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

by

E. M. Pennington

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Physics

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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)

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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 ^{4}He. Since ^{3}He 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% ^{4}He and 0.00013% ^{3}He. Because of the low abundance of ^{3}He, 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 ^{4}He 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 value[2] 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_{lab}, MeV	δ_0^+	δ_1^+	δ_1^-	δ_2^+	δ_2^-	E_{lab}, 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 ^{3}He is that recommended in the ^{3}He evaluation by J. Als-Nielsen.[7] Extension from 10 to 15 MeV was made using linear extrapolation on a log σ 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

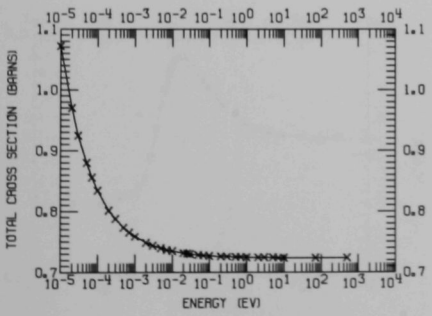

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Fig. 1. Helium Total Cross Section, 10^{-5} eV to 1 keV

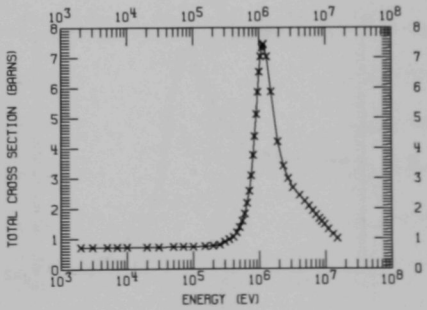

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Fig. 2. Helium Total Cross Section, 1 keV to 15 MeV

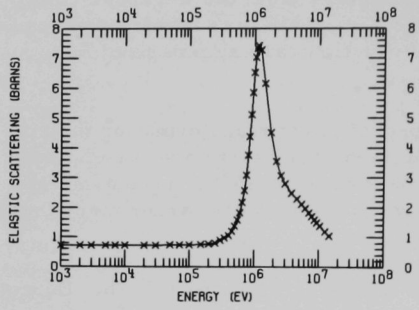

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Fig. 3. Helium Elastic Scattering Cross Section

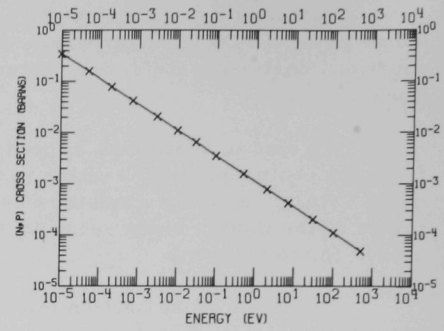

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Fig. 4. Helium (n,p) Cross Section, 10^{-5} eV to 1 keV

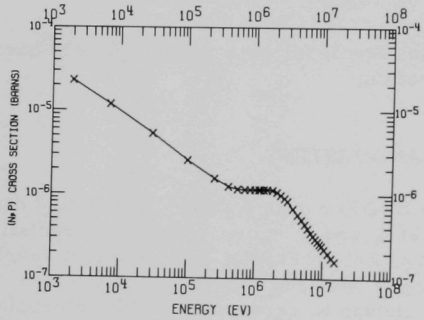

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Fig. 5. Helium (n,p) Cross Section, 1 keV to 15 MeV

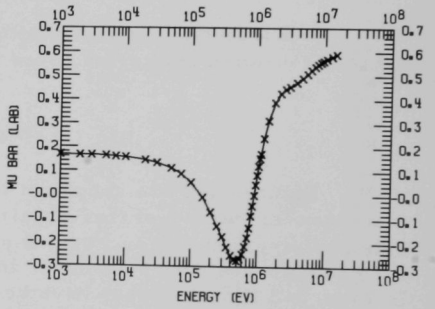

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Fig. 6. Helium Average Elastic Scattering Cosine, $\bar{\mu}_L$

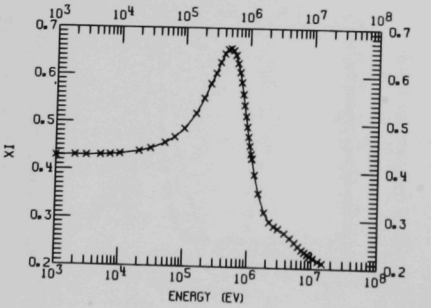

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Fig. 7. Helium Average Logarithmic Energy Decrement, ξ

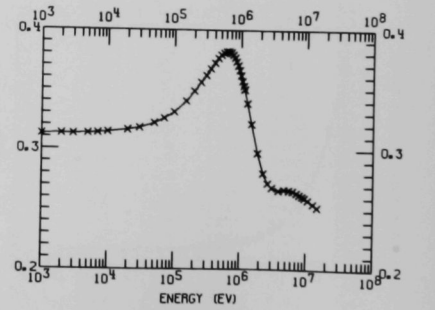

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Fig. 8. Helium Greuling-Goertzel Parameter, γ

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 by[8]

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

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

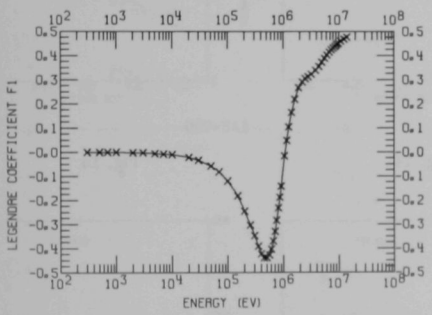

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Fig. 9. Helium Elastic Scattering Legendre Coefficient f_1

