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A Compilation of Theoretical Electron-Impact Excitation Cross Sections for Fe Atomic Ions

M. S. Pindzola
D. H. Crandall

OPERATED BY
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and
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PREFACE

This compilation by the ORNL Controlled Fusion Atomic Data Center of excitation cross sections for Fe ions represents the first part of compilation of recommended collision cross sections for impurity ions of fusion interest. Extensions to other species and other processes is ongoing. Specifically compilation of excitation and electron capture data for C and O ions is currently in progress in collaboration with Japanese data centers.

Data compilations for the processes of ionization and recombination are also needed. At present the Lotz formula is the best overall predictor for ionization cross sections with 0.85 of the Lotz formula found to be a slight improvement for ions of charge +1 through +3. However, indirect processes such as excitation-autoionization can cause the Lotz formula to be an underestimate of ionization for specific ions, particularly heavy ions with three or more attached electrons. Recombination formulas are in use but are of highly uncertain reliability. Insufficient data and lack of any test of reliability for recombination preclude meaningful data compilation for this process at present.

ACKNOWLEDGMENTS

The authors wish to thank Doug Post and Russell Hulse, Princeton Plasma Physics Laboratory; John Hogan, Ralph Isler, and Charles Crume, Oak Ridge National Laboratory; Al Merts, Norm Magee, Joe Mann, and Derek Robb, Los Alamos National Laboratory; A. K. Bhatia, NASA/Goddard; and R. Henry, Louisiana State University. Thanks also go to B. J. Farmer, K. P. Hamilton, and P. M. Hafford for calculating and inputting the data and typing and editing the manuscript. This work was supported through the U.S. Department of Energy, Office of Fusion Energy, Applied Plasma Physics Branch.

A COMPILATION OF THEORETICAL ELECTRON-IMPACT EXCITATION CROSS SECTIONS FOR Fe ATOMIC IONS

M. S. Pindzola* D. H. Crandall

This report compiles recommended "best available" cross sections for electron-impact excitation of Fe^{+25} through Fe^{+8} atomic ions in common units, cm^2 for cross section and eV for energy. It is hoped that this compilation will be useful to plasma physicists, astrophysicists, and atomic physicists who need these data in various applications. Fe ions were chosen because of specific interest in fusion and astrophysics and because of the substantial number of detailed calculations available. All of the available data are theoretical calculations. For Fe^{+25} through Fe^{+16} the outer-shell $\Delta n = 0$ and $\Delta n = 1$ transitions are included while for Fe^{+15} through Fe^{+8} only outer-shell $\Delta n = 0$ transitions are included. Primarily the selected cross sections are calculated in either close-coupling or distorted wave approximations with the R-matrix, close-coupling results generally taken as first choice. For optically allowed transitions accuracy of the calculated results tabulated here is generally believed to be better than ±40%. However, outstanding problems remain, particularly in calculation of forbidden transitions for which significant resonance level enhancement of the cross sections at energies near the threshold region can be dominant. Where calculations overlap and discrepancies are greater than ±40%, there are notations pointing out the disagreement.

Calculation of resonance effects has been carried out only for a few cases, which are reported separately in Sect. 1. Because these resonances result in excitation cross sections which fluctuate rapidly with small energy changes, it is sometimes convenient to tabulate resonance effects as averaged over some electron energy distribution. Thus, in Sect. 1 the Fe+24(He) results are tabulated as rate coefficients for a given "Maxwellian" electron temperature distribution as presented by the original authors.

Results tabulated in Sect. 2 contain only the nonresonant part of the

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total excitation cross sections, and for most optically allowed transitions these nonresonant results are believed to represent the total excitation cross section to within the ±40% uncertainty cited. However, for forbidden transitions caution should be exercised. The Gailitis extrapolation method [see M. Gailitis, *Sov. Phys. JETP* 17, 1328 (1963) and M. J. Seaton, *J. Phys. B* 2, 5 (1969)] requires only nonresonant cross sections to estimate resonance enhancement and should be applied in cases where a cross section or rate for a particular transition is of direct interest.

