875E+01	1.60E+06	0.5333E+01	1.70E+06	0.4882E+01	1088	3	1 109
1.80E+06	0.4509E+01	1.90E+06	0.4211E+01	2.00E+06	0.3944E+01	1088	3	1 110
2.10E+06	0.3734E+01	2.20E+06	0.3551E+01	2.30E+06	0.3399E+01	1088	3	1 111
2.40E+06	0.3273E+01	2.50E+06	0.3169E+01	2.60E+06	0.3071E+01	1088	3	1 112
2.70E+06	0.2988E+01	2.80E+06	0.2911E+01	2.90E+06	0.2849E+01	1088	3	1 113
3.00E+06	0.2789E+01	3.20E+06	0.2684E+01	3.40E+06	0.2595E+01	1088	3	1 114
3.60E+06	0.2524E+01	3.80E+06	0.2469E+01	4.00E+06	0.2424E+01	1088	3	1 115
4.20E+06	0.2373E+01	4.40E+06	0.2325E+01	4.60E+06	0.2278E+01	1088	3	1 116
4.80E+06	0.2232E+01	5.00E+06	0.2190E+01	5.20E+06	0.2149E+01	1088	3	1 117
5.40E+06	0.2107E+01	5.60E+06	0.2070E+01	5.80E+06	0.2031E+01	1088	3	1 118
6.00E+06	0.1994E+01	6.20E+06	0.1957E+01	6.40E+06	0.1921E+01	1088	3	1 119
6.60E+06	0.1887E+01	6.80E+06	0.1853E+01	7.00E+06	0.1821E+01	1088	3	1 120
7.20E+06	0.1787E+01	7.40E+06	0.1756E+01	7.60E+06	0.1726E+01	1088	3	1 121
7.80E+06	0.1696E+01	8.00E+06	0.1667E+01	8.20E+06	0.1640E+01	1088	3	1 122
8.40E+06	0.1612E+01	8.60E+06	0.1585E+01	8.80E+06	0.1559E+01	1088	3	1 123
9.00E+06	0.1534E+01	9.20E+06	0.1509E+01	9.40E+06	0.1485E+01	1088	3	1 124

9.60E+06	0.1462E+01	9.80E+06	0.1439E+01	1.00E+07	0.1418E+011088	3	1	125
1.05E+07	0.1365E+01	1.10E+07	0.1315E+01	1.15E+07	0.1268E+011088	3	1	126
1.20E+07	0.1224E+01	1.25E+07	0.1180E+01	1.30E+07	0.1140E+011088	3	1	127
1.35E+07	0.1102E+01	1.40E+07	0.1066E+01	1.45E+07	0.1032E+011088	3	1	128
1.50E+07	0.9992E+00				1088	3	1	129
0.0	0.0	0	0	0	01088	3	0	130
2000.0	3.96822	0	0	0	01088	3	2	131
0.0	0.0	0	0	1	1421088	3	2	132
142	3				1088	3	2	133
1.00E-05	0.7238E+00	2.00E-05	0.7238E+00	3.00E-05	0.7238E+001088	3	2	134
5.00E-05	0.7238E+00	7.00E-05	0.7238E+00	1.00E-04	0.7238E+001088	3	2	135
2.00E-04	0.7238E+00	3.00E-04	0.7238E+00	5.00E-04	0.7238E+001088	3	2	136
7.00E-04	0.7238E+00	1.00E-03	0.7238E+00	2.00E-03	0.7238E+001088	3	2	137
3.00E-03	0.7238E+00	5.00E-03	0.7238E+00	7.00E-03	0.7238E+001088	3	2	138
1.00E-02	0.7238E+00	2.00E-02	0.7238E+00	2.53E-02	0.7238E+001088	3	2	139
3.00E-02	0.7238E+00	5.00E-02	0.7238E+00	7.00E-02	0.7238E+001088	3	2	140
1.00E-01	0.7238E+00	2.00E-01	0.7238E+00	3.00E-01	0.7238E+001088	3	2	141
5.00E-01	0.7238E+00	7.00E-01	0.7238E+00	1.00E+00	0.7238E+001088	3	2	142
2.00E+00	0.7238E+00	3.00E+00	0.7238E+00	5.00E+00	0.7238E+001088	3	2	143
7.00E+00	0.7238E+00	1.00E+01	0.7238E+00	2.00E+01	0.7238E+001088	3	2	144
3.00E+01	0.7238E+00	5.00E+01	0.7238E+00	7.00E+01	0.7238E+001088	3	2	145
1.00E+02	0.7238E+00	2.00E+02	0.7238E+00	3.00E+02	0.7238E+001088	3	2	146
5.00E+02	0.7238E+00	7.00E+02	0.7238E+00	1.00E+03	0.7238E+001088	3	2	147
2.00E+03	0.7237E+00	3.00E+03	0.7237E+00	5.00E+03	0.7236E+001088	3	2	148
7.00E+03	0.7236E+00	1.00E+04	0.7235E+00	2.00E+04	0.7235E+001088	3	2	149
3.00E+04	0.7234E+00	5.00E+04	0.7241E+00	7.00E+04	0.7256E+001088	3	2	150
1.00E+05	0.7297E+00	1.50E+05	0.7425E+00	2.00E+05	0.7644E+001088	3	2	151
2.50E+05	0.7977E+00	3.00E+05	0.8978E+00	3.50E+05	0.9654E+001088	3	2	152
4.00E+05	0.1056E+01	4.50E+05	0.1197E+01	5.00E+05	0.1373E+011088	3	2	153
5.50E+05	0.1581E+01	6.00E+05	0.1826E+01	6.50E+05	0.2168E+011088	3	2	154
7.00E+05	0.2576E+01	7.50E+05	0.3076E+01	8.00E+05	0.3750E+011088	3	2	155
8.50E+05	0.4380E+01	9.00E+05	0.5114E+01	9.50E+05	0.5844E+011088	3	2	156
1.00E+06	0.6525E+01	1.05E+06	0.7038E+01	1.10E+06	0.7321E+011088	3	2	157
1.13E+06	0.7424E+01	1.15E+06	0.7456E+01	1.17E+06	0.7461E+011088	3	2	158