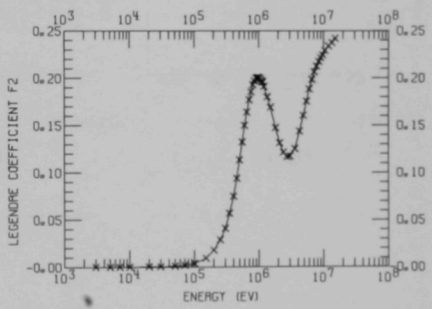

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Fig. 10. Helium Elastic Scattering Legendre Coefficient f_2

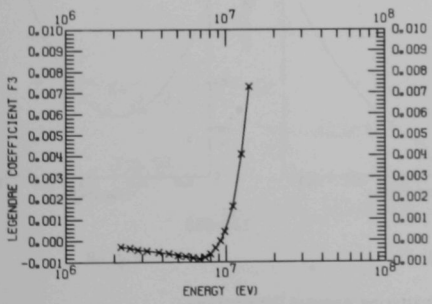

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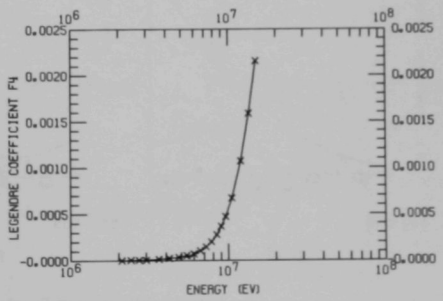
Fig. 11. Helium Elastic Scattering Legendre Coefficient f_3



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.

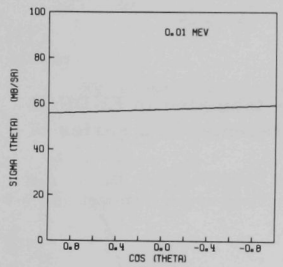


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Fig. 13

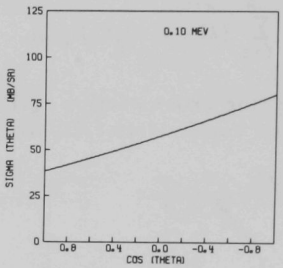

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Fig. 14

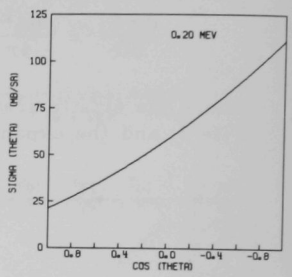

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Fig. 15

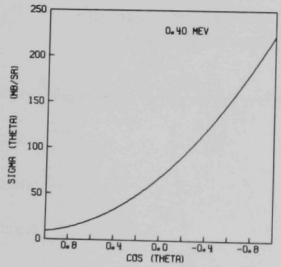

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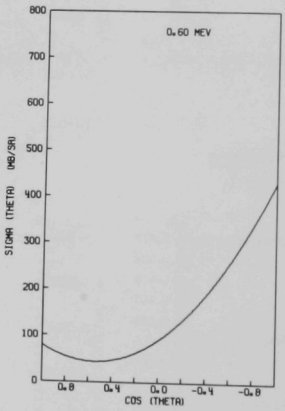
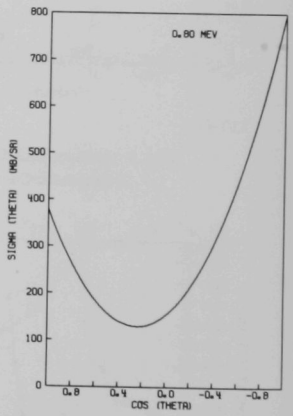
Fig. 16