The tables are intended to be self-explanatory. The ionization state and isoelectronic sequence of each ion appear at the top of a tabulation set [e.g., Fe+19(N) is 19 times ionized iron and is nitrogen-like]. The source of the data is given for each set of data, and there are comments as appropriate. The configurations, L-S spectroscopic designation, and energy of each level are given and numbered in the order of the excitation energy. The energy values given are those found in the authors' target state configuration-interaction calculation (except as noted) and thus are not a "best set" of atomic energy levels but are the energy levels used in the cross-section calculation cited. Finally the excitation cross sections are tabulated for each i-j transition where i and j refer to the energy level listing table for each individual ion. The number of different collisions energies for which the cross sections are tabulated are generally as available in the original publications. Interested users should obtain additional details from the publications cited. A thorough review on excitation theory, which contains an extensive bibliography, has recently been published by R.J.W. Henry in *Physics Reports* 68, 1 (1981) pp. 1-91.

FE+24(HE) IONIZATION POTENTIAL= 8828.00 EV

A. K. PRADHAN, D. W. NORCROSS, AND D. G. HUMMER, PHYS. REV. A 23, 619 (1981)

COMMENTS: PRADHAN, NORCROSS, AND HUMMER USE THE DISTORTED WAVE APPROXIMATION WITH CONFIGURATION-INTERACTION WAVE FUNCTIONS. ONLY LS TERM VALUES ARE AVAILABLE. THE ATOMIC ENERGY LEVELS ARE CALCULATED BY PRADHAN, NORCROSS, AND HUMMER. SINCE THE RESONANCE STRUCTURE IS QUITE COMPLEX, ONLY EXCITATION RATES (IN CM^3/SEC) ARE REPORTED. PRADHAN, NORCROSS, AND HUMMER FOUND A 15% AUTOIONIZATION RESONANT ENHANCEMENT OF THE DIPOLE ALLOWED 1-5 TRANSITION.

ATOMIC STATE AND EXCITATION ENERGY

1	1S(2)	1 S 0.0	0.0 EV
2	1S(1)2S(1)	3 S 1.0	6592.00 EV
3	1S(1)2P(1)	3 P 0.0	6618.00 EV
4	1S(1)2S(1)	2 S 0.0	6621.00 EV
5	1S(1)2P(1)	2 P 1.0	6639.00 EV

RATE COEFFICIENT (IN CM**3/SEC) VS TEMPERATURE

I	J	344.70 EV	689.40 EV	1723.50 EV	5170.60 EV	8617.60 EV	34470.40 EV	68940.80 EV
1	2	2.46D-20	2.75D-16	4.14D-14	1.62D-13	1.47D-13	4.85D-14	2.22D-14
1	3	6.15D-20	6.66D-16	1.08D-13	4.71D-13	4.44D-13	1.50D-13	6.76D-14
1	4	1.99D-20	2.18D-16	4.22D-14	3.07D-13	4.08D-13	4.17D-13	3.74D-13
1	5	5.12D-20	6.01D-16	1.42D-13	1.50D-12	2.40D-12	3.84D-12	4.63D-12

FE+13(AL) IONIZATION POTENTIAL= 392.20 EV

H. E. MASON, MON. NOT. R. ASTRON. SOC. (M.N.R.A.S.) 170, 651 (1975)

COMMENTS: MASON USES THE DISTORTED WAVE APPROXIMATION WITH CONFIGURATION-INTERACTION WAVE FUNCTIONS. FINE-STRUCTURE RECOUPLING IS HANDLED BY THE JAJOM PROGRAM OF SARAPH, COMPUT. PHYS. COMMUN. 3, 256 (1972). THE ATOMIC ENERGY LEVELS ARE CALCULATED BY MASON. MASON USES THE GAILITIS EXTRAPOLATION METHOD TO ESTIMATE THE AUTOIONIZATION RESONANT ENHANCEMENT OF THE 1-2 TRANSITION TO BE A FACTOR OF 12 NEAR THRESHOLD.

ATOMIC STATE AND EXCITATION ENERGY

1	3S(2)3P(1)	2 P 0.5	0.0 EV
2	3S(2)3P(1)	2 P 1.5	2.20 EV

CROSS SECTIONS IN CM**2 VS ENERGY

I	J	81.63 EV
1	2	2.08D-17

FE+10(S) IONIZATION POTENTIAL= 290.30 EV

H. E. MASON, M.N.R.A.S. 170, 651 (1975)

COMMENTS: MASON USES THE DISTORTED WAVE APPROXIMATION WITH CONFIGURATION-INTERACTION WAVE FUNCTIONS. FINE-STRUCTURE RECOUPLING IS HANDLED BY JAJOM. THE ATOMIC ENERGY LEVELS ARE CALCULATED BY MASON. MASON USES THE GAILITIS EXTRAPOLATION METHOD TO ESTIMATE THE AUTOIONIZATION RESONANT ENHANCEMENT OF THE 2→3 TRANSITION TO BE A FACTOR OF 38 NEAR THRESHOLD.

