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**BOLTZMAN AVERAGES OF THE FREE-FREE GAUNT FACTOR
IN THE SCREENED COULOMB POTENTIAL**

AUGUST 1974

By:
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Sponsored By:
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Subcontract ~~2932205~~ 2932205
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TABLE OF CONTENTS

	<u>Page</u>
1. Discussion	1
2. Figures and Tables	5
References	67

SECTION 1. DISCUSSION

It is usual to express, a , the free-free absorption coefficient, for the absorption of radiation of frequency ν , by a free electron of velocity v , in the following form:

$$a \approx g(E, \Delta E) \frac{Z^2 4\pi e^6}{3\sqrt{3} \text{ hcm}^2 \nu^3} \text{ cm}^5. \quad (1)$$

Of course, the energy of the absorbing electron in its initial state is

$$E = 1/2 m v^2, \quad (2)$$

and this electron absorbs an amount of energy ΔE ,

$$\Delta E = h\nu, \quad (3)$$

from the incident photon of frequency ν .

The Boltzman average, $\bar{a}$, of the absorption coefficient is

$$\bar{a} = \frac{\int_0^\infty a(E) e^{-E/kT} v^2 dv}{\int_0^\infty e^{-E/kT} v^2 dv}, \quad (4)$$

where T is the temperature of an ensemble of electrons.

From Equations (1), (2), and (4) it then follows that

$$\bar{a} = \frac{Z^2 4\pi e^6}{3\sqrt{3} \text{ hcm}^2 \nu^3} \sqrt{\frac{2m}{\pi kT}} \bar{g}, \quad (5)$$

where

$$\bar{g} = \frac{1}{kT} \int_0^{\infty} g(E, \Delta E) e^{-E/kT} dE \quad (6)$$

is the Boltzman average of the Gaunt factor.

The Gaunt factor, g , of course, contains all of the physics involved in the absorption process. Naturally, g will depend on the interaction potential connecting the electron and its scattering center. Here we assume that the absorbing electron is moving about a central charge Z in a screened Coulomb potential which is given by

$$V(r) = \frac{2Ze^{-\mu r}}{r}, \text{ Rydbergs} \quad (7)$$

where r is measured in units of Bohr radii. Of course, μ is the inverse Debye length λ_D , measured in units of Bohr radii

$$\mu = a_0 / \lambda_D. \quad (8)$$

By referring to the original Schroedinger equation, it can be shown that in a potential of this kind E and ΔE scale with $1/Z^2$, r scales with Z and μ scales with $1/Z$. Consequently, if $g(E, \Delta E; \mu, Z)$ is a Gaunt factor for a potential parameterized by μ, Z , then

$$g(E, \Delta E; \mu, Z) = g\left(\frac{E}{Z^2}, \frac{\Delta E}{Z^2}; \frac{\mu}{Z}, 1\right). \quad (9)$$

Thus, without loss of generality, we need only consider the $Z = 1$ case. Equation (9) provides the value of g when $Z \neq 1$. Furthermore, from Equations (6) and (9) it follows that

$$\bar{g}(\Delta E, kT; \mu, Z) = \bar{g}\left(\frac{\Delta E}{Z^2}, \frac{kT}{Z^2}; \frac{\mu}{Z}, 1\right). \quad (10)$$

Thus if $\bar{g}$, the Boltzman average, is known for $Z = 1$, it is known for all values of Z .

Elsewhere [1-2] we have described in detail the codes and physics underlying a rigorous calculation of $g(E, \Delta E; \mu, 1)$. We have also mentioned [2] that there exists a closed-form approximation to g which is g_{BE} , the Born-Elwert result. For fixed μ and ΔE we have

$$\lim_{E \rightarrow \infty} g_{BE}(E) = g(E). \quad (11)$$

Using the Brem IV code [2], extensive and rigorously accurate calculations of g were carried out. However, whenever $E/Z^2 > 10$, g was replaced by g_{BE} if the approximation differed from the precise result by no more than 0.5%. The results of these calculations are presented in Figures 2 through 9, with each figure corresponding to a different value of μ/Z . Figures 2 through 9 describe results for $\mu/Z = 0.1, 0.25, 0.35, 0.50, 0.75, 1.0, 1.25$ and 1.50 .

Figure 1, which gives results for the $\mu = 0$ case, corresponds to hydrogenic absorption. This special case was previously treated by Karzas and Latter [3]; it is their results which are quoted in Figure 1. In these figures E/Z^2 and $\Delta E/Z^2$ are given in Rydbergs, and μ/Z is measured in units of inverse Bohr radii.

With the energy dependent Gaunt factor at hand it is, in principle, trivial to find $\bar{g}$ through Equation (6). Figures 10 through 18 exhibit $\bar{g}$ as a function of kT/Z^2 for various values of μ/Z and $(\Delta E/Z^2)$.

By way of comparison we also show as dotted curves, $\bar{g}_{BE}$, the Boltzman average of g_{BE} . However, $\bar{g}_{BE}$ is shown over a sparse set of values of $\Delta E/Z^2$. We show $\bar{g}_{BE}$ only for $\Delta E/Z^2 = 0.01, 1.0, 100$ Rydbergs.

A comparison of $\bar{g}_{BE}$ with $\bar{g}$ defines a wide range of values of kT/Z^2 , μ/Z and $\Delta E/Z^2$ over which $\bar{g}_{BE}$ cannot be used successfully to approximate $\bar{g}$. Generally speaking, $\bar{g}_{BE}$ falls at low temperatures and low ΔE .

Tables 1 through 8 provide the numerical results underlying the values of $\bar{g}$ exhibited in Figures 11 through 18. The values of $\bar{g}$ in Figure 10 ($\mu=0$) come from the results quoted by Karzas and Latter [3]. Tables 9 through 17 list the values of $\bar{g}_{BE}$. It must be remembered, however, that $\bar{g}_{BE}$ is provided merely to show the limits of validity of the Born-Elwert approximation. Generally speaking (unless the choice of μ is fortuitous), $\bar{g}_{BE}$ can be used to approximate $\bar{g}$ only* if $\Delta E/Z^2 > 1.0$ and $kT/Z^2 > 10$.

* For instance, when $\mu = 1.25$

$$\bar{g}/\bar{g}_{BE} \approx 1.6 \text{ for } \frac{\Delta E}{Z^2} = 1, \frac{kT}{Z^2} = 1$$

and

$$\bar{g}/\bar{g}_{BE} \approx 1.1 \text{ for } \frac{\Delta E}{Z^2} = 1, \frac{kT}{Z^2} = 10.$$

SECTION 2. FIGURES AND TABLES

Figure 2

Figure 3

Figure 4

Figure 5

Figure 6

Figure 7

Figure 8

Figure 9

SCALED TEMPERATURE, kT

Figure 10

Figure 10.