113-703

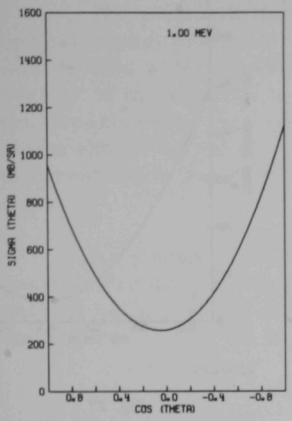
Fig. 17



113-683

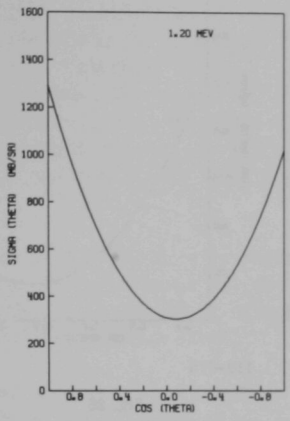
Fig. 18

Figs. 13-18. Helium Elastic Scattering Angular Distributions



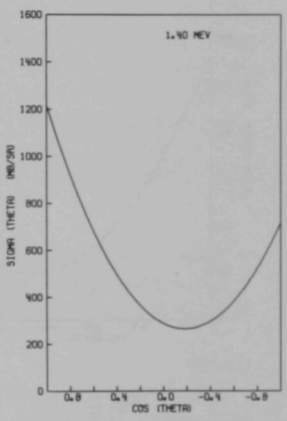
113-677

Fig. 19



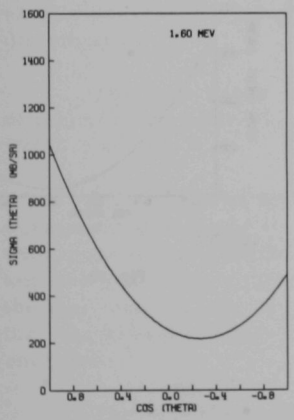
113-697

Fig. 20



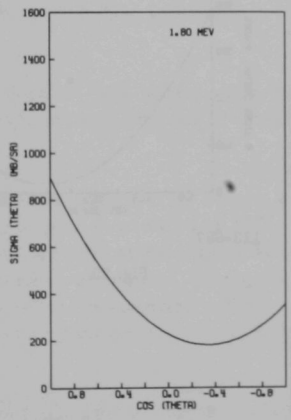
113-699

Fig. 21



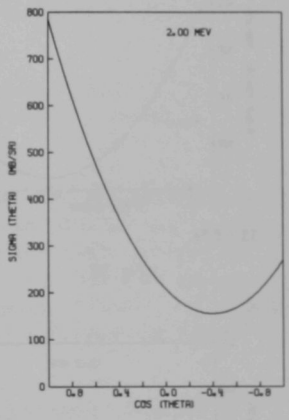
113-695

Fig. 22



113-684

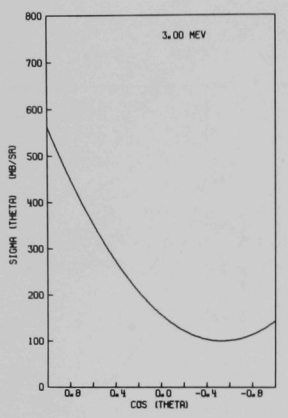
Fig. 23



113-692

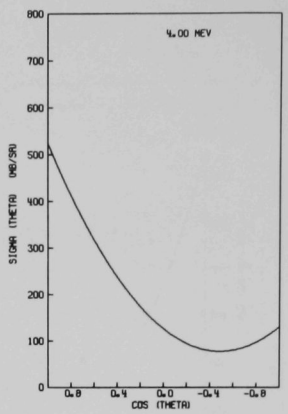
Fig. 24

Figs. 19-24. Helium Elastic Scattering Angular Distributions



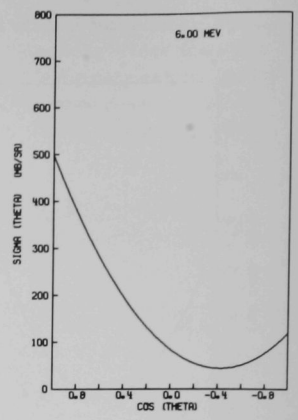
113-693

Fig. 25



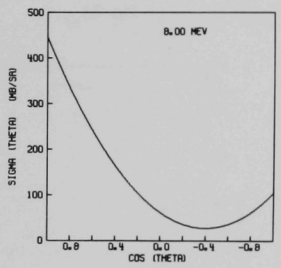
113-675

Fig. 26



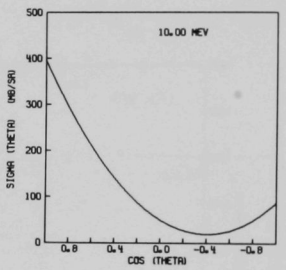
113-690

Fig. 27



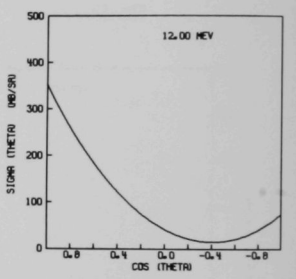
113-679

Fig. 28



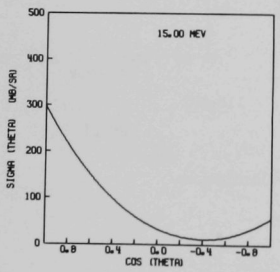
113-687

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 shifts[9] 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 ^{3}He (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 ^{3}He isotopic abundance than by the uncertainty in the ^{3}He (n,p) cross section itself.

Previous evaluations of natural helium for reactor calculations include those of Schmidt[10] and of Buckingham et al.[11,12] Schmidt's evaluation includes the (n,p) cross section for ^{3}He and σ_s, $\bar{\mu}_L$, and a set of phase shifts for ^{4}He. Buckingham et al. present separate compilations for ^{3}He and ^{4}He. For ^{3}He, elastic, (n,p), (n,d), and (n,2n) cross sections are given, as well as elastic angular distributions. The ^{4}He evaluation consists of σ_s and angular distributions.

The (n,p) cross section of ^{3}He, 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 values[10] 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 values[11] 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-120[10] 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 by[13]

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

where

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

and

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

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

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

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

$$k^2C_2 = 5 \sin^2 \delta_0^+ + 4 \sin^2 \delta_1^+ + 2 \sin^2 \delta_1^- + \frac{51}{7} \sin^2 \delta_2^+ + \frac{34}{7} \sin^2 \delta_2^-$$

$$- 2 \sin^2 (\delta_1^+ - \delta_1^-) - \frac{6}{7} \sin^2 (\delta_2^+ - \delta_2^-) - 3 \sin^2 (\delta_0^+ - \delta_2^+)$$

$$- 2 \sin^2 (\delta_0^+ - \delta_2^-), \tag{A.6}$$

$$k^2C_3 = 6 \sin^2 \delta_1^+ + 3 \sin^2 \delta_1^- + \frac{27}{5} \sin^2 \delta_2^+ + \frac{18}{5} \sin^2 \delta_2^-$$

$$- \frac{12}{5} \sin^2 (\delta_1^+ - \delta_2^+) - \frac{18}{5} \sin^2 (\delta_1^+ - \delta_2^-) - 3 \sin^2 (\delta_1^- - \delta_2^+), \tag{A.7}$$

and

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

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 is[14]

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

where

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

with

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

and

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

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

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

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

$$P_\ell = \frac{\rho}{F_\ell^2 + G_\ell^2} \tag{B.5}$$

and

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

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

$$R_{\ell J} = \frac{\gamma^2_{\lambda \ell J}}{E_{\lambda \ell J} - E}, \tag{B.7}$$

where $\gamma^2_{\lambda \ell J}$ 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

$$F_1 = \frac{\sin \rho - \rho \cos \rho}{\rho} \tag{B.8}$$

and

$$G_1 = \frac{\cos \rho + \rho \sin \rho}{\rho}. \tag{B.9}$$

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

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

where

$$\alpha = \frac{\gamma^2_{\lambda 1 J}}{E_{\lambda 1 J} + \gamma^2_{\lambda 1 J}} \tag{B.11}$$

and

$$\beta = \frac{E_{\lambda 1 J} - \frac{A}{A+1}\,\frac{1}{C^2}}{E_{\lambda 1 J} + \gamma^2_{\lambda 1 J}} \tag{B.12}$$

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 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.