ATOMIC STATE AND EXCITATION ENERGY

1	3S(2)3P(4)	3 P 2.0	0.0 EV
2	3S(2)3P(4)	3 P 1.0	1.44 EV
3	3S(2)3P(4)	3 P 0.0	1.63 EV
4	3S(2)3P(4)	1 D 2.0	4.94 EV
5	3S(2)3P(4)	1 S 0.0	9.28 EV

CROSS SECTIONS IN CM**2 VS ENERGY

I	J	108.84 EV
1	2	7.70D-18
1	3	1.78D-18
1	4	1.67D-18
1	5	4.42D-20
2	3	5.07D-18
2	4	4.10D-18
2	5	9.35D-20
3	4	6.60D-18
3	5	4.41D-19
4	5	1.13D-18

FE+9(CL) IONIZATION POTENTIAL= 262.10 EV

H. E. MASON, M.N.R.A.S. 170, 651 (1975)

COMMENTS: MASON USES THE DISTORTED WAVE APPROXIMATION WITH CONFIGURATION-INTERACTION WAVE FUNCTIONS. FINE STRUCTURE IS HANDLED BY JAJOM. THE ATOMIC ENERGY LEVELS ARE CALCULATED BY MASON. MASON USES THE GAILITIS EXTRAPOLATION METHOD TO ESTIMATE THE AUTOIONIZATION RESONANT ENHANCEMENT OF THE 1→2 TRANSITION TO BE A FACTOR OF SIX NEAR THRESHOLD.

ATOMIC STATE AND EXCITATION ENERGY

1	3S(2)3P(5)	2 P 1.5	0.0 EV
2	3S(2)3P(5)	2 P 0.5	1.81 EV

CROSS SECTIONS IN CM**2 VS ENERGY

I	J	74.83 EV
1	2	6.47D-18

FE+25(H) IONIZATION POTENTIAL= 9277.00 Ev

D.W.WALKER, J.PHYS.B8,760(1975)

COMMENTS: WALKER USES THE COULOMB-BORN-OPPENHEIMER APPROXIMATION WITH DIRAC WAVE FUNCTIONS. BESIDES THE COULOMB INTERACTION BETWEEN THE TWO ELECTRONS, WALKER ALSO INCLUDES MAGNETIC AND RETARDATION EFFECTS. THE ATOMIC ENERGY LEVELS ARE CALCULATED FROM THE DIRAC ENERGY EIGENVALUE EQUATION.

ATOMIC STATE AND EXCITATION ENERGY

1	1S(1)	2 S 0.5	0.0 Ev
2	2S(1)	2 S 0.5	6955.00 Ev
3	2P(1)	2 P 0.5	6955.00 Ev
4	2P(1)	2 P 1.5	6975.00 Ev

CROSS SECTIONS IN CM**2 VS ENERGY

I	J	7358.00 Ev	9197.00 Ev	36788.00 Ev
1	2	9.32D-23	7.75D-23	2.31D-23
1	3	1.19D-22	1.06D-22	6.62D-23
1	4	2.31D-22	2.08D-22	1.31D-22

FE+24(HE) IONIZATION POTENTIAL= 8828.00 Ev

W.D.ROBB, UNPUBLISHED

COMMENTS: ROBB USES THE R-MATRIX CLOSE-COUPLING APPROXIMATION WITH CONFIGURATION-INTERACTION WAVE FUNCTIONS. FINE-STRUCTURE RECOUPLING IS HANDLED BY JAJOM. THE ATOMIC ENERGY LEVELS ARE TAKEN FROM THE RELATIVISTIC CALCULATION OF ERMOLAEV AND JONES, J. PHYS. B 7, 199 (1974). NEAR THRESHOLD ROBB'S RESULTS ARE WITHIN 10% OF THE DISTORTED WAVE APPROXIMATION CALCULATIONS OF JONES, MON. NOT. R. ASTRON. SOC. 169, 211 (1974) AND PINDZOLA AND CARTER, PHYS. REV. A 22, 898 (1980), EXCEPT FOR THE 1-5 TRANSITION WHERE JONES AND ROBB AGREE TO WITHIN 20%.