1.20E+06	0.7432E+01	1.25E+06	0.7278E+01	1.30E+06	0.7040E+011088	3	2	159
1.35E+06	0.6757E+01	1.40E+06	0.6453E+01	1.45E+06	0.6157E+011088	3	2	160
1.50E+06	0.5875E+01	1.60E+06	0.5333E+01	1.70E+06	0.4882E+011088	3	2	161
1.80E+06	0.4509E+01	1.90E+06	0.4211E+01	2.00E+06	0.3944E+011088	3	2	162
2.10E+06	0.3734E+01	2.20E+06	0.3551E+01	2.30E+06	0.3399E+011088	3	2	163
2.40E+06	0.3273E+01	2.50E+06	0.3169E+01	2.60E+06	0.3071E+011088	3	2	164
2.70E+06	0.2988E+01	2.80E+06	0.2911E+01	2.90E+06	0.2849E+011088	3	2	165
3.00E+06	0.2789E+01	3.20E+06	0.2684E+01	3.40E+06	0.2595E+011088	3	2	166
3.60E+06	0.2524E+01	3.80E+06	0.2469E+01	4.00E+06	0.2424E+011088	3	2	167
4.20E+06	0.2373E+01	4.40E+06	0.2325E+01	4.60E+06	0.2278E+011088	3	2	168
4.80E+06	0.2232E+01	5.00E+06	0.2190E+01	5.20E+06	0.2149E+011088	3	2	169
5.40E+06	0.2107E+01	5.60E+06	0.2070E+01	5.80E+06	0.2031E+011088	3	2	170
6.00E+06	0.1994E+01	6.20E+06	0.1957E+01	6.40E+06	0.1921E+011088	3	2	171
6.60E+06	0.1887E+01	6.80E+06	0.1853E+01	7.00E+06	0.1821E+011088	3	2	172
7.20E+06	0.1787E+01	7.40E+06	0.1756E+01	7.60E+06	0.1726E+011088	3	2	173
7.80E+06	0.1696E+01	8.00E+06	0.1667E+01	8.20E+06	0.1640E+011088	3	2	174
8.40E+06	0.1612E+01	8.60E+06	0.1585E+01	8.80E+06	0.1559E+011088	3	2	175
9.00E+06	0.1534E+01	9.20E+06	0.1509E+01	9.40E+06	0.1485E+011088	3	2	176
9.60E+06	0.1462E+01	9.80E+06	0.1439E+01	1.00E+07	0.1418E+011088	3	2	177
1.05E+07	0.1365E+01	1.10E+07	0.1315E+01	1.15E+07	0.1268E+011088	3	2	178
1.20E+07	0.1224E+01	1.25E+07	0.1180E+01	1.30E+07	0.1140E+011088	3	2	179
1.35E+07	0.1102E+01	1.40E+07	0.1066E+01	1.45E+07	0.1032E+011088	3	2	180
1.50E+07	0.9992E+00				1088	3	2	181
0.0	0.0	0	0	0	01088	3	0	182
2000.0	3.96822	0	0	0	01088	3103		183
0.0	0.7644E+06	0	0	1	1421088	3103		184
142	5				1088	3103		185
1.00E-05	0.3483E+00	2.00E-05	0.2463E+00	3.00E-05	0.2011E+001088	3103		186

5.00E-05	0.1558E+00	7.00E-05	0.1317E+00	1.00E-04	0.1101E+00	3103	187
2.00E-04	0.7789E-01	3.00E-04	0.6359E-01	5.00E-04	0.4926E-01	3103	188
7.00E-04	0.4163E-01	1.00E-03	0.3483E-01	2.00E-03	0.2463E-01	3103	189
3.00E-03	0.2011E-01	5.00E-03	0.1558E-01	7.00E-03	0.1316E-01	3103	190
1.00E-02	0.1101E-01	2.00E-02	0.7787E-02	2.53E-02	0.6924E-02	3103	191
3.00E-02	0.6358E-02	5.00E-02	0.4924E-02	7.00E-02	0.4161E-02	3103	192
1.00E-01	0.3481E-02	2.00E-01	0.2461E-02	3.00E-01	0.2010E-02	3103	193
5.00E-01	0.1556E-02	7.00E-01	0.1316E-02	1.00E+00	0.1100E-02	3103	194
2.00E+00	0.7773E-03	3.00E+00	0.6344E-03	5.00E+00	0.4910E-03	3103	195
7.00E+00	0.4147E-03	1.00E+01	0.3467E-03	2.00E+01	0.2448E-03	3103	196
3.00E+01	0.1996E-03	5.00E+01	0.1542E-03	7.00E+01	0.1301E-03	3103	197
1.00E+02	0.1086E-03	2.00E+02	0.7631E-04	3.00E+02	0.6201E-04	3103	198
5.00E+02	0.4771E-04	7.00E+02	0.4004E-04	1.00E+03	0.3328E-04	3103	199
2.00E+03	0.2314E-04	3.00E+03	0.1859E-04	5.00E+03	0.1417E-04	3103	200
7.00E+03	0.1183E-04	1.00E+04	0.9880E-05	2.00E+04	0.6825E-05	3103	201
3.00E+04	0.5330E-05	5.00E+04	0.3900E-05	7.00E+04	0.3185E-05	3103	202
1.00E+05	0.2574E-05	1.50E+05	0.2067E-05	2.00E+05	0.1755E-05	3103	203
2.50E+05	0.1560E-05	3.00E+05	0.1430E-05	3.50E+05	0.1313E-05	3103	204
4.00E+05	0.1248E-05	4.50E+05	0.1196E-05	5.00E+05	0.1183E-05	3103	205
5.50E+05	0.1170E-05	6.00E+05	0.1157E-05	6.50E+05	0.1157E-05	3103	206
7.00E+05	0.1157E-05	7.50E+05	0.1157E-05	8.00E+05	0.1157E-05	3103	207
8.50E+05	0.1157E-05	9.00E+05	0.1157E-05	9.50E+05	0.1157E-05	3103	208