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

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

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

where

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

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

The average logarithmic energy decrement in elastic scattering is

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

where

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

and

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

The Greuling-Goertzel parameter, γ, is given by

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

where

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

The $\delta_{\ell 0}$ and $\delta_{\ell \ell'}$ 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                                1088 1451     3
COMPILED BY ED PENNINGTON, ARGONNE NATIONAL LAB., IN JUNE 1968.     1088 1451     4
NATURAL HELIUM CONSISTS OF 0.00013 PER CENT HE-3 AND 99.99987 PER1088 1451     5
CENT HE-4.                                                          1088 1451     6
BECAUSE OF THE LOW ABUNDANCE OF HE-3, ONLY ITS (N,P) CROSS          1088 1451     7
SECTION, WHICH IS VERY LARGE AT LOW ENERGIES, NEED BE CONSIDERED.1088 1451     8
ELASTIC SCATTERING IS THE ONLY POSSIBLE REACTION FOR NEUTRONS       1088 1451     9
INCIDENT ON HE-4 AT ENERGIES BELOW 15 MEV. THUS THE ELASTIC         1088 1451    10
SCATTERING CROSS SECTION AND VALUES OF MU BAR(LAB), XI, AND GAMMA1088 1451    11
ARE GIVEN IN FILE 3, AND ELASTIC SCATTERING LEGENDRE COEFFICIENTS1088 1451    12
ARE GIVEN IN FILE 4. PARAMETERS FOR A FREE GAS THERMAL SCATTERING1088 1451    13
LAW ARE IN FILE 7.                                                  1088 1451    14
THE ELASTIC SCATTERING CROSS SECTION AND THE LEGENDRE EXPANSION     1088 1451    15
COEFFICIENTS WERE CALCULATED FROM S-,P-, AND D-WAVE PHASE SHIFTS 1088 1451    16
USING A FORTRAN PROGRAM WRITTEN FOR THE PURPOSE. THE PHASE SHIFTS1088 1451    17
WERE READ FROM SMOOTH CURVES BASED ON TABLE I OF REF.1. AT          1088 1451    18
ENERGIES BELOW THE 300 KEV, LOWER LIMIT OF TABLE I, EACH OF THE     1088 1451    19
TWO P-WAVE PHASE SHIFTS WAS OBTAINED BY ASSUMING A FUNCTIONAL       1088 1451    20
FORM BASED ON THE LOW ENERGY LIMIT FOR A SINGLE P-WAVE RESONANCE,1088 1451    21
WITH PARAMETERS DETERMINED FROM FITTING THE LOW ENERGY PHASE        1088 1451    22
SHIFTS OF TABLE I. THE S-WAVE PHASE SHIFT BELOW 300 KEV, WAS        1088 1451    23
CALCULATED USING HARD SPHERE SCATTERING AND A NUCLEAR RADIUS, A= 1088 1451    24
2.4 FERMI, THIS YIELDS THE THERMAL SCATTERING CROSS SECTION =       1088 1451    25
4.*PI*A**2= 0.7238 BARNS IN AGREEMENT WITH THE EXPERIMENTAL VALUE1088 1451    26
OF 0.73+- 0.05 BARNS (REF.2). THE LOW ENERGY S-WAVE PHASE SHIFTS 1088 1451    27
OF REF.1 ARE CONSISTENT WITH A NUCLEAR RADIUS OF ABOUT 2.48         1088 1451    28
FERMI, AND SO WOULD YIELD A SOMEWHAT HIGH THERMAL CROSS SECTION. 1088 1451    29
VALUES OF MU BAR(LAB), XI, AND GAMMA WERE CALCULATED FROM THE       1088 1451    30
LEGENDRE COEFFICIENTS USING A FORTRAN PROGRAM, MUXIGA. THIS         1088 1451    31
PROGRAM USES THE EQUATIONS OF REF.3-5.                              1088 1451    32
AN ELASTIC SCATTERING TRANSFORMATION MATRIX FROM THE CENTER-OF-     1088 1451    33
MASS TO THE LABORATORY SYSTEM WAS COMPUTED USING CHAD (REF.6).      1088 1451    34
THE (N,P) CROSS SECTION FOR HE-3 IS THAT RECOMMENDED IN THE         1088 1451    35
EVALUATION OF HE-3 BY J. ALS-NIELSEN GIVEN IN REF.7. EXTENSION      1088 1451    36
FROM 10 TO 15 MEV. WAS MADE USING LINEAR EXTRAPOLATION ON A         1088 1451    37
LOG SIGMA- LOG E SCALE.                                             1088 1451    38
THE TOTAL CROSS SECTION IS THE SUM OF THE ELASTIC SCATTERING AND 1088 1451    39
(N,P) CROSS SECTIONS.                                               1088 1451    40
COMMENTS-                                                           1088 1451    41
THE PHASE SHIFTS OF REF.1 ARE OPTICAL MODEL PHASE SHIFTS CHOSEN     1088 1451    42
TO FIT BOTH ANGULAR DISTRIBUTION AND POLARIZATION DATA AT MANY      1088 1451    43
ENERGIES. THE TOTAL SCATTERING CROSS SECTION IS ALSO FIT WITHIN     1088 1451    44
THE SCATTER OF THE EXPERIMENTAL POINTS, ANOTHER RECENT SET OF       1088 1451    45
PHASE SHIFTS (REF.8) IS NOT VERY DIFFERENT FROM THOSE USED HERE,    1088 1451    46
AND COULD ALSO HAVE BEEN USED IN THE PRESENT WORK, THERE SHOULD     1088 1451    47
BE NO SERIOUS DISAGREEMENTS WITH EXPERIMENTAL VALUES IN THE HE-4    1088 1451    48
DATA CALCULATED FROM THE PHASE SHIFTS.                              1088 1451    49
AS DISCUSSED IN REF.7, THE HE-3 (N,P) CROSS SECTION IS RATHER       1088 1451    50
WELL KNOWN. PROBABLY MORE ERROR IS INTRODUCED INTO THE (N,P)        1088 1451    51
CROSS SECTION FOR NATURAL HELIUM BY THE UNCERTAINTY IN THE HE-3     1088 1451    52