Figure 11A.

ED TEMPERATURE, KT/Z^2 RYDBERGS

Figure 11A.

2

Figure 1

TEMPERATURE, KT/Z^2 RYDBERGS

2

Figure 11B.

Figure 12A.

TEMPERATURE, kT/Z^2 RYDBERGS

-21/22-

Figure 12A.

2

SCALED TEMPERATURE, k

Figure 12B

TEMPERATURE, KT/Z^2 RYDBERGS

Figure 12B.

2

SCALED TEMPERATURE, KT/Z

Figure 13A.

Figure 13A.

SCALED TEMPERATURE, $KT/Z^2 R$

FIGURE 13B.

D TEMPERATURE, KT/Z^2 RYDBERGS

FIGURE 13B.

2

Figure 14A.

URE, kT/Z^2 RYDBERGS

ure 14A.

2 -29/30-

SCALED TEMPERATURE, KT/

FIGURE 14B.

RATURE, KT/Z^2 RYDBERGS

FIGURE 14B.

2

Figure 15A.

URE, KT/Z^2 RYDBERGS

ure 15A.

2

-33/34-

SCALED TEMPERATURE, k

Figure 15E

TEMPERATURE, KT/Z^2 RYDBERGS

Figure 15B.

2

BOLTZMAN AVERAGED GAUNT FACTOR

Figure 1.

TEMPERATURE, KT/Z^2 RYDBERGS

-37/38-

Figure 16A.

2

FIGURE 16-

LED TEMPERATURE, kT/Z^2 RYDBERGS

FIGURE 16B.

2

Figure 17

Figure 17A.

SCALED TEMPERATURE,

Figure 1.

RE, kT/Z^2 RYDBERGS

Fe 17B.

BOLTZMAN AVERAGED GAUNT FACTOR

SCALED TEMPERATURE, KT

Figure 18A.

TEMPERATURE, kT/Z^2 RYDBERGS

Figure 18A.

SCALED TEMPERATURE, kT/Z

Figure 188.

ERATURE, KT/Z^2 RYDBERGS

Figure 18B.

2

Table 1. Precise Brem-IV Values of the Boltzman Averaged Screened
Free-Free Gaunt Factors for $\mu/Z = 0.1$

$\frac{kT}{Z^2}$ \ $\frac{\Delta E}{Z^2}$	0.003	0.01	0.03	0.1	0.3	1.0	3.0	10.0	30.0	100.0	300.0	1000.0
0.03	1.207 (-1)*	1.700 (-1)	3.845 (-1)	7.134 (-1)	8.963 (-1)	9.965 (-1)	1.013 (0)	9.107 (-1)	7.219 (-1)	4.936 (-1)	3.219 (-1)	1.905 (-1)
0.05	1.918	2.323	4.066	7.149	9.113	1.018 (0)	1.033	9.263	7.337	5.016	3.271	1.936
0.1	3.231	3.523	4.777	7.437	9.404	1.042	1.050	9.390	7.429	5.078	3.311	1.961
0.2	4.928	5.126	5.978	8.105	9.896	1.072	1.065	9.466	7.477	5.108	3.331	1.973
0.3	6.080	6.233	6.894	8.693	1.032 (0)	1.095	1.075	9.501	7.493	5.118	3.338	1.977
0.5	7.666	7.775	8.245	9.645	1.102	1.135	1.092	9.550	7.511	5.128	3.345	1.981
1.0	9.989	1.005 (0)	1.034 (0)	1.127 (0)	1.228	1.215	1.127	9.657	7.553	5.151	3.361	1.989
2.0	1.240 (0)	1.244	1.260	1.318	1.386	1.333	1.189	9.889	7.667	5.218	3.405	2.014
3.0	1.380	1.383	1.394	1.437	1.490	1.421	1.242	1.013 (0)	7.799	5.299	3.458	2.045
5.0	1.554	1.556	1.563	1.591	1.629	1.549	1.332	1.060	8.073	5.470	3.569	2.111
10.0	1.781	1.782	1.786	1.802	1.827	1.748	1.498	1.161	8.713	5.875	3.835	2.271
20.0	1.999	1.999	2.001	2.009	2.028	1.961	1.711	1.314	9.763	6.561	4.289	2.547
30.0	2.122	2.127	2.124	2.129	2.144	2.087	1.851	1.429	1.060 (0)	7.127	4.668	2.779
50.0	2.273	2.273	2.275	2.277	2.290	2.246	2.038	1.598	1.191	8.043	5.293	3.164
100.0	2.474	2.474	2.475	2.476	2.484	2.457	2.296	1.864	1.412	9.685	6.451	3.894

*THE INTEGER IN PARENTHESES IS THE POWER OF TEN BY WHICH THE NUMBER TO THE LEFT IS MULTIPLIED.
IT IS NOT REPEATED FOR EACH COLUMN UNTIL ITS VALUE CHANGES.

Table 2. Precise Brem-IV Values of the Boltzman Averaged Screened
Free-Free Gaunt Factors for $\mu/Z = 0.25$

kT/Z^2	0.003	0.01	0.03	0.1	0.3	1.0	3.0	10.0	30.0	100.0	300.0	1000.0
0.03	4.780 (-2)	5.809 (-2)	1.161 (-1)	4.041 (-1)	8.137 (-1)	1.058 (0)	1.029 (0)	9.598 (-1)	7.634 (-1)	5.201 (-1)	3.361 (-1)	2.006 (-1)
0.05	8.226	9.212	1.431	3.920	7.719	1.029	1.080	9.716	7.676	5.217	3.412	2.021
0.1	1.576 (-1)	1.661 (-1)	2.058	3.971	7.252	9.856 (-1)	1.060	9.641	7.647	5.226	3.407	2.017
0.2	2.707	2.774	3.064	4.450	7.149	9.708	1.046	9.555	7.594	5.195	3.388	2.006
0.3	3.544	3.598	3.834	4.953	7.298	9.731	1.045	9.524	7.567	5.176	3.378	2.001
0.5	4.758	4.798	4.975	5.808	7.711	9.959	1.050	9.511	7.545	5.165	3.370	1.996
1.0	6.622	6.648	6.762	7.235	8.643	1.042 (1)	1.075	9.562	7.547	5.170	3.373	1.998
2.0	8.628	8.645	8.714	9.036	9.928	1.125	1.125	9.752	7.624	5.226	3.410	2.021
3.0	9.826	9.839	9.891	1.013 (0)	1.061 (0)	1.188	1.170	9.971	7.719	5.302	3.460	2.051
5.0	1.133 (0)	1.114 (0)	1.118 (0)	1.153	1.200	1.287	1.244	1.041 (0)	7.995	5.469	3.570	2.116
10.0	1.334	1.335	1.337	1.346	1.373	1.423	1.376	1.138	8.617	5.891	3.835	2.276
20.0	1.532	1.532	1.534	1.538	1.554	1.584	1.519	1.285	9.652	6.555	4.289	2.554
30.0	1.645	1.646	1.647	1.650	1.661	1.673	1.643	1.392	1.048 (0)	7.120	4.668	2.782
50.0	1.788	1.788	1.789	1.791	1.799	1.813	1.781	1.546	1.177	8.033	5.293	3.167
100.0	1.980	1.980	1.981	1.982	1.985	1.994	1.974	1.777	1.393	9.668	6.151	3.896

