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AUSTRALIAN ATOMIC ENERGY COMMISSION
RESEARCH ESTABLISHMENT
LUCAS HEIGHTS

ADL1 - AN ATOMIC DATA LIBRARY FOR USE IN COMPUTING THE BEHAVIOUR OF PLASMA DEVICES INCLUDING FUSION REACTORS

by

B.E. CLANCY
J.L. COOK
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ABSTRACT

A data library with self-descriptive format is presented. This library provides, on a fixed temperature grid, reaction rate coefficients, effective degree of ionisation, and data for line radiation power emission for 59 ion or neutral species. Data are presented for neutral and ionised atoms of the hydrogen isotopes and for 49 'impurity' ion species ranging from helium-3 and -4 to uranium. Data origins are also discussed.

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The following descriptors have been selected from the INIS Thesaurus to describe the subject content of this report for information retrieval purposes. For further details please refer to IAEA-INIS-12 (INIS: Manual for Indexing) and IAEA-INIS-13 (INIS: Thesaurus) published in Vienna by the International Atomic Energy Agency.

NUCLEAR DATA COLLECTIONS; IMPURITIES; PLASMA; IONIZED GASES; HYDROGEN; DEUTERIUM; TRITIUM; TOKAMAK DEVICES; ELECTRICAL PROPERTIES; IONIZATION; POWER COEFFICIENT; PLASMA DIAGNOSTICS

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1. INTRODUCTION

Several years ago, the development of a computer code SCORCH to simulate the behaviour of tokamak devices was begun. This code uses the plasma transport theory described by Hinton and Hazeltine [1976] and computes the time development of various plasma properties, such as the average number densities, temperatures and the associated losses and gains. Parallel to this development, a preliminary data library was compiled by the present authors to enable them to ascertain the importance of impurity species in calculating the properties of the plasma. Most of the data for the impurities treated were derived from a study of the systematics of the corona model reported in a review article by Drawin [1977], while information on ionisation and recombination rates was taken from a review by McWhirter [1977].

It is clear that compilation of data for impurities in all states of ionisation/excitation is impracticable, since detailed data are not obtainable, and even if they were, this would lead to a data library of prohibitive size. The library therefore contains data for both ionised and neutral atoms of the hydrogen isotopes H, D and T; atoms with a nuclear charge greater than one are compiled as if they had a degree of ionisation $\langle Z \rangle$ equal to that expected for specified electron temperatures in the plasma. The expected value $\langle Z \rangle$ is one of the properties compiled in the library. Partly for reasons which reflect the development history of SCORCH, data for neutral atoms of light hydrogen are compiled in two forms. In one of these, neutral hydrogen may be treated as consisting of the first four states, H_{1s}, H_{2s}, H_{2p}, H_{3s}; in the second, neutral hydrogen consists simply of a species named H0. If the first form is used, power radiated from individual lines could be evaluated for use in diagnostics.

Data are compiled for many ion species which will not be present in any plasma systems but they have been included to allow for later study of systematics of the power radiation coefficients.

2. LIBRARY FORMAT

The format chosen for the library reflects the dual design requirements that (a) it should be easy to list and modify with the text editors available at the AAEC Research Establishment, and (b) it should be open-ended – in the sense that addition of further materials to the library should be simple. The library is thus comprised of card images and two main sections. The second section contains a set of tables, each of which has the data values for a particular property of a particular atom/ion, while the first section takes the form of a set of indexes, many of which spell out, for a given property, the particular table number which contains the appropriate data. Each index is preceded by two cards which describe the index entries.

3. LIBRARY DETAILS

3.1 Indexes to the Tables

After a library title card, the first index appears preceded by two header records. Then follows one card for each atom/ion species referenced in the library; this card contains the species name (up to 8 characters), followed by the mass number and nominal charge carried by the species. For the specifically neutral species, this charge number is zero. To signal the end of the species list, a separator card beginning ENDLIST is inserted.

Index 2 then appears, again preceded by two header cards. This index identifies the tables which contain the average degree of ionisation <Z> for individual species; each card in the body of the index contains the species name and the appropriate table number. The index ends with a separator card.