ISOTOPIC ABUNDANCE THAN BY THE UNCERTAINTY IN THE HE-3 (N,P)        1088 1451    53
CROSS SECTION ITSELF.                                               1088 1451    54
PREVIOUS EVALUATIONS OF HELIUM FOR REACTOR CALCULATIONS INCLUDE     1088 1451    55
THOSE OF J.J.SCHMIDT (REF.9) AND B.R.S.BUCKINGHAM ET AL (REF.10).1088 1451    56
SCHMIDT-S EVALUATION INCLUDES THE (N,P) CROSS SECTION FOR HE-3,     1088 1451    57
AND SIGMA ELASTIC, MU BAR(LAB), AND A SET OF PHASE SHIFTS FOR       1088 1451    58
HE-4. BUCKINGHAM ET AL GIVE SEPARATE EVALUATIONS FOR HE-3 AND       1088 1451    59
HE-4. FOR HE-3 ELASTIC, (N,P), (N,D), AND (N,2N) CROSS SECTIONS     1088 1451    60
ARE GIVEN, AS WELL AS ELASTIC ANGULAR DISTRIBUTIONS. THE HE-4       1088 1451    61
EVALUATION GIVES THE ELASTIC CROSS SECTION AND ANGULAR              1088 1451    62
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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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11.E.M.PENNINGTON ANL-7462,(TO BE ISSUED).                              1088 1451   76
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       0.0        0.0            0            0            0         01088 0  0   78
    2000.0    3.96822            0            0            0         01088 3  1   79
       0.0        0.0            0            0            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+001088 3  1   82
 5.00E-05 0.8796E+00   7.00E-05 0.8555E+00   1.00E-04 0.8339E+001088 3  1   83
 2.00E-04 0.8017E+00   3.00E-04 0.7874E+00   5.00E-04 0.7731E+001088 3  1   84
 7.00E-04 0.7654E+00   1.00E-03 0.7586E+00   2.00E-03 0.7484E+001088 3  1   85
 3.00E-03 0.7439E+00   5.00E-03 0.7394E+00   7.00E-03 0.7370E+001088 3  1   86
 1.00E-02 0.7348E+00   2.00E-02 0.7316E+00   2.53E-02 0.7307E+001088 3  1   87
 3.00E-02 0.7302E+00   5.00E-02 0.7287E+00   7.00E-02 0.7280E+001088 3  1   88
 1.00E-01 0.7273E+00   2.00E-01 0.7263E+00   3.00E-01 0.7258E+001088 3  1   89
 5.00E-01 0.7254E+00   7.00E-01 0.7251E+00   1.00E+00 0.7249E+001088 3  1   90
 2.00E+00 0.7246E+00   3.00E+00 0.7244E+00   5.00E+00 0.7243E+001088 3  1   91
 7.00E+00 0.7242E+00   1.00E+01 0.7241E+00   2.00E+01 0.7240E+001088 3  1   92
 3.00E+01 0.7240E+00   5.00E+01 0.7240E+00   7.00E+01 0.7239E+001088 3  1   93
 1.00E+02 0.7239E+00   2.00E+02 0.7239E+00   3.00E+02 0.7239E+001088 3  1   94
 5.00E+02 0.7238E+00   7.00E+02 0.7238E+00   1.00E+03 0.7238E+001088 3  1   95
 2.00E+03 0.7237E+00   3.00E+03 0.7237E+00   5.00E+03 0.7236E+001088 3  1   96
 7.00E+03 0.7236E+00   1.00E+04 0.7235E+00   2.00E+04 0.7235E+001088 3  1   97
 3.00E+04 0.7234E+00   5.00E+04 0.7241E+00   7.00E+04 0.7256E+001088 3  1   98
 1.00E+05 0.7297E+00   1.50E+05 0.7425E+00   2.00E+05 0.7644E+001088 3  1   99
 2.50E+05 0.7977E+00   3.00E+05 0.8978E+00   3.50E+05 0.9654E+001088 3  1  100
 4.00E+05 0.1056E+01   4.50E+05 0.1197E+01   5.00E+05 0.1373E+011088 3  1  101
 5.50E+05 0.1581E+01   6.00E+05 0.1826E+01   6.50E+05 0.2168E+011088 3  1  102
 7.00E+05 0.2576E+01   7.50E+05 0.3076E+01   8.00E+05 0.3750E+011088 3  1  103
 8.50E+05 0.4380E+01   9.00E+05 0.5114E+01   9.50E+05 0.5844E+011088 3  1  104
 1.00E+06 0.6525E+01   1.05E+06 0.7038E+01   1.10E+06 0.7321E+011088 3  1  105
 1.13E+06 0.7424E+01   1.15E+06 0.7456E+01   1.17E+06 0.7461E+011088 3  1  106
 1.20E+06 0.7432E+01   1.25E+06 0.7278E+01   1.30E+06 0.7040E+011088 3  1  107
 1.35E+06 0.6757E+01   1.40E+06 0.6453E+01   1.45E+06 0.6157E+011088 3  1  108
 1.50E+06 0.5875E+01   1.60E+06 0.5333E+01   1.70E+06 0.4882E+011088 3  1  109
 1.80E+06 0.4509E+01   1.90E+06 0.4211E+01   2.00E+06 0.3944E+011088 3  1  110
 2.10E+06 0.3734E+01   2.20E+06 0.3551E+01   2.30E+06 0.3399E+011088 3  1  111
 2.40E+06 0.3273E+01   2.50E+06 0.3169E+01   2.60E+06 0.3071E+011088 3  1  112
 2.70E+06 0.2988E+01   2.80E+06 0.2911E+01   2.90E+06 0.2849E+011088 3  1  113
 3.00E+06 0.2789E+01   3.20E+06 0.2684E+01   3.40E+06 0.2595E+011088 3  1  114
 3.60E+06 0.2524E+01   3.80E+06 0.2469E+01   4.00E+06 0.2424E+011088 3  1  115
 4.20E+06 0.2373E+01   4.40E+06 0.2325E+01   4.60E+06 0.2278E+011088 3  1  116
 4.80E+06 0.2232E+01   5.00E+06 0.2190E+01   5.20E+06 0.2149E+011088 3  1  117
 5.40E+06 0.2107E+01   5.60E+06 0.2070E+01   5.80E+06 0.2031E+011088 3  1  118
 6.00E+06 0.1994E+01   6.20E+06 0.1957E+01   6.40E+06 0.1921E+011088 3  1  119
 6.60E+06 0.1887E+01   6.80E+06 0.1853E+01   7.00E+06 0.1821E+011088 3  1  120
 7.20E+06 0.1787E+01   7.40E+06 0.1756E+01   7.60E+06 0.1726E+011088 3  1  121
 7.80E+06 0.1696E+01   8.00E+06 0.1667E+01   8.20E+06 0.1640E+011088 3  1  122
 8.40E+06 0.1612E+01   8.60E+06 0.1585E+01   8.80E+06 0.1559E+011088 3  1  123
 9.00E+06 0.1534E+01   9.20E+06 0.1509E+01   9.40E+06 0.1485E+011088 3  1  124
```

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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
```