1.00E+06	0.1157E-05	1.05E+06	0.1157E-05	1.10E+06	0.1157E-05	3103	209
1.13E+06	0.1157E-05	1.15E+06	0.1157E-05	1.17E+06	0.1157E-05	3103	210
1.20E+06	0.1157E-05	1.25E+06	0.1157E-05	1.30E+06	0.1157E-05	3103	211
1.35E+06	0.1157E-05	1.40E+06	0.1157E-05	1.45E+06	0.1157E-05	3103	212
1.50E+06	0.1157E-05	1.60E+06	0.1151E-05	1.70E+06	0.1144E-05	3103	213
1.80E+06	0.1138E-05	1.90E+06	0.1118E-05	2.00E+06	0.1092E-05	3103	214
2.10E+06	0.1066E-05	2.20E+06	0.1040E-05	2.30E+06	0.1014E-05	3103	215
2.40E+06	0.9880E-06	2.50E+06	0.9620E-06	2.60E+06	0.9360E-06	3103	216
2.70E+06	0.9100E-06	2.80E+06	0.8840E-06	2.90E+06	0.8580E-06	3103	217
3.00E+06	0.8320E-06	3.20E+06	0.7800E-06	3.40E+06	0.7280E-06	3103	218
3.60E+06	0.6825E-06	3.80E+06	0.6435E-06	4.00E+06	0.6110E-06	3103	219
4.20E+06	0.5785E-06	4.40E+06	0.5460E-06	4.60E+06	0.5265E-06	3103	220
4.80E+06	0.5005E-06	5.00E+06	0.4810E-06	5.20E+06	0.4615E-06	3103	221
5.40E+06	0.4420E-06	5.60E+06	0.4225E-06	5.80E+06	0.4095E-06	3103	222
6.00E+06	0.3965E-06	6.20E+06	0.3770E-06	6.40E+06	0.3640E-06	3103	223
6.60E+06	0.3510E-06	6.80E+06	0.3406E-06	7.00E+06	0.3315E-06	3103	224
7.20E+06	0.3211E-06	7.40E+06	0.3133E-06	7.60E+06	0.3055E-06	3103	225
7.80E+06	0.2977E-06	8.00E+06	0.2912E-06	8.20E+06	0.2847E-06	3103	226
8.40E+06	0.2769E-06	8.60E+06	0.2717E-06	8.80E+06	0.2665E-06	3103	227
9.00E+06	0.2600E-06	9.20E+06	0.2548E-06	9.40E+06	0.2483E-06	3103	228
9.60E+06	0.2431E-06	9.80E+06	0.2379E-06	1.00E+07	0.2340E-06	3103	229
1.05E+07	0.2236E-06	1.10E+07	0.2145E-06	1.15E+07	0.2054E-06	3103	230
1.20E+07	0.1976E-06	1.25E+07	0.1898E-06	1.30E+07	0.1833E-06	3103	231
1.35E+07	0.1768E-06	1.40E+07	0.1703E-06	1.45E+07	0.1651E-06	3103	232
1.50E+07	0.1599E-06					1088	3103
0.0	0.0	0	0	0	01088	3	0
2000.0	3.96822	0	0	0	01088	3251	235
0.0	0.0	0	0	1	1081088	3251	236
108	3				1088	3251	237
1.00E-05	0.1680E+00	2.53E-02	0.1680E+00	1.00E+02	0.1679E+00	3251	238
2.00E+02	0.1678E+00	3.00E+02	0.1677E+00	5.00E+02	0.1675E+00	3251	239
7.00E+02	0.1672E+00	1.00E+03	0.1669E+00	2.00E+03	0.1658E+00	3251	240
3.00E+03	0.1647E+00	5.00E+03	0.1625E+00	7.00E+03	0.1603E+00	3251	241
1.00E+04	0.1570E+00	2.00E+04	0.1458E+00	3.00E+04	0.1344E+00	3251	242
5.00E+04	0.1116E+00	7.00E+04	0.8798E-01	1.00E+05	0.5208E-01	3251	243
1.50E+05	0.9740E-02	2.00E+05	0.7161E-01	2.50E+05	0.1304E+00	3251	244
3.00E+05	0.1739E+00	3.50E+05	0.2185E+00	4.00E+05	0.2518E+00	3251	245
4.50E+05	0.2702E+00	5.00E+05	0.2746E+00	5.50E+05	0.2658E+00	3251	246
6.00E+05	0.2457E+00	6.50E+05	0.2143E+00	7.00E+05	0.1276E+00	3251	247
7.50E+05	0.1357E+00	8.00E+05	0.8704E-01	8.50E+05	0.4441E-01	3251	248

9.00E+05	0.5200E-04	9.50E+05	0.4267E-01	1.00E+06	0.8390E-011088	3251	249
1.05E+06	0.1213E+00	1.10E+06	0.1529E+00	1.13E+06	0.1720E+001088	3251	250
1.15E+06	0.1836E+00	1.17E+06	0.1948E+00	1.20E+06	0.2115E+001088	3251	251
1.25E+06	0.2370E+00	1.30E+06	0.2585E+00	1.35E+06	0.2784E+001088	3251	252
1.40E+06	0.2967E+00	1.45E+06	0.3122E+00	1.50E+06	0.3258E+001088	3251	253
1.60E+06	0.3520E+00	1.70E+06	0.3718E+00	1.80E+06	0.3878E+001088	3251	254
1.90E+06	0.4002E+00	2.00E+06	0.4104E+00	2.10E+06	0.4185E+001088	3251	255
2.20E+06	0.4255E+00	2.30E+06	0.4315E+00	2.40E+06	0.4363E+001088	3251	256
2.50E+06	0.4402E+00	2.60E+06	0.4434E+00	2.70E+06	0.4460E+001088	3251	257
2.80E+06	0.4489E+00	2.90E+06	0.4512E+00	3.00E+06	0.4530E+001088	3251	258
3.20E+06	0.4585E+00	3.40E+06	0.4634E+00	3.60E+06	0.4675E+001088	3251	259
3.80E+06	0.4710E+00	4.00E+06	0.4749E+00	4.20E+06	0.4795E+001088	3251	260