The body of index 3 simply contains decay constants λ_{ij} in s^{-1} for the specific set of neutral hydrogen species, H_{1s}, H_{2s}, etc. The decay constants are defined so that if the only reactions occurring were these decays, the number densities of the species would be related by the equation

$$\frac{dn_j}{dt} = \sum_i \lambda_{ij} n_i - \left(\sum_i \lambda_{ji} \, n_j \right) \quad .$$

The body of index 4 contains data for the energy appearing from the fusion reactions. For each process referenced, a single card appears containing the names of the two initiating ions, the names of the two reaction products, and the energy (J) appearing with each product ion. The end of the list is marked by a separator.

Index 5 specifies tables which contain power density coefficients P_i for individual species. Thus, if number densities for electrons and a species are n_e, n_i (m^{-3}), the power density radiated is $P_i \, n_e \, n_i$ ($W \, m^{-3}$). The individual cards of index 5 contain a species name and the table number in which P_i is tabulated against electron temperature. This radiated power comes from dielectronic and radiative recombination, electron collisional ionisation and excitation and the inverse processes, and radiative line transitions. Bremsstrahlung energy is specifically omitted. A separator card ends this index.

Index 6 specifies the tables in which are compiled reaction rate coefficients for elastic scattering - usually momentum transfer through Coulomb effects. Thus, if two species are present with number densities n_i n_j (m^{-3}), the collision rate (m^{-3} s^{-1}) between these species is C_{ij} $n_i n_j$ or C_{ji} $n_i n_j$. In the index, one card appears for each pair i,j for which data have been compiled. This card has the names of the two species and the table number in which the coefficient C_{ij} is tabulated against the temperature of the first named species. Electron-ion collisions are included in this index. A separator card closes index 6.

Index 7 specifies tables for rate coefficients of those reactions in which the emerging species are not identical to the species initiating the reaction. Thus, if species i,j react and species k,ℓ are emitted as the reaction products, two rate coefficients will be compiled, C_{ijk} and $C_{ij\ell}$. These are defined so that if the number densities of species i,j are n_i, n_j, then the rate (m^{-3} s^{-1}) at which particles of species k emerge from this reaction per unit volume is n_i n_j C_{ijk}. For such reactions as ionisation by proton collision, species i and k may be identical. Each card in the index contains the names of species i,j,k and the table number in which C_{ijk} is tabulated as a function of the temperature of species i. As with the elastic collision rate coefficients, species i may be an electron. In both index 6 and index 7, the rate coefficients are compiled so that if species i,j are identical, the reaction rate density will be $\frac{1}{2}n_i$ n_i C_{ii} or $\frac{1}{2}n_i$ n_i C_{iik}. A separator card signals the end of this final index.

3.2 Tables

The first table specifies the temperature values at which all coefficients are tabulated and consists of four heading cards followed by a set of energy values in keV from which the temperatures (K) can be calculated. The header cards contain the number of energies/temperatures which are used, as well as the conversion factor to convert from keV to K. The use of an energy scale facilitates comparison with other compilations. The present version of the library uses 45 energy values spanning the range 10 eV to 1 MeV.

The remaining tables have a fixed layout similar to that for the temperature table. The first card of a table contains the table number, and the second card a multiplier which must be applied to the tabulated values to convert them to SI units. Most of the reaction rate coefficients were originally computed in CGS units, and the multiplier is then 10^{-6}. Next come two comment cards which describe the table followed by the tabulated values in fixed format.

4. SOURCES FOR COMPILED DATA

Data for the effective degree of ionisation and for the radiative power coefficients were taken primarily from the calculated results of Post et al. [1977]. Their results are presented in the form of polynomial coefficients applicable over various energy ranges and the irregularities at the energy range break points were smoothed out by eye after subtraction of the bremsstrahlung power, which was also calculated according to Post et al. Power rate coefficients for hydrogen were taken from Drawin [1977] and McWhirter [1977].

The decay constants for hydrogen levels were taken from Weise [1966] and the fusion energy release values from Ribe [1975].

Electron-ion Coulomb scattering was computed from the standard cross section formula reported, for instance, by Glasstone and Lovberg [1950]. These data assume a Coulomb logarithm value $\ell n\Lambda = 20$, so calculations using the data must incorporate the correction for $\ell n\Lambda$ to agree with the formulae given by Braginski [1965]:

$$\ell n\Lambda = 23.4 - 1.15 \log n_e + 3.45 \log T_e \; ; \; T_e < 50 \text{ eV}$$

$$\ell n\Lambda = 25.3 - 1.15 \log n_e + 2.3 \log T_e \; ; \; T_e > 50 \text{ eV} \quad ,$$

where n_e is the electron number density (cm^{-3}) and T_e is the 'temperature' in eV. For partially ionised materials, the $\langle Z \rangle$ value appropriate to the electron temperature was used in the calculation. As ion-ion Coulomb scattering rates were computed according to the same procedure, corrections for $\ln\Lambda$ must be applied to them.