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5.00E-05 0.1558E+00   7.00E-05 0.1317E+00   1.00E-04 0.1101E+001088 3103  187
2.00E-04 0.7789E-01   3.00E-04 0.6359E-01   5.00E-04 0.4926E-011088 3103  188
7.00E-04 0.4163E-01   1.00E-03 0.3483E-01   2.00E-03 0.2463E-011088 3103  189
3.00E-03 0.2011E-01   5.00E-03 0.1558E-01   7.00E-03 0.1316E-011088 3103  190
1.00E-02 0.1101E-01   2.00E-02 0.7787E-02   2.53E-02 0.6924E-021088 3103  191
3.00E-02 0.6358E-02   5.00E-02 0.4924E-02   7.00E-02 0.4161E-021088 3103  192
1.00E-01 0.3481E-02   2.00E-01 0.2461E-02   3.00E-01 0.2010E-021088 3103  193
5.00E-01 0.1556E-02   7.00E-01 0.1316E-02   1.00E+00 0.1100E-021088 3103  194
2.00E+00 0.7773E-03   3.00E+00 0.6344E-03   5.00E+00 0.4910E-031088 3103  195
7.00E+00 0.4147E-03   1.00E+01 0.3467E-03   2.00E+01 0.2448E-031088 3103  196
3.00E+01 0.1996E-03   5.00E+01 0.1542E-03   7.00E+01 0.1301E-031088 3103  197
1.00E+02 0.1086E-03   2.00E+02 0.7631E-04   3.00E+02 0.6201E-041088 3103  198
5.00E+02 0.4771E-04   7.00E+02 0.4004E-04   1.00E+03 0.3328E-041088 3103  199
2.00E+03 0.2314E-04   3.00E+03 0.1859E-04   5.00E+03 0.1417E-041088 3103  200
7.00E+03 0.1183E-04   1.00E+04 0.9880E-05   2.00E+04 0.6825E-051088 3103  201
3.00E+04 0.5330E-05   5.00E+04 0.3900E-05   7.00E+04 0.3185E-051088 3103  202
1.00E+05 0.2574E-05   1.50E+05 0.2067E-05   2.00E+05 0.1755E-051088 3103  203
2.50E+05 0.1560E-05   3.00E+05 0.1430E-05   3.50E+05 0.1313E-051088 3103  204
4.00E+05 0.1248E-05   4.50E+05 0.1196E-05   5.00E+05 0.1183E-051088 3103  205
5.50E+05 0.1170E-05   6.00E+05 0.1157E-05   6.50E+05 0.1157E-051088 3103  206
7.00E+05 0.1157E-05   7.50E+05 0.1157E-05   8.00E+05 0.1157E-051088 3103  207
8.50E+05 0.1157E-05   9.00E+05 0.1157E-05   9.50E+05 0.1157E-051088 3103  208
1.00E+06 0.1157E-05   1.05E+06 0.1157E-05   1.10E+06 0.1157E-051088 3103  209
1.13E+06 0.1157E-05   1.15E+06 0.1157E-05   1.17E+06 0.1157E-051088 3103  210
1.20E+06 0.1157E-05   1.25E+06 0.1157E-05   1.30E+06 0.1157E-051088 3103  211
1.35E+06 0.1157E-05   1.40E+06 0.1157E-05   1.45E+06 0.1157E-051088 3103  212
1.50E+06 0.1157E-05   1.60E+06 0.1151E-05   1.70E+06 0.1144E-051088 3103  213
1.80E+06 0.1138E-05   1.90E+06 0.1118E-05   2.00E+06 0.1092E-051088 3103  214
2.10E+06 0.1066E-05   2.20E+06 0.1040E-05   2.30E+06 0.1014E-051088 3103  215
2.40E+06 0.9880E-06   2.50E+06 0.9620E-06   2.60E+06 0.9360E-061088 3103  216
2.70E+06 0.9100E-06   2.80E+06 0.8840E-06   2.90E+06 0.8580E-061088 3103  217
3.00E+06 0.8320E-06   3.20E+06 0.7800E-06   3.40E+06 0.7280E-061088 3103  218
3.60E+06 0.6825E-06   3.80E+06 0.6435E-06   4.00E+06 0.6110E-061088 3103  219
4.20E+06 0.5785E-06   4.40E+06 0.5460E-06   4.60E+06 0.5265E-061088 3103  220
4.80E+06 0.5005E-06   5.00E+06 0.4810E-06   5.20E+06 0.4615E-061088 3103  221
5.40E+06 0.4420E-06   5.60E+06 0.4225E-06   5.80E+06 0.4095E-061088 3103  222
6.00E+06 0.3965E-06   6.20E+06 0.3770E-06   6.40E+06 0.3640E-061088 3103  223
6.60E+06 0.3510E-06   6.80E+06 0.3406E-06   7.00E+06 0.3315E-061088 3103  224
7.20E+06 0.3211E-06   7.40E+06 0.3133E-06   7.60E+06 0.3055E-061088 3103  225
7.80E+06 0.2977E-06   8.00E+06 0.2912E-06   8.20E+06 0.2847E-061088 3103  226
8.40E+06 0.2769E-06   8.60E+06 0.2717E-06   8.80E+06 0.2665E-061088 3103  227
9.00E+06 0.2600E-06   9.20E+06 0.2548E-06   9.40E+06 0.2483E-061088 3103  228
9.60E+06 0.2431E-06   9.80E+06 0.2379E-06   1.00E+07 0.2340E-061088 3103  229