4.40E+06	0.4845E+00	4.60E+06	0.4892E+00	4.80E+06	0.4940E+001088	3251	261
5.00E+06	0.4987E+00	5.20E+06	0.5035E+00	5.40E+06	0.5077E+001088	3251	262
5.60E+06	0.5117E+00	5.80E+06	0.5153E+00	6.00E+06	0.5195E+001088	3251	263
6.20E+06	0.5231E+00	6.40E+06	0.5264E+00	6.60E+06	0.5301E+001088	3251	264
6.80E+06	0.5333E+00	7.00E+06	0.5365E+00	7.20E+06	0.5390E+001088	3251	265
7.40E+06	0.5418E+00	7.60E+06	0.5443E+00	7.80E+06	0.5470E+001088	3251	266
8.00E+06	0.5492E+00	8.20E+06	0.5513E+00	8.40E+06	0.5530E+001088	3251	267
8.60E+06	0.5549E+00	8.80E+06	0.5565E+00	9.00E+06	0.5584E+001088	3251	268
9.20E+06	0.5603E+00	9.40E+06	0.5618E+00	9.60E+06	0.5635E+001088	3251	269
9.80E+06	0.5649E+00	1.00E+07	0.5666E+00	1.05E+07	0.5696E+001088	3251	270
1.10E+07	0.5728E+00	1.15E+07	0.5756E+00	1.20E+07	0.5783E+001088	3251	271
1.25E+07	0.5804E+00	1.30E+07	0.5828E+00	1.35E+07	0.5850E+001088	3251	272
1.40E+07	0.5872E+00	1.45E+07	0.5894E+00	1.50E+07	0.5917E+001088	3251	273
0.0	0.0	0	0	0	01088	3	274
2000.0	3.96822	0	0	0	01088	3252	275
0.0	0.0	0	0	1	1081088	3252	276
108	3				1088	3252	277
1.00E-05	0.4282E+00	2.53E-02	0.4282E+00	1.00E+02	0.4282E+001088	3252	278
2.00E+02	0.4283E+00	3.00E+02	0.4284E+00	5.00E+02	0.4285E+001088	3252	279
7.00E+02	0.4286E+00	1.00E+03	0.4287E+00	2.00E+03	0.4293E+001088	3252	280
3.00E+03	0.4299E+00	5.00E+03	0.4310E+00	7.00E+03	0.4322E+001088	3252	281
1.00E+04	0.4339E+00	2.00E+04	0.4397E+00	3.00E+04	0.4455E+001088	3252	282
5.00E+04	0.4574E+00	7.00E+04	0.4696E+00	1.00E+05	0.4881E+001088	3252	283
1.50E+05	0.5201E+00	2.00E+05	0.5521E+00	2.50E+05	0.5826E+001088	3252	284
3.00E+05	0.6051E+00	3.50E+05	0.6281E+00	4.00E+05	0.6454E+001088	3252	285
4.50E+05	0.6550E+00	5.00E+05	0.6572E+00	5.50E+05	0.6527E+001088	3252	286
6.00E+05	0.6423E+00	6.50E+05	0.6261E+00	7.00E+05	0.6071E+001088	3252	287
7.50E+05	0.5855E+00	8.00E+05	0.5603E+00	8.50E+05	0.5382E+001088	3252	288
9.00E+05	0.5152E+00	9.50E+05	0.4932E+00	1.00E+06	0.4719E+001088	3252	289
1.05E+06	0.4525E+00	1.10E+06	0.4362E+00	1.13E+06	0.4263E+001088	3252	290
1.15E+06	0.4203E+00	1.17E+06	0.4145E+00	1.20E+06	0.4059E+001088	3252	291
1.25E+06	0.3927E+00	1.30E+06	0.3816E+00	1.35E+06	0.3712E+001088	3252	292
1.40E+06	0.3618E+00	1.45E+06	0.3538E+00	1.50E+06	0.3467E+001088	3252	293
1.60E+06	0.3331E+00	1.70E+06	0.3229E+00	1.80E+06	0.3146E+001088	3252	294
1.90E+06	0.3082E+00	2.00E+06	0.3029E+00	2.10E+06	0.2988E+001088	3252	295
2.20E+06	0.2951E+00	2.30E+06	0.2920E+00	2.40E+06	0.2895E+001088	3252	296
2.50E+06	0.2875E+00	2.60E+06	0.2858E+00	2.70E+06	0.2845E+001088	3252	297
2.80E+06	0.2830E+00	2.90E+06	0.2818E+00	3.00E+06	0.2809E+001088	3252	298
3.20E+06	0.2781E+00	3.40E+06	0.2755E+00	3.60E+06	0.2734E+001088	3252	299
3.80E+06	0.2716E+00	4.00E+06	0.2696E+00	4.20E+06	0.2672E+001088	3252	300
4.40E+06	0.2646E+00	4.60E+06	0.2622E+00	4.80E+06	0.2597E+001088	3252	301
5.00E+06	0.2573E+00	5.20E+06	0.2548E+00	5.40E+06	0.2526E+001088	3252	302
5.60E+06	0.2506E+00	5.80E+06	0.2487E+00	6.00E+06	0.2465E+001088	3252	303
6.20E+06	0.2447E+00	6.40E+06	0.2430E+00	6.60E+06	0.2411E+001088	3252	304
6.80E+06	0.2394E+00	7.00E+06	0.2378E+00	7.20E+06	0.2365E+001088	3252	305
7.40E+06	0.2350E+00	7.60E+06	0.2337E+00	7.80E+06	0.2323E+001088	3252	306
8.00E+06	0.2312E+00	8.20E+06	0.2301E+00	8.40E+06	0.2293E+001088	3252	307
8.60E+06	0.2283E+00	8.80E+06	0.2274E+00	9.00E+06	0.2265E+001088	3252	308