Table 3. Precise Brem-IV Values of the Boltzman Averaged Screened
Free-Free Gaunt Factors for $\mu/Z = 0.35$

$\frac{kT}{Z^2}$	0.003	0.01	0.03	0.1	0.3	1.0	3.0	10.0	30.0	100.0	300.0	1000.0
0.03	1.848 (-2)	2.079 (-2)	2.947 (-2)	9.266 (-2)	3.101 (-1)	7.127 (-1)	9.555 (-1)	1.023 (0)	8.414 (-1)	5.819 (-1)	3.806 (-1)	2.255 (-1)
0.05	4.192	4.509	5.649	1.251 (-1)	3.424	7.221	9.787	9.901 (-1)	8.111	5.603	3.669	2.171
0.1	1.007 (-1)	1.045 (-1)	1.176 (-1)	1.865	3.945	7.444	9.643	9.575	7.803	5.381	3.517	2.084
0.2	1.967	2.004	2.129	2.738	4.585	7.765	9.648	9.407	7.627	5.251	3.431	2.032
0.3	2.705	2.738	2.851	3.388	5.044	8.004	9.769	9.365	7.571	5.208	3.402	2.016
0.5	3.796	3.825	3.918	4.354	5.735	8.366	9.841	9.354	7.532	5.177	3.381	2.003
1.0	5.498	5.518	5.585	5.890	6.889	8.996	1.013 (0)	9.407	7.524	5.164	3.372	1.998
2.0	7.348	7.362	7.406	7.604	8.272	9.830	1.063	9.588	7.547	5.204	3.398	2.014
3.0	8.461	8.471	8.505	8.655	9.165	1.042 (0)	1.102	9.786	7.707	5.271	3.442	2.040
5.0	9.871	9.878	9.901	1.000 (0)	1.036 (0)	1.129	1.167	1.021 (0)	7.957	5.428	3.545	2.102
10.0	1.178 (0)	1.178 (0)	1.180 (0)	1.185	1.205	1.264	1.284	1.113	8.570	5.823	3.806	2.259
20.0	1.367	1.367	1.368	1.371	1.382	1.417	1.426	1.249	9.592	6.408	4.261	2.533
30.0	1.477	1.477	1.478	1.479	1.487	1.513	1.519	1.348	1.041 (0)	7.177	4.644	2.766
50.0	1.615	1.615	1.616	1.616	1.620	1.638	1.643	1.489	1.168	7.597	5.275	3.154
100.0	1.803	1.803	1.803	1.803	1.805	1.815	1.819	1.699	1.379	9.638	6.439	3.888

Table 4. Precise Brem-IV Values of the Boltzman Averaged Screened
Free-Free Gaunt Factors for $\mu/Z = 0.5$

$\frac{kT}{Z^2}$ \ $\frac{AE}{Z^2}$	0.003	0.01	0.03	0.1	0.3	1.0	3.0	10.0	30.0	100.0	300.0	1000.0
0.03	7.885 (-3)	8.878 (-3)	1.248 (-2)	3.335 (-2)	1.162 (-1)	3.135 (-1)	4.769 (-1)	5.059 (-1)	4.186 (-1)	2.901 (-1)	1.898 (-1)	1.125 (-1)
0.05	2.059 (-2)	2.212 (-2)	2.723	5.298	1.478	3.712	5.550	5.845	4.839	3.352	2.193	1.300
0.1	5.970	6.187	6.873	9.944	2.049	4.544	6.582	6.861	5.666	3.922	2.566	1.521
0.2	1.345 (-1)	1.369 (-1)	1.444 (-1)	1.758 (-1)	2.808	5.377	7.492	7.705	6.342	4.387	2.869	1.700
0.3	1.963	1.986	2.058	2.355	3.345	5.848	7.941	8.092	6.645	4.594	3.004	1.781
0.5	2.909	2.929	2.993	3.251	4.117	6.426	8.420	8.467	6.930	4.787	3.131	1.855
1.0	4.417	4.433	4.481	4.674	5.330	7.226	8.971	8.828	7.183	4.956	3.241	1.921
2.0	6.080	6.091	6.124	6.256	6.709	8.122	9.529	9.152	7.384	5.086	3.326	1.972
3.0	7.090	7.098	7.214	7.226	7.578	8.721	9.915	9.394	7.533	5.181	3.388	2.009
5.0	8.381	8.387	8.405	8.476	8.725	9.569	1.050 (0)	9.816	7.810	5.360	3.506	2.080
10.0	1.015 (0)	1.015 (0)	1.017 (0)	1.021 (0)	1.036 (0)	1.089 (0)	1.152	1.068 (0)	8.434	5.772	3.778	2.243
20.0	1.194	1.194	1.194	1.196	1.206	1.237	1.279	1.193	9.845	6.467	4.241	2.521
30.0	1.298	1.299	1.299	1.300	1.308	1.330	1.362	1.282	1.024 (0)	7.039	4.628	2.755
50.0	1.431	1.431	1.432	1.431	1.438	1.453	1.475	1.437	1.147	7.959	5.262	3.145
100.0	1.613	1.613	1.614	1.613	1.618	1.626	1.639	1.591	1.348	9.593	6.430	3.881

Table 5. Precise Brem-IV Values of the Boltzman Averaged Screened Free-Free Gaunt Factors for $\mu/Z = 0.75$