1.05E+07 0.2236E-06   1.10E+07 0.2145E-06   1.15E+07 0.2054E-061088 3103  230
1.20E+07 0.1976E-06   1.25E+07 0.1898E-06   1.30E+07 0.1833E-061088 3103  231
1.35E+07 0.1768E-06   1.40E+07 0.1703E-06   1.45E+07 0.1651E-061088 3103  232
1.50E+07 0.1599E-06                                            1088 3103  233
     0.0        0.0          0          0          0          01088 3  0  234
  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+001088 3251  238
2.00E+02 0.1678E+00   3.00E+02 0.1677E+00   5.00E+02 0.1675E+001088 3251  239
7.00E+02 0.1672E+00   1.00E+03 0.1669E+00   2.00E+03 0.1658E+001088 3251  240
3.00E+03 0.1647E+00   5.00E+03 0.1625E+00   7.00E+03 0.1603E+001088 3251  241
1.00E+04 0.1570E+00   2.00E+04 0.1458E+00   3.00E+04 0.1344E+001088 3251  242
5.00E+04 0.1116E+00   7.00E+04 0.8798E-01   1.00E+05 0.5208E-011088 3251  243
1.50E+05-0.9740E-02   2.00E+05-0.7161E-01   2.50E+05-0.1304E+001088 3251  244
3.00E+05-0.1739E+00   3.50E+05-0.2185E+00   4.00E+05-0.2518E+001088 3251  245
4.50E+05-0.2702E+00   5.00E+05-0.2746E+00   5.50E+05-0.2658E+001088 3251  246
6.00E+05-0.2457E+00   6.50E+05-0.2143E+00   7.00E+05-0.1776E+001088 3251  247
7.50E+05-0.1357E+00   8.00E+05-0.8704E-01   8.50E+05-0.4441E-011088 3251  248
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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  0  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
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 1.10E+07 0.2190E+00   1.15E+07 0.2176E+00   1.20E+07 0.2162E+001088 3252  311
 1.25E+07 0.2151E+00   1.30E+07 0.2139E+00   1.35E+07 0.2127E+001088 3252  312
 1.40E+07 0.2116E+00   1.45E+07 0.2104E+00   1.50E+07 0.2093E+001088 3252  313
      0.0        0.0            0            0        0          01088 3  0  314
   2000.0    3.96822            0            0        0          01088 3253  315
      0.0        0.0            0            0        1        1081088 3253  316
      108          3                                             1088 3253  317
 1.00E-05 0.3121E+00   2.53E-02 0.3121E+00   1.00E+02 0.3121E+001088 3253  318
 2.00E+02 0.3122E+00   3.00E+02 0.3122E+00   5.00E+02 0.3122E+001088 3253  319
 7.00E+02 0.3122E+00   1.00E+03 0.3123E+00   2.00E+03 0.3125E+001088 3253  320
 3.00E+03 0.3127E+00   5.00E+03 0.3131E+00   7.00E+03 0.3135E+001088 3253  321
 1.00E+04 0.3141E+00   2.00E+04 0.3161E+00   3.00E+04 0.3180E+001088 3253  322
 5.00E+04 0.3219E+00   7.00E+04 0.3257E+00   1.00E+05 0.3312E+001088 3253  323
 1.50E+05 0.3402E+00   2.00E+05 0.3485E+00   2.50E+05 0.3561E+001088 3253  324
 3.00E+05 0.3617E+00   3.50E+05 0.3675E+00   4.00E+05 0.3724E+001088 3253  325
 4.50E+05 0.3762E+00   5.00E+05 0.3790E+00   5.50E+05 0.3808E+001088 3253  326
 6.00E+05 0.3818E+00   6.50E+05 0.3817E+00   7.00E+05 0.3809E+001088 3253  327
 7.50E+05 0.3791E+00   8.00E+05 0.3765E+00   8.50E+05 0.3736E+001088 3253  328
 9.00E+05 0.3702E+00   9.50E+05 0.3662E+00   1.00E+06 0.3618E+001088 3253  329
 1.05E+06 0.3572E+00   1.10E+06 0.3530E+00   1.13E+06 0.3501E+001088 3253  330
 1.15E+06 0.3482E+00   1.17E+06 0.3464E+00   1.20E+06 0.3435E+001088 3253  331
 1.25E+06 0.3388E+00   1.30E+06 0.3344E+00   1.35E+06 0.3300E+001088 3253  332
 1.40E+06 0.3256E+00   1.45E+06 0.3216E+00   1.50E+06 0.3179E+001088 3253  333
 1.60E+06 0.3100E+00   1.70E+06 0.3034E+00   1.80E+06 0.2975E+001088 3253  334