9.20E+06	0.2255E+00	9.40E+06	0.2247E+00	9.60E+06	0.2238E+001088	3252	309
9.80E+06	0.2231E+00	1.00E+07	0.2222E+00	1.05E+07	0.2207E+001088	3252	310

1.10E+07	0.2190E+00	1.15E+07	0.2176E+00	1.20E+07	0.2162E+00	0.01088	3252	311
1.25E+07	0.2151E+00	1.30E+07	0.2139E+00	1.35E+07	0.2127E+00	0.01088	3252	312
1.40E+07	0.2116E+00	1.45E+07	0.2104E+00	1.50E+07	0.2093E+00	0.01088	3252	313
0.0	0.0	0	0	0	0	0.01088	3	0
2000.0	3.96822	0	0	0	0	0.01088	3253	315
0.0	0.0	0	0	1	1	0.01088	3253	316
108	3					1088	3253	317
1.00E-05	0.3121E+00	2.53E-02	0.3121E+00	1.00E+02	0.3121E+00	0.01088	3253	318
2.00E+02	0.3122E+00	3.00E+02	0.3122E+00	5.00E+02	0.3122E+00	0.01088	3253	319
7.00E+02	0.3122E+00	1.00E+03	0.3123E+00	2.00E+03	0.3125E+00	0.01088	3253	320
3.00E+03	0.3127E+00	5.00E+03	0.3131E+00	7.00E+03	0.3135E+00	0.01088	3253	321
1.00E+04	0.3141E+00	2.00E+04	0.3161E+00	3.00E+04	0.3180E+00	0.01088	3253	322
5.00E+04	0.3219E+00	7.00E+04	0.3257E+00	1.00E+05	0.3312E+00	0.01088	3253	323
1.50E+05	0.3402E+00	2.00E+05	0.3485E+00	2.50E+05	0.3561E+00	0.01088	3253	324
3.00E+05	0.3617E+00	3.50E+05	0.3675E+00	4.00E+05	0.3724E+00	0.01088	3253	325
4.50E+05	0.3762E+00	5.00E+05	0.3790E+00	5.50E+05	0.3808E+00	0.01088	3253	326
6.00E+05	0.3818E+00	6.50E+05	0.3817E+00	7.00E+05	0.3809E+00	0.01088	3253	327
7.50E+05	0.3791E+00	8.00E+05	0.3765E+00	8.50E+05	0.3736E+00	0.01088	3253	328
9.00E+05	0.3702E+00	9.50E+05	0.3662E+00	1.00E+06	0.3618E+00	0.01088	3253	329
1.05E+06	0.3572E+00	1.10E+06	0.3530E+00	1.13E+06	0.3501E+00	0.01088	3253	330
1.15E+06	0.3482E+00	1.17E+06	0.3464E+00	1.20E+06	0.3435E+00	0.01088	3253	331
1.25E+06	0.3388E+00	1.30E+06	0.3344E+00	1.35E+06	0.3300E+00	0.01088	3253	332
1.40E+06	0.3256E+00	1.45E+06	0.3216E+00	1.50E+06	0.3179E+00	0.01088	3253	333
1.60E+06	0.3100E+00	1.70E+06	0.3034E+00	1.80E+06	0.2975E+00	0.01088	3253	334
1.90E+06	0.2925E+00	2.00E+06	0.2879E+00	2.10E+06	0.2842E+00	0.01088	3253	335
2.20E+06	0.2808E+00	2.30E+06	0.2779E+00	2.40E+06	0.2756E+00	0.01088	3253	336
2.50E+06	0.2738E+00	2.60E+06	0.2722E+00	2.70E+06	0.2711E+00	0.01088	3253	337
2.80E+06	0.2699E+00	2.90E+06	0.2691E+00	3.00E+06	0.2687E+00	0.01088	3253	338
3.20E+06	0.2671E+00	3.40E+06	0.2661E+00	3.60E+06	0.2658E+00	0.01088	3253	339
3.80E+06	0.2664E+00	4.00E+06	0.2671E+00	4.20E+06	0.2672E+00	0.01088	3253	340
4.40E+06	0.2671E+00	4.60E+06	0.2671E+00	4.80E+06	0.2670E+00	0.01088	3253	341
5.00E+06	0.2669E+00	5.20E+06	0.2666E+00	5.40E+06	0.2665E+00	0.01088	3253	342
5.60E+06	0.2664E+00	5.80E+06	0.2664E+00	6.00E+06	0.2661E+00	0.01088	3253	343
6.20E+06	0.2659E+00	6.40E+06	0.2656E+00	6.60E+06	0.2652E+00	0.01088	3253	344
6.80E+06	0.2648E+00	7.00E+06	0.2644E+00	7.20E+06	0.2641E+00	0.01088	3253	345
7.40E+06	0.2636E+00	7.60E+06	0.2634E+00	7.80E+06	0.2628E+00	0.01088	3253	346
8.00E+06	0.2624E+00	8.20E+06	0.2622E+00	8.40E+06	0.2620E+00	0.01088	3253	347
8.60E+06	0.2616E+00	8.80E+06	0.2614E+00	9.00E+06	0.2610E+00	0.01088	3253	348
9.20E+06	0.2604E+00	9.40E+06	0.2601E+00	9.60E+06	0.2597E+00	0.01088	3253	349
9.80E+06	0.2594E+00	1.00E+07	0.2590E+00	1.05E+07	0.2583E+00	0.01088	3253	350
1.10E+07	0.2576E+00	1.15E+07	0.2568E+00	1.20E+07	0.2559E+00	0.01088	3253	351
1.25E+07	0.2552E+00	1.30E+07	0.2543E+00	1.35E+07	0.2536E+00	0.01088	3253	352
1.40E+07	0.2529E+00	1.45E+07	0.2522E+00	1.50E+07	0.2515E+00	0.01088	3253	353
0.0	0.0	0	0	0	0	0.01088	3	0
0.0	0.0	0	0	0	0	0.01088	0	0
2000.0	3.96822	1	1	0	0	0.01088	4	2
0.0	3.96822	0	2	100	100	0.01088	4	2