$\frac{kT}{Z^2} \backslash \frac{aE}{Z^2}$	0.003	0.01	0.03	0.1	0.3	1.0	3.0	10.0	30.0	100.0	300.0	1000.0
0.03	9.308 (-3)	1.043 (-2)	1.412 (-2)	3.195 (-2)	1.015 (-1)	3.014 (-1)	5.062 (-1)	5.668 (-1)	4.784 (-1)	3.334 (-1)	2.184 (-1)	1.295 (-1)
0.05	1.997 (-2)	2.141	2.600	4.686	1.249	3.502	5.851	6.554	5.534	3.858	2.528	1.499
0.1	4.981	5.160	5.713	8.071	1.647	4.112	6.774	7.584	6.408	4.469	2.928	1.737
0.2	1.057 (-1)	1.076 (-1)	1.134 (-1)	1.369 (-1)	2.178	4.632	7.424	8.289	7.004	4.886	3.203	1.899
0.3	1.525	1.543	1.598	1.818	2.570	4.906	7.673	8.535	7.211	5.031	3.298	1.956
0.5	2.255	2.271	2.320	2.511	3.159	5.249	7.879	8.701	7.344	5.125	3.360	1.993
1.0	3.454	3.466	3.503	3.647	4.132	5.785	8.072	8.777	7.388	5.155	3.380	2.006
2.0	4.822	4.830	4.856	4.955	5.289	6.484	8.322	8.854	7.417	5.172	3.392	2.013
3.0	5.675	5.682	5.703	5.780	6.040	6.994	8.554	8.972	7.489	5.219	3.424	2.032
5.0	6.794	6.799	6.813	6.868	7.053	7.748	8.972	9.251	7.689	5.353	3.513	2.086
10.0	8.374	8.378	8.386	8.420	8.531	8.963	9.794	9.917	8.233	5.727	3.763	2.237
20.0	1.002 (0)	1.002 (0)	1.003 (0)	1.005 (0)	1.011 (0)	1.037 (0)	1.090 (0)	1.093 (0)	9.165	6.395	4.213	2.510
30.0	1.101	1.101	1.101	1.102	1.107	1.126	1.166	1.166	9.906	6.953	4.594	2.743
50.0	1.227	1.228	1.227	1.228	1.231	1.244	1.271	1.271	1.104 (0)	7.855	5.224	3.132
100.0	1.403	1.403	1.402	1.403	1.404	1.412	1.428	1.429	1.286	9.460	6.389	3.870

Table 6. Precise Brem-IV Values of the Boltzman Averaged Screened
Free-Free Gaunt Factors for $\mu/Z = 1.0$

$\frac{kT}{Z^2\mu}$	0.003	0.01	0.03	0.1	0.3	1.0	3.0	10.0	30.0	100.0	300.0	1000.0
0.03	1.431 (-2)	1.611 (-2)	2.243 (-2)	5.451 (-2)	1.852 (-1)	6.216 (-1)	1.165 (0)	1.399 (0)	1.214 (0)	8.546 (-1)	5.614 (-1)	3.332 (-1)
0.05	2.564	2.758	3.416	6.637	1.946	6.226	1.162	1.398	1.214	8.547	5.616	3.333
0.1	5.240	5.437	6.083	9.095	2.072	5.974	1.103	1.330	1.156	8.145	5.352	3.177
0.2	9.739	9.919	1.050 (-1)	1.309 (-1)	2.280	5.585	1.007	1.216	1.059	7.467	4.908	2.914
0.3	1.338 (-1)	1.354 (-1)	1.406	1.633	2.475	5.378	9.458 (-1)	1.142	9.960 (-1)	7.030	4.622	2.744
0.5	1.905	1.919	1.953	2.149	2.826	5.210	8.751	1.054	9.206	6.503	4.277	2.540
1.0	2.858	2.868	2.900	3.033	3.507	5.230	8.029	9.570 (-1)	8.365	5.916	3.894	2.313
2.0	3.990	3.997	4.019	4.107	4.420	5.590	7.687	8.961	7.830	5.544	3.651	2.170
3.0	4.721	4.726	4.743	4.812	5.051	5.961	7.685	8.802	7.684	5.443	3.586	2.132
5.0	5.705	5.709	5.721	5.770	5.937	6.584	7.895	8.815	7.691	5.451	3.595	2.138
10.0	7.139	7.142	7.149	7.179	7.279	7.671	8.532	9.209	8.061	5.725	3.782	2.252
20.0	8.675	8.677	8.681	8.698	8.757	8.986	9.524	9.998	8.860	6.339	4.201	2.508
30.0	9.615	9.617	9.620	9.633	9.674	9.839	1.024 (0)	1.062 (0)	9.520	6.874	4.573	2.735
50.0	1.084 (0)	1.084 (0)	1.084 (0)	1.085 (0)	1.088 (0)	1.099 (0)	1.126	1.153	1.054 (0)	7.749	5.193	3.121
100.0	1.256	1.256	1.256	1.257	1.258	1.264	1.279	1.296	1.218	9.307	6.350	3.856

Table 7. Precise Brem-IV values of the Boltzman Averaged Screened
Free-Free Gaunt Factors for $\mu/Z = 1.25$

$\frac{kT}{Z^2}$	0.003	0.01	0.03	0.1	0.3	1.0	3.0	10.0	30.0	100.0	300.0	1000.0
0.05	1.456 (-2)	1.680 (-2)	2.565 (-2)	7.352 (-2)	2.765 (-1)	1.053 (0)	2.239 (0)	2.938 (0)	2.644 (0)	1.889 (0)	1.245 (0)	7.412 (-1)
0.05	2.353	2.562	3.353	7.504	2.480	9.056 (-1)	1.919	2.521	2.269	1.622	1.070	6.364
0.1	4.396	4.580	5.243	8.559	2.202	7.304	1.527	2.009	1.811	1.295	8.540 (-1)	5.082
0.2	7.822	7.979	8.515	1.107 (-1)	2.114	5.933	1.206	1.590	1.435	1.028	6.789	4.037
0.3	1.064 (-1)	1.078 (-1)	1.125 (-1)	1.340	2.173	5.343	1.055	1.382	1.260	9.027 (-1)	5.961	3.544
0.5	1.516	1.528	1.566	1.735	2.377	4.836	9.048 (-1)	1.191	1.080	7.752	5.121	3.045
1.0	2.305	2.314	2.341	2.458	2.891	4.570	7.652	9.954 (-1)	9.069 (-1)	6.572	4.312	2.556
2.0	3.283	3.289	3.308	3.386	3.665	4.761	6.941	8.783	8.029	5.789	3.932	2.281
3.0	3.935	3.939	3.954	4.014	4.226	5.064	4.810	8.411	7.701	5.562	3.685	2.194
5.0	4.831	4.834	4.845	4.887	5.035	5.420	6.913	8.233	7.553	5.468	3.627	2.161
10.0	6.168	6.170	6.177	6.201	6.290	6.643	7.467	8.447	7.787	5.667	3.769	2.249
20.0	7.629	7.631	7.635	7.650	7.701	7.975	8.408	9.101	8.479	6.243	4.170	2.495
30.0	8.533	8.534	8.537	8.548	8.585	8.734	9.095	9.648	9.070	6.759	4.538	2.722
50.0	9.713	9.713	9.715	9.723	9.747	9.806	1.007 (0)	1.048 (0)	9.974	7.589	5.154	3.110
100.0	1.137 (0)	1.137 (0)	1.137 (0)	1.138 (0)	1.139 (0)	1.145 (0)	1.156	1.181	1.143 (0)	9.037	6.316	3.850