Recombination rate coefficients were computed according to a theory of Spitzer [1956]. All other neutral-ion, electron-neutral and neutral-neutral collision rate coefficients were calculated from the cross sections given by Barnett et al. [1977], and the low energy points were taken from Takayanagi and Suzuki [1978]. Ionisation rates were computed from formulae given by McWhirter [1977].

The D-D and D-T fusion rate coefficients were computed from the formulae quoted by Glasstone and Lovberg [1960].

Since much of the data behaves approximately like a power of the temperature, log-log interpolation should be used for intermediate values.

5. LIBRARY PROCESSING PROGRAMS

The pointer-to-table concept used in the indexes is flexible and makes it easy to insert new material in the library; however, it is even easier to insert a wrong pointer value. When checking the library, we found it essential to have library processing programs to provide a library cross reference, to produce plots of various tables and to modify tables found to be in error.

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Weise, W. [1966] - Atomic transition probabilities, a critical data compilation. US National Standards Bureau Publication, Washington.

APPENDIX A

CURRENT LISTING OF ADL1 INDEX

```
=== SCORCH LIBRARY === BEC.ADL1.EASYREAD ==================
SPECIES LIST
ATOM      MASS NO. CHARGE NO.
H+               1        1
H1S              1        0
H2S              1        0
H2P              1        0
H3S              1        0
HO               1        0
D+               2        1
DO               2        0
T+               3        1
TO               3        0
HELIUM3          3        2
HELIUM4          4        2
LITHIUM          7        3
BERYLIUM         9        4
BORON           10        5
CARBON          12        6
NITROGEN        14        7
OXYGEN          16        8
FLUORINE        19        9
NEON            20       10
SODIUM          23       11
MAGNESUM        24       12
ALUMINUM        27       13
SILICON         28       14
SULPHUR         32       16
ARGON           40       18
POTASSUM        39       19
CALCIUM         40       20
SCANDIUM        45       21
TITANIUM        48       22
VANADIUM        51       23
CHROMIUM        52       24
IRON            56       26
COBALT          59       27
NICKEL          59       28
COPPER          64       29
ZINC            65       30
ARSENIC         75       33
KRYPTON         84       36
RUBIDIUM        86       37
ZIRCONUM        91       40
NIOBIUM         93       41
MOLYBDEN        96       42
RHODIUM        103       45
SILVER         108       47
TIN            119       50
XENON          131       54
CESIUM         133       55
BARIUM         137       56
GADOLINM       157       64
TANTALUM       181       73
TUNGSTEN       184       74
IRIDIUM        192       77
GOLD           197       79
MERCURY        201       80
BISMUTH        209       83
RADON          222       86
THORIUM        232       90
URANIUM        238       92
ENDLIST   ---------------------------------------------------
```

(Continued)

ZAVERAGE TABLE	INDEX	(INTERPOLATE AGAINST ELECT.TEMP)
ATOM		
HELIUM3	TABLE	136
HELIUM4	TABLE	136
LITHIUM	TABLE	137
BERYLIUM	TABLE	138
BORON	TABLE	139
CARBON	TABLE	86
NITROGEN	TABLE	87
OXYGEN	TABLE	79
FLUORINE	TABLE	140
NEON	TABLE	141
SODIUM	TABLE	142
MAGNESUM	TABLE	143
ALUMINUM	TABLE	88
SILICON	TABLE	144
SULPHUR	TABLE	145
ARGON	TABLE	146
POTASSUM	TABLE	147
CALCIUM	TABLE	148
SCANDIUM	TABLE	149
TITANIUM	TABLE	89
VANADIUM	TABLE	150
CHROMIUM	TABLE	151
IRON	TABLE	80
COBALT	TABLE	90
NICKEL	TABLE	91
COPPER	TABLE	92
ZINC	TABLE	152
ARSENIC	TABLE	153
KRYPTON	TABLE	154
RUBIDIUM	TABLE	155
ZIRCONUM	TABLE	156
NIOBIUM	TABLE	93
MOLYBDEN	TABLE	81
RHODIUM	TABLE	157
SILVER	TABLE	158
TIN	TABLE	159
XENON	TABLE	160
CESIUM	TABLE	161
BARIUM	TABLE	162
GADOLINM	TABLE	163
TANTALUM	TABLE	164
TUNGSTEN	TABLE	94
IRIDIUM	TABLE	165
GOLD	TABLE	95
MERCURY	TABLE	166
BISMUTH	TABLE	167
RADON	TABLE	168
THORIUM	TABLE	169
URANIUM	TABLE	170
ENDLIST		