1.0000E+00	1.6800E-01	1.2819E-02	0.0-6.6316E-05	0.01088	0.01088	4	2	358
6.3701E-07	0.0-7.4839E-09	0.0	0.0	9.6190E-01	0.01088	4	2	359
2.9686E-01	4.3546E-02	3.1027E-03	0.0-1.4971E-05	0.01088	0.01088	4	2	360
1.3935E-07	0.0	0.0-1.5886E-01	9.0195E-01	4.1067E-01	0.01088	4	2	361
8.8718E-02	1.1085E-02	7.1925E-04	0.0-3.1239E-06	0.01088	0.01088	4	2	362
0.0	3.5863E-02	-2.7304E-01	8.1319E-01	5.0658E-01	1.4568E-01	0.01088	4	2
2.5474E-02	2.8077E-03	1.6752E-04	0.0	0.0-8.5905E-03	0.01088	4	2	364
7.8689E-02	-3.6481E-01	7.0133E-01	5.8110E-01	2.1109E-01	4.7327E-02	0.01088	4	2
7.1261E-03	7.0975E-04	0.0	2.1026E-03	-2.2043E-02	1.2928E-01	0.01088	4	2
-4.3373E-01	5.7179E-01	6.3117E-01	2.8107E-01	7.7131E-02	1.4600E-02	0.01088	4	2
0.0-5.1992E-04	6.0621E-03	4.1723E-02	1.8451E-01	-4.7795E-01	0.01088	4	2	368
4.3070E-01	6.5479E-01	3.5139E-01	1.1474E-01	0.0	1.2929E-04	0.01088	4	2
-1.6456E-03	1.2786E-02	-6.7791E-02	2.4055E-01	-4.9642E-01	2.8461E-01	0.01088	4	2
6.5122E-01	4.1767E-01	0.0-3.2264E-05	4.4243E-04	-3.7901E-03	0.01088	4	2	371
2.2986E-02	-9.9735E-02	2.9341E-01	-4.8921E-01	1.4018E-01	6.2111E-01	0.01088	4	2

0.0	8.0695E-06	-1.1807E-04	1.0976E-03	-7.4043E-03	3.7198E-02	1088	4	2	373
-1.3644E-01	3.3928E-01	-4.5769E-01	3.8210E-03			1088	4	2	374
0.0	0.0	0	0	1		1081088	4	2	375
108	3					1088	4	2	376
0.0	1.00E-05	0	0	1		01088	4	2	377
0.0						1088	4	2	378
0.0	2.53E-02	0	0	1		01088	4	2	379
0.0						1088	4	2	380
0.0	1.00E+02	0	0	2		01088	4	2	381
-1.130E-04	0.0					1088	4	2	382
0.0	2.00E+02	0	0	2		01088	4	2	383
-2.270E-04	0.0					1088	4	2	384
0.0	3.00E+02	0	0	2		01088	4	2	385
-3.400E-04	0.0					1088	4	2	386
0.0	5.00E+02	0	0	2		01088	4	2	387
-5.670E-04	0.0					1088	4	2	388
0.0	7.00E+02	0	0	2		01088	4	2	389
-7.940E-04	0.0					1088	4	2	390
0.0	1.00E+03	0	0	2		01088	4	2	391
-1.135E-03	0.0					1088	4	2	392
0.0	2.00E+03	0	0	2		01088	4	2	393
-2.272E-03	1.000E-06					1088	4	2	394
0.0	3.00E+03	0	0	2		01088	4	2	395
-3.410E-03	3.000E-06					1088	4	2	396
0.0	5.00E+03	0	0	2		01088	4	2	397
-5.691E-03	9.000E-06					1088	4	2	398
0.0	7.00E+03	0	0	2		01088	4	2	399
-7.979E-03	1.700E-05					1088	4	2	400
0.0	1.00E+04	0	0	2		01088	4	2	401
-1.142E-02	3.500E-05					1088	4	2	402
0.0	2.00E+04	0	0	2		01088	4	2	403
-2.303E-02	1.410E-04					1088	4	2	404
0.0	3.00E+04	0	0	2		01088	4	2	405
-3.483E-02	3.230E-04					1088	4	2	406
0.0	5.00E+04	0	0	2		01088	4	2	407
-5.853E-02	9.160E-04					1088	4	2	408
0.0	7.00E+04	0	0	2		01088	4	2	409
-8.289E-02	1.850E-03					1088	4	2	410
0.0	1.00E+05	0	0	2		01088	4	2	411
-1.199E-01	3.916E-03					1088	4	2	412
0.0	1.50E+05	0	0	2		01088	4	2	413
-1.832E-01	9.426E-03					1088	4	2	414
0.0	2.00E+05	0	0	2		01088	4	2	415
-2.462E-01	1.777E-02					1088	4	2	416
0.0	2.50E+05	0	0	2		01088	4	2	417
-3.054E-01	2.902E-02					1088	4	2	418
0.0	3.00E+05	0	0	2		01088	4	2	419
-3.487E-01	4.071E-02					1088	4	2	420
0.0	3.50E+05	0	0	2		01088	4	2	421
-3.924E-01	5.688E-02					1088	4	2	422
0.0	4.00E+05	0	0	2		01088	4	2	423
-4.240E-01	7.510E-02					1088	4	2	424
0.0	4.50E+05	0	0	2		01088	4	2	425
-4.401E-01	9.412E-02					1088	4	2	426
0.0	5.00E+05	0	0	2		01088	4	2	427
-4.414E-01	1.134E-01					1088	4	2	428
0.0	5.50E+05	0	0	2		01088	4	2	429
-4.291E-01	1.322E-01					1088	4	2	430
0.0	6.00E+05	0	0	2		01088	4	2	431
-4.053E-01	1.499E-01					1088	4	2	432
0.0	6.50E+05	0	0	2		01088	4	2	433
-3.704E-01	1.641E-01					1088	4	2	434

0.0	7.00E+05	0	0	2	01088	4	2	435
-3.301E-01	1.769E-01				1088	4	2	436