Table 8. Precise Brem-IV Values of the Boltzman Averaged Screened
Free-Free Gaunt Factors for $\mu/Z = 1.5$

$\frac{kT}{Z^2} \backslash \frac{\Delta E}{Z^2}$	0.003	0.01	0.03	0.1	0.3	1.0	3.0	10.0	30.0	100.0	300.0	1000.0
0.03	5.424 (-3)	6.074 (-3)	8.203 (-3)	1.820 (-2)	5.923 (-2)	2.312 (-1)	5.519 (-1)	8.028 (-1)	7.570 (-1)	5.518 (-1)	3.662 (-1)	2.182 (-1)
0.05	1.061 (-2)	1.137 (-2)	1.381 (-2)	2.481	6.860	2.503	5.911	8.603	8.119	5.920	3.930	2.341
0.1	2.412	2.499	2.769	3.933	8.381	2.659	6.119	8.912	8.426	6.148	4.083	2.432
0.2	4.939	5.027	5.298	6.425	1.056 (-1)	2.733	5.994	8.725	8.274	6.045	4.015	2.393
0.3	7.156	7.241	7.501	8.558	1.237	2.773	5.823	8.459	8.039	5.879	3.907	2.328
0.5	1.087 (-1)	1.095 (-1)	1.118 (-1)	1.212 (-1)	1.540	2.863	5.576	8.046	7.674	5.621	3.737	2.228
1.0	1.767	1.773	1.792	1.865	2.116	3.125	5.310	7.502	7.193	5.284	3.517	2.097
2.0	2.646	2.651	2.665	2.718	2.896	3.614	5.263	7.133	6.873	5.066	3.377	2.015
3.0	3.247	3.251	3.262	3.305	3.447	4.018	5.376	7.044	6.804	5.027	3.354	2.002
5.0	4.086	4.089	4.097	4.130	4.233	4.651	5.682	7.091	6.867	5.090	3.402	2.033
10.0	5.359	5.361	5.366	5.387	5.452	5.715	6.389	7.454	7.244	5.410	3.627	2.171
20.0	6.768	6.769	6.773	6.786	6.825	6.984	7.402	8.159	7.971	6.041	4.073	2.444
30.0	7.649	7.650	7.653	7.662	7.691	7.802	8.116	8.716	8.552	6.572	4.454	2.680
50.0	8.811	8.811	8.813	8.819	8.838	8.896	9.122	9.549	9.430	7.426	5.085	3.073
100.0	1.047 (0)	1.047 (0)	1.047 (0)	1.047 (0)	1.047 (0)	1.047 (0)	1.054 (0)	1.088 (0)	1.083 (0)	8.913	6.247	3.817

Table 9. Born-Elwert Approximation to the Boltzman Averaged Screened Free-Free Gaunt Factors for $\mu/Z = 0$

$\frac{kT}{Z^2}$ \ $\frac{\mu}{Z}$	0.003	0.01	0.03	0.1	0.3	1.0	3.0	10.0	30.0	100.0	300.0	1000.0
0.03	1.990 (0)*	1.586 (0)	1.341 (0)	1.195 (0)	1.137 (0)	1.111 (0)	1.076 (0)	9.520 (-1)	7.526 (-1)	5.144 (-1)	3.355 (-1)	1.987 (-1)
0.05	2.198	1.741	1.440	1.243	1.157	1.118	1.078	9.524	7.527	5.144	3.355	1.987
0.10	2.508	1.990	1.616	1.341	1.203	1.134	1.083	9.531	7.527	5.144	3.355	1.987
0.20	2.842	2.277	1.839	1.482	1.278	1.163	1.092	9.548	7.529	5.144	3.355	1.987
0.30	3.046	2.459	1.990	1.586	1.340	1.190	1.101	9.564	7.532	5.145	3.355	1.987
0.50	3.309	2.701	2.198	1.741	1.438	1.236	1.118	9.601	7.540	5.148	3.358	1.989
1.0	3.674	3.046	2.508	1.989	1.613	1.328	1.156	9.709	7.579	5.169	3.371	1.999
2.0	4.046	3.404	2.842	2.275	1.833	1.464	1.223	9.956	7.693	5.236	3.415	2.023
3.0	4.265	3.618	3.045	2.456	1.982	1.565	1.280	1.021 (0)	7.826	5.317	3.468	2.055
5.0	4.543	3.890	3.308	2.697	2.189	1.716	1.375	1.069	8.101	5.487	3.579	2.121
10.0	4.921	4.265	3.673	3.042	2.498	1.963	1.550	1.173	8.743	5.893	3.845	2.281
20.0	5.301	4.642	4.044	3.400	2.832	2.251	1.777	1.329	9.796	6.579	4.299	2.555
30.0	5.523	4.863	4.264	3.614	3.037	2.435	1.932	1.446	1.064 (1)	7.145	4.679	2.786
50.0	5.803	5.143	4.542	3.888	3.301	2.690	2.148	1.618	1.195	8.062	5.304	3.171
100.0	6.184	5.523	4.920	4.263	3.668	3.029	2.458	1.892	1.417	9.705	6.463	3.901

* THE INTEGER IN PARENTHESES IS THE POWER OF TEN BY WHICH THE NUMBER TO THE LEFT IS MULTIPLIED. IT IS NOT REPEATED FOR EACH COLUMN UNTIL ITS VALUE CHANGES.