DECAY	CONSTANTS (/SECOND)	
FROM	TO	
H2S	H1S	5.000E+03
H2P	H1S	6.265E+08
H2P	H2S	4.699E+08
H3S	H1S	5.000E+03
H3S	H2S	5.000E+03
H3S	H2P	6.313E+06
ENDLIST		

FUSION ENERGY PER		REACTION		ENERGY (J) TO	ENERGY (J) TO
INCOMER	TARGET	OUTGOER1	OUTGOER2	OUTGOER1	OUTGOER2
D+	T+	HELIUM4	NEUTRON	5.640E-13	2.260E-12
D+	D+	HELIUM3	NEUTRON	1.314E-13	3.925E-13
D+	D+	H+	T+	4.842E-13	1.614E-13
ENDLIST					

(Continued)

```
POWER    RADIATN. TABLE INDEX    (INTERPOLATE AGAINST ELECT.TEMP)
ATOM
H1S                            TABLE     40     ( TABLE HAS POWER FOR       )
H2S                            TABLE     40     ( EQUILIBRIUM CONCNS        )
H3S                            TABLE     40     ( OF ALL NEUTRALS, SO       )
H2P                            TABLE     40     ( EACH IS POINTED AT IT     )
HD                             TABLE     40
DD                             TABLE     40
TD                             TABLE     40
HELIUM3                        TABLE    101
HELIUM4                        TABLE    101
LITHIUM                        TABLE    102
BERYLIUM                       TABLE    103
BORON                          TABLE    104
CARBON                         TABLE     22
NITROGEN                       TABLE     23
OXYGEN                         TABLE     37
FLUORINE                       TABLE    105
NEON                           TABLE    106
SODIUM                         TABLE    107
MAGNESUM                       TABLE    108
ALUMINUM                       TABLE     24
SILICON                        TABLE    109
SULPHUR                        TABLE    110
ARGON                          TABLE    111
POTASSUM                       TABLE    112
CALCIUM                        TABLE    113
SCANDIUM                       TABLE    114
TITANIUM                       TABLE     25
VANADIUM                       TABLE    115
CHROMIUM                       TABLE    116
IRON                           TABLE     36
COBALT                         TABLE     26
NICKEL                         TABLE     27
COPPER                         TABLE     28
ZINC                           TABLE    117
ARSENIC                        TABLE    118
KRYPTON                        TABLE    119
RUBIDIUM                       TABLE    120
ZIRCONUM                       TABLE    121
NIOBIUM                        TABLE     29
MOLYBDEN                       TABLE     39
RHODIUM                        TABLE    122
SILVER                         TABLE    123
TIN                            TABLE    124
XENON                          TABLE    125
CESIUM                         TABLE    126
BARIUM                         TABLE    127
GADOLINM                       TABLE    128
TANTALUM                       TABLE    129
TUNGSTEN                       TABLE     30
IRIDIUM                        TABLE    130
GOLD                           TABLE     31
MERCURY                        TABLE    131
BISMUTH                        TABLE    132
RADON                          TABLE    133
THORIUM                        TABLE    134
URANIUM                        TABLE    135
ENDLIST  -------------------------------------------------------------------
```

(Continued)

ELASTIC SCATTER TABLE INDEX (INTERPOLATE AGAINST INCOMER TEMP.