0.0	7.50E+05	0	0	2	01088	4	2	437
-2.852E-01	1.852E-01				1088	4	2	438
0.0	8.00E+05	0	0	2	01088	4	2	439
-2.333E-01	1.929E-01				1088	4	2	440
0.0	8.50E+05	0	0	2	01088	4	2	441
-1.884E-01	1.967E-01				1088	4	2	442
0.0	9.00E+05	0	0	2	01088	4	2	443
-1.416E-01	1.997E-01				1088	4	2	444
0.0	9.50E+05	0	0	2	01088	4	2	445
-9.717E-02	2.006E-01				1088	4	2	446
0.0	1.00E+06	0	0	2	01088	4	2	447
-5.435E-02	2.003E-01				1088	4	2	448
0.0	1.05E+06	0	0	2	01088	4	2	449
-1.572E-02	1.988E-01				1088	4	2	450
0.0	1.10E+06	0	0	2	01088	4	2	451
1.681E-02	1.970E-01				1088	4	2	452
0.0	1.13E+06	0	0	2	01088	4	2	453
3.635E-02	1.952E-01				1088	4	2	454
0.0	1.15E+06	0	0	2	01088	4	2	455
4.831E-02	1.941E-01				1088	4	2	456
0.0	1.17E+06	0	0	2	01088	4	2	457
5.970E-02	1.929E-01				1088	4	2	458
0.0	1.20E+06	0	0	2	01088	4	2	459
7.677E-02	1.910E-01				1088	4	2	460
0.0	1.25E+06	0	0	2	01088	4	2	461
1.026E-01	1.873E-01				1088	4	2	462
0.0	1.30E+06	0	0	2	01088	4	2	463
1.244E-01	1.837E-01				1088	4	2	464
0.0	1.35E+06	0	0	2	01088	4	2	465
1.445E-01	1.800E-01				1088	4	2	466
0.0	1.40E+06	0	0	2	01088	4	2	467
1.629E-01	1.760E-01				1088	4	2	468
0.0	1.45E+06	0	0	2	01088	4	2	469
1.783E-01	1.723E-01				1088	4	2	470
0.0	1.50E+06	0	0	2	01088	4	2	471
1.919E-01	1.687E-01				1088	4	2	472
0.0	1.60E+06	0	0	2	01088	4	2	473
2.179E-01	1.608E-01				1088	4	2	474
0.0	1.70E+06	0	0	2	01088	4	2	475
2.372E-01	1.538E-01				1088	4	2	476
0.0	1.80E+06	0	0	2	01088	4	2	477
2.528E-01	1.474E-01				1088	4	2	478
0.0	1.90E+06	0	0	2	01088	4	2	479
2.649E-01	1.419E-01				1088	4	2	480
0.0	2.00E+06	0	0	4	01088	4	2	481
2.745E-01	1.357E-01	-2.430E-04	1.000E-06		1088	4	2	482
0.0	2.10E+06	0	0	4	01088	4	2	483
2.821E-01	1.314E-01	-2.440E-04	1.000E-06		1088	4	2	484
0.0	2.20E+06	0	0	4	01088	4	2	485
2.888E-01	1.272E-01	-2.730E-04	1.000E-06		1088	4	2	486
0.0	2.30E+06	0	0	4	01088	4	2	487
2.944E-01	1.239E-01	-3.210E-04	2.000E-06		1088	4	2	488
0.0	2.40E+06	0	0	4	01088	4	2	489
2.989E-01	1.213E-01	-3.130E-04	2.000E-06		1088	4	2	490
0.0	2.50E+06	0	0	4	01088	4	2	491
3.028E-01	1.195E-01	-3.510E-04	2.000E-06		1088	4	2	492
0.0	2.60E+06	0	0	4	01088	4	2	493
3.058E-01	1.180E-01	-3.870E-04	3.000E-06		1088	4	2	494
0.0	2.70E+06	0	0	4	01088	4	2	495
3.084E-01	1.171E-01	-3.940E-04	3.000E-06		1088	4	2	496

0.0	2.80E+06	0	0	4	01088	4	2	497
3.113E-01	1.165E-01	-4.240E-04	4.000E-06		1088	4	2	498
0.0	2.90E+06	0	0	4	01088	4	2	499
3.137E-01	1.166E-01	-4.440E-04	5.000E-06		1088	4	2	500
0.0	3.00E+06	0	0	4	01088	4	2	501
3.157E-01	1.173E-01	-4.680E-04	5.000E-06		1088	4	2	502
0.0	3.20E+06	0	0	4	01088	4	2	503
3.216E-01	1.186E-01	-4.810E-04	7.000E-06		1088	4	2	504
0.0	3.40E+06	0	0	4	01088	4	2	505
3.271E-01	1.210E-01	-5.350E-04	9.000E-06		1088	4	2	506
0.0	3.60E+06	0	0	4	01088	4	2	507
3.321E-01	1.252E-01	-5.480E-04	1.200E-05		1088	4	2	508
0.0	3.80E+06	0	0	4	01088	4	2	509
3.367E-01	1.312E-01	-5.400E-04	1.400E-05		1088	4	2	510
0.0	4.00E+06	0	0	4	01088	4	2	511
3.418E-01	1.381E-01	-5.780E-04	1.700E-05		1088	4	2	512
0.0	4.20E+06	0	0	4	01088	4	2	513
3.476E-01	1.438E-01	-5.920E-04	2.200E-05		1088	4	2	514
0.0	4.40E+06	0	0	4	01088	4	2	515
3.537E-01	1.495E-01	-6.160E-04	2.600E-05		1088	4	2	516
0.0	4.60E+06	0	0	4	01088	4	2	517
3.596E-01	1.552E-01	-6.410E-04	3.000E-05		1088	4	2	518
0.0	4.80E+06	0	0	4	01088	4	2	519
3.654E-01	1.604E-01	-6.740E-04	3.600E-05		1088	4	2	520
0.0	5.00E+06	0	0	4	01088	4	2	521
3.713E-01	1.658E-01	-6.910E-04	4.100E-05		1088	4	2	522
0.0	5.20E+06	0	0	4	01088	4	2	523