Table 10. Born-Elwert Approximation to the Boltzman Averaged Screened Free-Free Gaunt Factors for $\mu/Z = 0.1$

$\frac{kT}{Z^2}$ \ $\frac{\Delta E}{Z^2}$	0.003	0.01	0.03	0.1	0.3	1.0	3.0	10.0	30.0	100.0	300.0	1000.0
0.03	4.151 (-1)	5.174 (-1)	7.252 (-1)	9.649 (-1)	1.060 (0)	1.069 (0)	1.069 (0)	9.501 (-1)	7.521 (-1)	5.143 (-1)	3.355 (-1)	1.987 (-1)
0.05	5.119	5.949	7.709	9.917	1.077	1.095	1.071	9.504	7.522	5.143	3.355	1.987
0.10	6.594	7.193	8.533	1.044 (0)	1.113	1.110	1.076	9.512	7.522	5.143	3.355	1.987
0.20	8.214	8.628	9.598	1.116	1.170	1.137	1.085	9.528	7.524	5.143	3.355	1.987
0.30	9.212	9.539	1.033 (0)	1.169	1.215	1.162	1.093	9.545	7.527	5.144	3.355	1.987
0.50	1.051 (0)	1.075 (0)	1.134	1.246	1.285	1.274	1.110	9.581	7.535	5.147	3.357	1.989
1.0	1.232	1.247	1.286	1.367	1.399	1.287	1.147	9.689	7.574	5.168	3.371	1.997
2.0	1.417	1.426	1.451	1.507	1.534	1.405	1.212	9.934	7.688	5.235	3.415	2.023
3.0	1.526	1.533	1.552	1.596	1.621	1.490	1.267	1.019 (0)	7.821	5.316	3.467	2.055
5.0	1.665	1.670	1.682	1.714	1.715	1.612	1.357	1.067	8.095	5.486	3.578	2.121
10.0	1.854	1.857	1.864	1.884	1.900	1.796	1.521	1.169	8.736	5.891	3.845	2.281
20.0	2.043	2.045	2.050	2.062	2.073	1.999	1.728	1.323	9.786	6.577	4.299	2.555
30.0	2.154	2.156	2.160	2.168	2.177	2.119	1.866	1.438	1.062 (0)	7.144	4.679	2.786
50.0	2.294	2.296	2.298	2.304	2.311	2.269	2.047	1.606	1.193	8.060	5.304	3.171
100.0	2.485	2.486	2.488	2.491	2.495	2.471	2.392	1.870	1.414	9.701	6.463	3.901

Table 11. Born-Elwert Approximation to the Boltzman Averaged Screened
Free-Free Gaunt Factors for $\mu/Z = 0.25$

$\frac{kT}{Z^2}$	0.003	0.01	0.03	0.1	0.3	1.0	3.0	10.0	30.0	100.0	300.0	1000.0
0.03	1.123 (-1)	1.380 (-1)	2.187 (-1)	4.612 (-1)	7.708 (-1)	9.824 (-1)	1.033 (0)	9.402 (-1)	7.495 (-1)	5.138 (-1)	3.354 (-1)	1.987 (-1)
0.05	1.672	1.912	2.642	4.845	7.801	9.871	1.034	9.405	7.495	5.138	3.354	1.987
0.10	2.656	2.861	3.465	5.317	8.007	9.983	1.039	9.413	7.496	5.138	3.354	1.987
0.20	3.897	4.060	4.533	6.005	8.347	1.018 (0)	1.056	9.428	7.498	5.138	3.353	1.987
0.30	4.724	4.862	5.262	6.518	8.525	1.035	1.054	9.444	7.500	5.138	3.354	1.987
0.50	5.853	5.963	6.278	7.281	9.075	1.065	1.058	9.479	7.509	5.142	3.356	1.989
1.0	7.506	7.583	7.801	8.509	9.881	1.122	1.101	9.582	7.547	5.163	3.370	1.997
2.0	9.257	9.308	9.453	9.930	1.092 (0)	1.200	1.156	9.817	7.660	5.230	3.414	2.023
3.0	1.031 (0)	1.035 (0)	1.046 (0)	1.083 (0)	1.163	1.256	1.202	1.006 (0)	7.792	5.310	3.466	2.054
5.0	1.167	1.169	1.177	1.204	1.262	1.318	1.276	1.052	8.064	5.400	3.577	2.121
10.0	1.353	1.354	1.359	1.375	1.413	1.466	1.406	1.150	8.698	5.885	3.843	2.281
20.0	1.541	1.542	1.545	1.554	1.577	1.613	1.563	1.294	9.737	6.570	4.297	2.555
30.0	1.652	1.652	1.654	1.662	1.678	1.706	1.664	1.399	1.056 (0)	7.134	4.677	2.786
50.0	1.791	1.792	1.793	1.798	1.809	1.829	1.798	1.551	1.185	8.048	5.302	3.170
100.0	1.981	1.982	1.982	1.985	1.992	2.024	1.955	1.780	1.400	9.684	6.460	3.900

Table 12. Born-Elwert Approximation to the Boltzman Averaged Screened
Free-Free Gaunt Factors for $\mu/Z = 0.35$

$\frac{kT}{Z^2}$ \ $\frac{eE}{Z^2}$	0.003	0.01	0.03	0.1	0.3	1.0	3.0	10.0	30.0	100.0	300.0	1000.0
0.03	5.675 (-2)	6.909 (-2)	1.104 (-1)	2.681 (-1)	5.707 (-1)	8.793 (-1)	9.932 (-1)	9.290 (-1)	7.465 (-1)	5.132 (-1)	3.352 (-1)	1.987 (-1)
0.05	9.284	1.057 (-1)	1.453	2.921	5.798	8.830	9.947	9.294	7.465	5.132	3.352	1.987
0.10	1.648 (-1)	1.766	2.126	3.404	6.061	8.917	9.983	9.301	7.466	5.132	3.352	1.987
0.20	2.647	2.749	3.051	4.106	6.342	9.072	1.005 (0)	9.315	7.468	5.132	3.352	1.987
0.30	3.354	3.443	3.708	4.526	6.625	9.208	1.012	9.330	7.470	5.132	3.353	1.987
0.50	4.355	4.429	4.647	5.397	7.086	9.441	1.024	9.363	7.479	5.136	3.355	1.988
1.0	5.877	5.932	6.090	6.635	7.912	9.901	1.053	9.462	7.516	5.156	3.368	1.996
2.0	7.539	7.578	7.687	8.063	8.976	1.056 (0)	1.100	9.687	7.628	5.223	3.412	2.023
3.0	8.558	8.590	8.675	8.971	9.702	1.104	1.139	9.919	7.758	5.304	3.485	2.054
5.0	9.876	9.901	9.963	1.018 (0)	1.072 (0)	1.177	1.292	1.036 (0)	8.028	5.473	3.576	2.121
10.0	1.171 (0)	1.173 (0)	1.176 (0)	1.190	1.224	1.296	1.313	1.129	8.656	5.077	3.842	2.281
20.0	1.358	1.359	1.361	1.369	1.390	1.437	1.448	1.264	9.681	6.561	4.296	2.555
30.0	1.468	1.469	1.470	1.476	1.491	1.527	1.537	1.361	1.049 (0)	7.124	4.675	2.786
50.0	1.607	1.608	1.609	1.613	1.623	1.647	1.655	1.500	1.175	8.035	5.299	3.170
100.0	1.797	1.797	1.798	1.800	1.806	1.820	1.826	1.707	1.384	9.664	6.457	3.400