INCOMER	TARGET		
ELECTRON	H+	TABLE	7
ELECTRON	D+	TABLE	7
ELECTRON	H1S	TABLE	13
ELECTRON	H2S	TABLE	13
ELECTRON	H2P	TABLE	13
ELECTRON	H3S	TABLE	13
ELECTRON	HO	TABLE	13
ELECTRON	DO	TABLE	13
ELECTRON	T+	TABLE	7
ELECTRON	TO	TABLE	13
ELECTRON	HELIUM3	TABLE	82
ELECTRON	HELIUM4	TABLE	82
ELECTRON	LITHIUM	TABLE	83
ELECTRON	BERYLIUM	TABLE	84
ELECTRON	BORON	TABLE	85
ELECTRON	CARBON	TABLE	46
ELECTRON	NITROGEN	TABLE	47
ELECTRON	OXYGEN	TABLE	43
ELECTRON	FLUORINE	TABLE	98
ELECTRON	NEON	TABLE	171
ELECTRON	SODIUM	TABLE	172
ELECTRON	MAGNESUM	TABLE	173
ELECTRON	ALUMINUM	TABLE	48
ELECTRON	SILICON	TABLE	174
ELECTRON	SULPHUR	TABLE	175
ELECTRON	ARGON	TABLE	176
ELECTRON	POTASSUM	TABLE	177
ELECTRON	CALCIUM	TABLE	178
ELECTRON	SCANDIUM	TABLE	179
ELECTRON	TITANIUM	TABLE	49
ELECTRON	VANADIUM	TABLE	180
ELECTRON	CHROMIUM	TABLE	181
ELECTRON	IRON	TABLE	44
ELECTRON	COBALT	TABLE	50
ELECTRON	NICKEL	TABLE	51
ELECTRON	COPPER	TABLE	52
ELECTRON	ZINC	TABLE	182
ELECTRON	ARSENIC	TABLE	183
ELECTRON	KRYPTON	TABLE	184
ELECTRON	RUBIDIUM	TABLE	185
ELECTRON	ZIRCONUM	TABLE	186
ELECTRON	NIOBIUM	TABLE	53
ELECTRON	MOLYBDEN	TABLE	45
ELECTRON	RHODIUM	TABLE	187
ELECTRON	SILVER	TABLE	188
ELECTRON	TIN	TABLE	189
ELECTRON	XENON	TABLE	190
ELECTRON	CESIUM	TABLE	191
ELECTRON	BARIUM	TABLE	192
ELECTRON	GADOLINM	TABLE	193
ELECTRON	TANTALUM	TABLE	194
ELECTRON	TUNGSTEN	TABLE	54
ELECTRON	IRIDIUM	TABLE	195
ELECTRON	GOLD	TABLE	63
ELECTRON	MERCURY	TABLE	196
ELECTRON	BISMUTH	TABLE	197
ELECTRON	RADON	TABLE	198
ELECTRON	THORIUM	TABLE	199
ELECTRON	URANIUM	TABLE	200
H+	H1S	TABLE	2
H+	H2S	TABLE	2
H+	H2P	TABLE	2
H+	H3S	TABLE	2
H+	HO	TABLE	55
H+	H+	TABLE	73
H+	D+	TABLE	42
H+	DO	TABLE	55
H+	T+	TABLE	56
H+	HELIUM3	TABLE	57
H1S	H1S	TABLE	32
H2S	H2S	TABLE	32
H2P	H2P	TABLE	32
H3S	H3S	TABLE	32
H1S	H2S	TABLE	32
H1S	H2P	TABLE	32
H1S	H3S	TABLE	32

(Continued)