3.770E-01	1.707E-01	-7.030E-04	4.700E-05		1088	4	2	524
0.0	5.40E+06	0	0	4	01088	4	2	525
3.821E-01	1.753E-01	-7.400E-04	5.500E-05		1088	4	2	526
0.0	5.60E+06	0	0	4	01088	4	2	527
3.870E-01	1.800E-01	-7.320E-04	6.300E-05		1088	4	2	528
0.0	5.80E+06	0	0	4	01088	4	2	529
3.916E-01	1.844E-01	-7.660E-04	7.200E-05		1088	4	2	530
0.0	6.00E+06	0	0	4	01088	4	2	531
3.966E-01	1.884E-01	-8.190E-04	8.400E-05		1088	4	2	532
0.0	6.20E+06	0	0	4	01088	4	2	533
4.009E-01	1.922E-01	-8.170E-04	9.200E-05		1088	4	2	534
0.0	6.40E+06	0	0	4	01088	4	2	535
4.049E-01	1.953E-01	-8.200E-04	1.050E-04		1088	4	2	536
0.0	6.60E+06	0	0	4	01088	4	2	537
4.092E-01	1.984E-01	-8.480E-04	1.180E-04		1088	4	2	538
0.0	6.80E+06	0	0	4	01088	4	2	539
4.130E-01	2.011E-01	-8.700E-04	1.330E-04		1088	4	2	540
0.0	7.00E+06	0	0	4	01088	4	2	541
4.168E-01	2.039E-01	-8.630E-04	1.470E-04		1088	4	2	542
0.0	7.20E+06	0	0	4	01088	4	2	543
4.198E-01	2.062E-01	-8.140E-04	1.610E-04		1088	4	2	544
0.0	7.40E+06	0	0	4	01088	4	2	545
4.231E-01	2.083E-01	-7.800E-04	1.790E-04		1088	4	2	546
0.0	7.60E+06	0	0	4	01088	4	2	547
4.260E-01	2.106E-01	-7.500E-04	1.950E-04		1088	4	2	548
0.0	7.80E+06	0	0	4	01088	4	2	549
4.291E-01	2.124E-01	-6.990E-04	2.140E-04		1088	4	2	550
0.0	8.00E+06	0	0	4	01088	4	2	551
4.316E-01	2.140E-01	-6.410E-04	2.390E-04		1088	4	2	552
0.0	8.20E+06	0	0	4	01088	4	2	553
4.342E-01	2.159E-01	-5.640E-04	2.650E-04		1088	4	2	554
0.0	8.40E+06	0	0	4	01088	4	2	555
4.362E-01	2.175E-01	-4.670E-04	2.900E-04		1088	4	2	556
0.0	8.60E+06	0	0	4	01088	4	2	557
4.384E-01	2.189E-01	-3.500E-04	3.180E-04		1088	4	2	558

0.0	8.80E+06	0	0	4	01088	4	2	559
4.403E-01	2.202E-01	-2.490E-04	3.480E-04		1088	4	2	560
0.0	9.00E+06	0	0	4	01088	4	2	561
4.424E-01	2.216E-01	-1.320E-04	3.800E-04		1088	4	2	562
0.0	9.20E+06	0	0	4	01088	4	2	563
4.445E-01	2.223E-01	-1.200E-05	4.110E-04		1088	4	2	564
0.0	9.40E+06	0	0	4	01088	4	2	565
4.463E-01	2.234E-01	1.110E-04	4.480E-04		1088	4	2	566
0.0	9.60E+06	0	0	4	01088	4	2	567
4.482E-01	2.245E-01	2.700E-04	4.840E-04		1088	4	2	568
0.0	9.80E+06	0	0	4	01088	4	2	569
4.498E-01	2.254E-01	4.340E-04	5.220E-04		1088	4	2	570
0.0	1.00E+07	0	0	4	01088	4	2	571
4.517E-01	2.265E-01	6.160E-04	5.600E-04		1088	4	2	572
0.0	1.05E+07	0	0	4	01088	4	2	573
4.553E-01	2.287E-01	1.128E-03	6.820E-04		1088	4	2	574
0.0	1.10E+07	0	0	4	01088	4	2	575
4.589E-01	2.310E-01	1.609E-03	7.830E-04		1088	4	2	576
0.0	1.15E+07	0	0	4	01088	4	2	577
4.621E-01	2.326E-01	2.313E-03	9.250E-04		1088	4	2	578
0.0	1.20E+07	0	0	4	01088	4	2	579
4.651E-01	2.340E-01	3.169E-03	1.083E-03		1088	4	2	580
0.0	1.25E+07	0	0	4	01088	4	2	581
4.674E-01	2.351E-01	4.082E-03	1.231E-03		1088	4	2	582
0.0	1.30E+07	0	0	4	01088	4	2	583
4.701E-01	2.362E-01	5.001E-03	1.429E-03		1088	4	2	584
0.0	1.35E+07	0	0	4	01088	4	2	585
4.725E-01	2.374E-01	6.139E-03	1.600E-03		1088	4	2	586
0.0	1.40E+07	0	0	4	01088	4	2	587
4.750E-01	2.388E-01	7.284E-03	1.781E-03		1088	4	2	588
0.0	1.45E+07	0	0	4	01088	4	2	589
4.775E-01	2.402E-01	8.515E-03	1.971E-03		1088	4	2	590
0.0	1.50E+07	0	0	4	01088	4	2	591
4.801E-01	2.418E-01	9.809E-03	2.171E-03		1088	4	2	592
0.0	0.0	0	0	0	01088	4	0	593
0.0	0.0	0	0	0	01088	0	0	594
2000.0	3.96822	0	0	0	01088	7	4	595
0.0	0.0	0	0	12	11088	7	4	596
0.0	59.3	3.96822	1.5	0.0	0.01088	7	4	597
1.0	0.7238	3.96822	0.0	0.0	0.01088	7	4	598
0.0	0.0	0	0	0	01088	7	0	599
0.0	0.0	0	0	0	01088	0	0	600
0.0	0.0	0	0	0	0	0	0	601

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