Table 13. Born-Elwert Approximation to the Boltzman Averaged Screened Free-Free Gaunt Factors for $\mu/Z = 0.5$

$\frac{kT}{Z^2}$	0.003	0.01	0.03	0.1	0.3	1.0	3.0	10.0	30.0	100.0	300.0	1000.0
0.03	2.388 (-2)	2.881 (-2)	4.596 (-2)	1.242 (-1)	3.450 (-1)	2.090 (-1)	9.165 (-1)	9.061 (-1)	7.402 (-1)	5.119 (-1)	3.349 (-1)	1.986 (-1)
0.05	4.356	4.906	6.705	1.436	3.552	7.119	9.177	9.063	7.403	5.119	3.349	1.986
0.10	8.860	9.448	1.126 (-1)	1.842	3.779	7.188	9.206	9.070	7.403	5.119	3.349	1.986
0.20	1.599 (-1)	1.656 (-1)	1.825	2.458	4.153	7.314	9.261	9.082	7.405	5.118	3.349	1.986
0.30	2.147	2.201	2.357	2.929	4.459	7.428	9.312	9.095	7.407	5.120	3.350	1.986
0.50	2.970	3.017	3.153	3.642	4.951	7.629	9.410	9.125	7.415	5.123	3.352	1.988
1.00	4.297	4.333	4.439	4.814	5.821	8.038	9.631	9.215	7.452	5.143	3.365	1.996
2.00	5.817	5.843	5.920	6.193	6.924	8.649	1.001 (0)	9.422	7.561	5.210	3.409	2.022
3.00	6.774	6.796	6.958	7.079	7.670	9.116	1.032	9.634	7.689	5.290	3.462	2.054
5.00	8.035	8.052	8.099	8.263	8.703	9.825	1.084	1.004 (0)	7.953	5.459	3.573	2.120
10.0	9.816	9.829	9.858	9.964	1.025 (0)	1.100 (0)	1.176	1.088	8.568	5.861	3.838	2.280
20.0	1.165 (0)	1.166 (0)	1.168 (0)	1.174 (0)	1.192	1.240	1.294	1.209	9.565	6.541	4.292	2.554
30.0	1.274	1.275	1.276	1.281	1.294	1.330	1.373	1.295	1.035 (0)	7.102	4.671	2.785
50.0	1.413	1.413	1.414	1.417	1.426	1.450	1.482	1.416	1.156	8.007	5.294	3.170
100.0	1.601	1.602	1.602	1.604	1.609	1.623	1.643	1.597	1.354	9.623	6.450	3.899

Table 14. Born-Elwert Approximation to the Boltzman Averaged Screened Free-Free Gaunt Factors for $\mu/Z = 0.75$

$\frac{kT}{Z^2}$	0.003	0.01	0.03	0.1	0.3	1.0	3.0	10.0	30.0	100.0	300.0	1000.0
0.03	7.446 (-3)	8.917 (-3)	1.414 (-2)	4.109 (-2)	1.480 (-1)	4.556 (-1)	7.625 (-1)	8.532 (-1)	7.252 (-1)	5.087 (-1)	3.342 (-1)	1.985 (-1)
0.05	1.535 (-2)	1.719 (-2)	2.325	5.257	1.570	4.588	7.633	8.534	7.252	5.087	3.342	1.985
0.10	3.694	3.922	4.627	7.595	1.774	4.652	7.654	8.538	7.252	5.087	3.342	1.985
0.20	7.787	8.042	8.795	1.175 (-1)	2.117	4.799	7.693	8.548	7.253	5.087	3.342	1.985
0.30	1.134 (-1)	1.160 (-1)	1.235 (-1)	1.521	2.402	4.922	7.730	8.558	7.255	5.087	3.343	1.985
0.50	1.718	1.743	1.814	2.077	2.866	5.142	7.801	8.581	7.263	5.091	3.345	1.987
1.00	2.755	2.777	2.837	3.058	3.700	5.587	7.966	8.653	7.297	5.111	3.358	1.995
2.00	4.047	4.063	4.111	4.282	4.773	6.243	8.261	8.825	7.402	5.177	3.402	2.021
3.00	4.900	4.914	4.954	5.096	5.504	6.738	8.519	9.002	7.523	5.256	3.455	2.052
5.00	6.057	6.068	6.099	6.209	6.521	7.481	8.957	9.339	7.775	5.424	3.565	2.119
10.00	7.740	7.747	7.768	7.841	8.048	8.697	9.776	1.004 (0)	8.359	5.822	3.830	2.278
20.00	9.512	9.516	9.529	9.575	9.706	1.012 (0)	1.086 (0)	1.105	9.297	6.495	4.282	2.552
30.00	1.058 (0)	1.058 (0)	1.059 (0)	1.062 (0)	1.072 (0)	1.103	1.161	1.177	1.003 (0)	7.049	4.660	2.783
50.00	1.194	1.194	1.195	1.197	1.204	1.225	1.267	1.279	1.114	7.940	5.282	3.167
100.00	1.381	1.381	1.381	1.383	1.386	1.399	1.424	1.434	1.293	9.523	6.433	3.896

Table 15. Born-Elwert Approximation to the Boltzman Averaged Screened Free-Free Gaunt Factors for $\mu/Z = 1.0$