H2S	H2P	TABLE	32
H2S	H3S	TABLE	32
H2P	H3S	TABLE	32
H+	HELIUM4	TABLE	58
D+	D+	TABLE	1
D+	D0	TABLE	55
D+	T+	TABLE	60
D+	HELIUM3	TABLE	61
D+	HELIUM4	TABLE	62
D0	H1S	TABLE	32
D0	H2S	TABLE	32
D0	H2P	TABLE	32
D0	H3S	TABLE	32
D0	H0	TABLE	32
D0	D0	TABLE	32
D0	T+	TABLE	55
D0	T0	TABLE	32
D0	HELIUM3	TABLE	55
D0	HELIUM4	TABLE	55
T0	H1S	TABLE	32
T0	H2S	TABLE	32
T0	H2P	TABLE	32
T0	H3S	TABLE	32
T0	H0	TABLE	32
T+	T+	TABLE	76
T+	HELIUM3	TABLE	67
T+	HELIUM4	TABLE	68
HELIUM3	HELIUM3	TABLE	77
HELIUM3	HELIUM4	TABLE	70
HELIUM4	HELIUM4	TABLE	78
H+	T0	TABLE	55
D+	H0	TABLE	55
D+	T0	TABLE	55
T+	H0	TABLE	55
T+	D0	TABLE	55
T+	T0	TABLE	55
H0	HELIUM3	TABLE	55
T0	HELIUM3	TABLE	55
T0	HELIUM4	TABLE	55
H0	HELIUM4	TABLE	55
H0	H0	TABLE	32
T0	T0	TABLE	32
D+	H1S	TABLE	55
D+	H2S	TABLE	55
D+	H2P	TABLE	55
D+	H3S	TABLE	55
T+	H1S	TABLE	55
T+	H2S	TABLE	55
T+	H2P	TABLE	55
T+	H3S	TABLE	55
HELIUM3	H1S	TABLE	55
HELIUM3	H2S	TABLE	55
HELIUM3	H2P	TABLE	55
HELIUM3	H3S	TABLE	55
HELIUM4	H1S	TABLE	55
HELIUM4	H2S	TABLE	55
HELIUM4	H2P	TABLE	55
HELIUM4	H3S	TABLE	55
ENDLIST	---		

(Continued)

```
INELAST. REACTION TABLE INDEX   (INTERPOLATE AGAINST INCOMER TEMP.
INCOMER  TARGET    OUTGOER
ELECTRON D+        DO        TABLE     34
ELECTRON DO        D+        TABLE     35
ELECTRON T+        TO        TABLE     34
ELECTRON TO        T+        TABLE     35
ELECTRON H+        H1S       TABLE      8
ELECTRON H+        H2S       TABLE      9
ELECTRON H+        H2P       TABLE      9
ELECTRON H+        H3S       TABLE     11
ELECTRON H1S       H+        TABLE     12
ELECTRON H2S       H+        TABLE     17
ELECTRON H2P       H+        TABLE     17
ELECTRON H3S       H+        TABLE     20
ELECTRON H1S       H2S       TABLE     14
ELECTRON H1S       H2P       TABLE     15
ELECTRON H1S       H3S       TABLE     16
ELECTRON H2S       H1S       TABLE     14
ELECTRON H2S       H2P       TABLE     18
ELECTRON H2S       H3S       TABLE     19
ELECTRON H2P       H1S       TABLE     15
ELECTRON H2P       H2S       TABLE     18
ELECTRON H2P       H3S       TABLE     19
ELECTRON H3S       H1S       TABLE     16
ELECTRON H3S       H2S       TABLE     19
ELECTRON H3S       H2P       TABLE     19
ELECTRON H+        HO        TABLE     34
ELECTRON HO        H+        TABLE     35
H+       H1S       H2S       TABLE      3
H+       H2S       H2P       TABLE      3
H+       H2P       H3S       TABLE      3
H+       H1S       H2P       TABLE      4
H+       H2S       H3S       TABLE      4
H+       H1S       H3S       TABLE      5
H+       H1S       H+        TABLE     64
H+       H2S       H+        TABLE     65
H+       H2P       H+        TABLE     66
H+       HO        H+        TABLE     69
D+       D+        H+        TABLE     96
D+       D+        T+        TABLE     96
D+       D+        HELIUM3   TABLE     96
D+       T+        HELIUM4   TABLE     97
ENDLIST  ---------------------------------------------------------------------

TABLE            0 HAS 45 ENTRIES
MULTIPLY BY         1.1605E+07 FOR CONVERSION TO DEGK
*                   NUMBERS BELOW ARE KEV ENERGIES
*
 1.000E-02 2.000E-02 3.000E-02 4.000E-02 5.000E-02 6.000E-02 7.000E-02
 8.000E-02 9.000E-02 1.000E-01 2.000E-01 3.000E-01 4.000E-01 5.000E-01
 6.000E-01 7.000E-01 8.000E-01 9.000E-01 1.000E+00 2.000E+00 3.000E+00
 4.000E+00 5.000E+00 6.000E+00 7.000E+00 8.000E+00 9.000E+00 1.000E+01
 1.200E+01 1.400E+01 1.600E+01 1.800E+01 2.000E+01 3.000E+01 4.000E+01
 5.000E+01 6.000E+01 7.000E+01 8.000E+01 9.000E+01 1.000E+02 2.500E+02
 5.000E+02 7.500E+02 1.000E+03
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