 1.90E+06 0.2925E+00   2.00E+06 0.2879E+00   2.10E+06 0.2842E+001088 3253  335
 2.20E+06 0.2808E+00   2.30E+06 0.2779E+00   2.40E+06 0.2756E+001088 3253  336
 2.50E+06 0.2738E+00   2.60E+06 0.2722E+00   2.70E+06 0.2711E+001088 3253  337
 2.80E+06 0.2699E+00   2.90E+06 0.2691E+00   3.00E+06 0.2687E+001088 3253  338
 3.20E+06 0.2671E+00   3.40E+06 0.2661E+00   3.60E+06 0.2658E+001088 3253  339
 3.80E+06 0.2664E+00   4.00E+06 0.2671E+00   4.20E+06 0.2672E+001088 3253  340
 4.40E+06 0.2671E+00   4.60E+06 0.2671E+00   4.80E+06 0.2670E+001088 3253  341
 5.00E+06 0.2669E+00   5.20E+06 0.2666E+00   5.40E+06 0.2665E+001088 3253  342
 5.60E+06 0.2664E+00   5.80E+06 0.2664E+00   6.00E+06 0.2661E+001088 3253  343
 6.20E+06 0.2659E+00   6.40E+06 0.2656E+00   6.60E+06 0.2652E+001088 3253  344
 6.80E+06 0.2648E+00   7.00E+06 0.2644E+00   7.20E+06 0.2641E+001088 3253  345
 7.40E+06 0.2636E+00   7.60E+06 0.2634E+00   7.80E+06 0.2628E+001088 3253  346
 8.00E+06 0.2624E+00   8.20E+06 0.2622E+00   8.40E+06 0.2620E+001088 3253  347
 8.60E+06 0.2616E+00   8.80E+06 0.2614E+00   9.00E+06 0.2610E+001088 3253  348
 9.20E+06 0.2604E+00   9.40E+06 0.2601E+00   9.60E+06 0.2597E+001088 3253  349
 9.80E+06 0.2594E+00   1.00E+07 0.2590E+00   1.05E+07 0.2583E+001088 3253  350
 1.10E+07 0.2576E+00   1.15E+07 0.2568E+00   1.20E+07 0.2559E+001088 3253  351
 1.25E+07 0.2552E+00   1.30E+07 0.2543E+00   1.35E+07 0.2536E+001088 3253  352
 1.40E+07 0.2529E+00   1.45E+07 0.2522E+00   1.50E+07 0.2515E+001088 3253  353
      0.0        0.0            0            0        0          01088 3  0  354
      0.0        0.0            0            0        0          01088 0  0  355
   2000.0    3.96822            1            1        0          01088 4  2  356
      0.0    3.96822            0            2      100          91088 4  2  357
 1.0000E+00 1.6800E-01 1.2819E-02         0.0-6.6316E-05         0.01088 4  2  358
 6.3701E-07         0.0-7.4839E-09         0.0        0.0 9.6190E-011088 4  2  359
 2.9686E-01 4.3546E-02 3.1027E-03         0.0-1.4971E-05         0.01088 4  2  360
 1.3935E-07         0.0         0.0-1.5886E-01 9.0195E-01 4.1067E-011088 4  2  361
 8.8718E-02 1.1085E-02 7.1925E-04         0.0-3.1239E-06         0.01088 4  2  362
        0.0 3.5863E-02-2.7304E-01 8.1319E-01 5.0658E-01 1.4568E-011088 4  2  363
 2.5474E-02 2.8077E-03 1.6752E-04         0.0        0.0-8.5905E-031088 4  2  364
 7.8689E-02-3.6481E-01 7.0133E-01 5.8110E-01 2.1109E-01 4.7327E-021088 4  2  365
 7.1261E-03 7.0975E-04         0.0 2.1026E-03-2.2043E-02 1.2928E-011088 4  2  366
-4.3373E-01 5.7179E-01 6.3117E-01 2.8107E-01 7.7131E-02 1.4600E-021088 4  2  367
        0.0-5.1992E-04 6.0621E-03-4.1723E-02 1.8451E-01-4.7795E-011088 4  2  368
 4.3070E-01 6.5479E-01 3.5139E-01 1.1474E-01         0.0 1.2929E-041088 4  2  369
-1.6456E-03 1.2786E-02-6.7791E-02 2.4055E-01-4.9642E-01 2.8461E-011088 4  2  370
 6.5122E-01 4.1767E-01         0.0-3.2264E-05 4.4243E-04-3.7901E-031088 4  2  371
 2.2986E-02-9.9735E-02 2.9341E-01-4.8921E-01 1.4018E-01 6.2111E-011088 4  2  372
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        0.0 8.0695E-06-1.1807E-04 1.0976E-03-7.4043E-03 3.7198E-021088 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
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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	0	601

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