$\frac{kT}{Z^2}$	0.003	0.01	0.03	0.1	0.3	1.0	3.0	10.0	30.0	100.0	300.0	2000.0
0.03	2.932 (-3)	3.495 (-3)	5.518 (-3)	1.655 (-2)	6.828 (-2)	2.805 (-1)	6.050 (-1)	7.866 (-1)	7.048 (-1)	5.043 (-1)	3.333 (-1)	1.983 (-1)
0.05	6.526	7.280	9.788	2.198	7.444	2.839	6.058	7.867	7.048	5.043	3.333	1.983
0.10	1.764 (-2)	1.868 (-2)	2.192 (-2)	3.584	8.900	2.920	6.077	7.870	7.049	5.043	3.333	1.983
0.20	4.190	4.319	4.704	6.229	1.150 (-1)	3.068	6.113	7.877	7.049	5.043	3.333	1.983
0.30	6.520	6.658	7.065	8.624	1.376	3.202	6.149	7.884	7.051	5.043	3.333	1.983
0.50	1.067 (-1)	1.081 (-1)	1.122 (-1)	1.276	1.760	3.437	6.217	7.901	7.057	5.047	3.335	1.985
1.00	1.871	1.884	1.922	2.052	2.483	3.908	6.379	7.958	7.089	5.067	3.349	1.993
2.00	2.954	2.966	2.998	3.113	3.454	4.592	6.670	8.098	7.187	5.132	3.392	2.019
3.00	3.706	3.716	3.743	3.843	4.133	5.102	6.927	8.245	7.301	5.210	3.444	2.051
5.00	4.757	4.765	4.787	4.867	5.097	5.863	7.363	8.528	7.538	5.375	3.555	2.117
10.00	6.333	6.339	6.354	6.409	6.567	7.095	8.182	9.126	8.084	5.769	3.819	2.276
20.00	8.034	8.037	8.048	8.084	8.186	8.531	9.271	9.996	8.955	6.431	4.269	2.550
30.00	9.070	9.073	9.080	9.107	9.185	9.447	1.052 (0)	1.063 (0)	9.627	6.975	4.646	2.781
50.00	1.040 (0)	1.041 (0)	1.041 (0)	1.043 (0)	1.048 (0)	1.067 (0)	1.108	1.155	1.064 (0)	7.848	5.265	3.165
100.00	1.225	1.225	1.226	1.227	1.230	1.241	1.266	1.298	1.225	9.390	6.409	3.692

Table 16. Born-Elwert Approximation to the Boltzman Averaged Screened Free-Free Gaunt Factors for $\mu/Z = 1.25$

$\frac{kT}{Z^2} \frac{h^2}{m^2 c^2}$	0.003	0.01	0.03	0.1	0.3	1.0	3.0	10.0	30.0	100.0	300.0	1000.0
0.03	1.355 (-3)	1.609 (-3)	2.534 (-3)	7.722 (-3)	3.442 (-2)	1.725 (-1)	4.654 (-1)	7.119 (-1)	6.799 (-1)	4.987 (-1)	3.320 (-1)	1.981 (-1)
0.05	3.170	3.525	4.722	1.066 (-2)	3.833	1.757	4.663	7.120	6.799	4.987	3.320	1.981
0.10	9.302	9.834	1.150 (-2)	1.872	4.800	1.833	4.685	7.122	6.799	4.987	3.320	1.981
0.20	2.421 (-1)	2.493 (-2)	2.709	3.563	6.637	1.973	4.727	7.127	6.800	4.987	3.320	1.981
0.30	3.977	4.058	4.297	5.212	8.328	2.100	4.767	7.132	6.801	4.987	3.321	1.981
0.50	6.943	7.031	7.289	8.244	1.133 (-1)	2.325	4.845	7.145	6.806	4.991	3.323	1.983
1.00	1.318 (-1)	1.327 (-1)	1.353 (-1)	1.446 (-1)	1.732	2.780	5.024	7.191	6.835	5.010	3.336	1.991
2.00	2.224	2.232	2.255	2.337	2.581	3.447	5.339	7.309	6.925	5.074	3.380	2.017
3.00	2.682	2.689	2.910	2.982	3.196	3.947	5.611	7.436	7.032	5.152	3.432	2.042
5.00	3.831	3.837	3.855	3.915	4.089	4.696	6.067	7.683	7.252	5.314	3.541	2.115
10.00	5.300	5.304	5.316	5.360	5.484	5.913	6.910	8.216	7.759	5.701	3.804	2.274
20.00	6.925	6.928	6.936	6.965	7.049	7.335	8.016	9.010	8.561	6.351	4.253	2.547
30.00	7.928	7.930	7.937	7.959	8.026	8.245	8.777	9.601	9.177	6.883	4.627	2.777
50.00	9.233	9.234	9.240	9.254	9.303	9.457	9.836	1.047 (0)	1.010 (0)	7.735	5.242	3.161
100.00	1.105 (0)	1.105 (0)	1.106 (0)	1.107	1.110 (0)	1.119 (0)	1.142 (0)	1.184	1.157	9.227	6.380	3.688

Table 17. Born-Elwert Approximation to the Boltzman Averaged Screened
Fres-Free Gaunt Factors for $\mu/Z = 1.5$

$\frac{kT}{Z^2}$ \ $\frac{\Delta E}{Z^2}$	0.003	0.01	0.03	0.1	0.3	1.0	3.0	10.0	30.0	100.0	300.0	1000.0
0.03	7.029 (-4)	8.357 (-4)	1.309 (-3)	4.022 (-3)	1.881 (-2)	1.082 (-1)	3.520 (-1)	6.342 (-1)	6.512 (-1)	4.920 (-1)	3.305 (-1)	1.978 (-1)
0.05	1.699 (-3)	1.890 (-3)	2.520	5.706	2.129	1.109	3.531	6.343	6.512	4.920	3.305	1.978
0.10	5.292	5.593	6.518	1.058 (-2)	2.766	1.173	3.555	6.345	6.512	4.920	3.305	1.978
0.20	1.480 (-2)	1.523 (-2)	1.651 (-2)	2.162	4.043	1.292	3.603	6.349	6.512	4.920	3.305	1.978
0.30	2.542	2.592	2.740	3.309	5.277	1.403	3.649	6.353	6.513	4.920	3.305	1.978
0.50	4.690	4.740	4.916	5.540	7.672	1.603	3.735	6.365	6.517	4.924	3.308	1.980
1.00	9.547	9.610	9.790	1.044 (-1)	1.243 (-1)	2.016	3.932	6.406	6.543	4.943	3.321	1.988
2.00	1.711 (-1)	1.718 (-1)	1.734 (-1)	1.794	1.974	2.636	4.269	6.513	6.626	5.006	3.364	2.014
3.00	2.285	2.292	2.307	2.361	2.523	3.179	4.554	6.629	6.724	5.081	3.416	2.046
5.00	3.140	3.145	3.159	3.205	3.341	3.825	5.025	6.857	6.928	5.241	3.525	2.112
10.00	4.503	4.507	4.517	4.552	4.653	5.004	5.866	7.356	7.395	5.620	3.787	2.271
20.00	6.052	6.054	6.061	6.085	6.155	6.396	7.005	8.113	8.134	6.256	4.232	2.544
30.00	7.022	7.024	7.030	7.048	7.102	7.292	7.769	8.682	8.701	6.774	4.604	2.774
50.00	8.200	8.200	8.202	8.314	8.352	8.489	8.832	9.527	9.550	7.601	5.216	3.156
100.00	1.009 (0)	1.009 (0)	1.009	1.010 (0)	1.012 (0)	1.021 (0)	1.042 (0)	1.068 (0)	1.091 (0)	9.041	6.343	3.882

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