ATOMIC STATE AND EXCITATION ENERGY

1	1S(2)	1 S 0.0	0.0 Ev
2	1S(1)2S(1)	3 S 1.0	6637.00 Ev
3	1S(1)2P(1)	3 P 0.0	6666.00 Ev
4	1S(1)2P(1)	3 P 1.0	6668.00 Ev
5	1S(1)2S(1)	1 S 0.0	6668.00 Ev
6	1S(1)2P(1)	3 P 2.0	6683.00 Ev
7	1S(1)2P(1)	1 P 1.0	6701.00 Ev

CROSS SECTIONS IN CM**2 VS ENERGY

I	J	6721.00 Ev	6911.00 Ev	7306.00 Ev	8626.00 Ev	10626.00 Ev	13278.00 Ev
1	2	6.54D-23	6.13D-23	5.42D-23	3.61D-23	2.47D-23	1.38D-23
1	3	4.02D-23	3.74D-23	3.26D-23	2.14D-23	1.23D-23	6.76D-24
1	4	1.44D-22	1.37D-22	1.24D-22	9.66D-23	7.40D-23	5.84D-23
1	5	1.26D-22	1.25D-22	1.25D-22	1.13D-22	1.03D-22	8.96D-23
1	6	2.01D-22	1.87D-22	1.63D-22	1.07D-22	6.15D-23	3.37D-23
1	7	4.08D-22	4.16D-22	4.29D-22	4.68D-22	4.94D-22	4.92D-22

FE+23(LI) IONIZATION POTENTIAL= 2024.00 EV

M.A.HAYES, M.N.R.A.S.189,55P(1979)

COMMENTS: HAYES USES THE DISTORTED WAVE APPROXIMATION WITH CONFIGURATION-INTERACTION WAVE FUNCTIONS. FINE-STRUCTURE RECOUPLING IS HANDLED BY JAJOM, AND THE ATOMIC ENERGY LEVELS ARE CALCULATED BY HAYES. HAYES' 2S → 2P RESULTS ARE IN GOOD AGREEMENT WITH A COULOMB-BORN APPROXIMATION CALCULATION OF CALLAWAY ET AL., PHYS. REV. A 19, 1416 (1979).

ATOMIC STATE AND EXCITATION ENERGY

1	1S(2)2S(1)	2 S	0.5	0.0 EV
2	1S(2)2P(1)	2 P	0.5	49.12 EV
3	1S(2)2P(1)	2 P	1.5	64.81 EV
4	1S(2)3S(1)	2 S	0.5	1150.03 EV
5	1S(2)3P(1)	2 P	0.5	1163.75 EV
6	1S(2)3P(1)	2 P	1.5	1168.26 EV
7	1S(2)3D(1)	2 D	1.5	1173.63 EV
8	1S(2)3D(1)	2 D	2.5	1175.11 EV

CROSS SECTIONS IN CM**2 VS ENERGY

I	J	1184.00 EV	1633.00 EV	2286.00 EV	3428.00 EV	4571.00 EV
1	2	1.18D-19	9.13D-20	6.99D-20	5.04D-20	3.99D-20
1	3	2.15D-19	1.68D-19	1.29D-19	9.39D-20	7.34D-20
1	4	6.22D-21	4.84D-21	3.67D-21	2.58D-21	1.99D-21
1	5	1.85D-21	1.73D-21	1.67D-21	1.59D-21	1.48D-21
1	6	3.59D-21	3.35D-21	3.22D-21	3.05D-21	2.85D-21
1	7	5.61D-21	4.36D-21	3.46D-21	2.62D-21	2.12D-21
1	8	8.44D-21	6.56D-21	5.16D-21	3.91D-21	3.18D-21
2	3	1.08D-20	7.11D-21	4.63D-21	2.90D-21	2.09D-21
2	4	5.21D-22	3.58D-22	2.72D-22	2.25D-22	2.02D-22
2	5	6.57D-21	4.95D-21	3.64D-21	2.51D-21	1.91D-21
2	6	2.28D-21	1.37D-21	8.33D-22	5.01D-22	3.67D-22
2	7	2.50D-20	2.15D-20	1.86D-20	1.55D-20	1.35D-20
2	8	4.58D-21	2.43D-21	1.29D-21	6.67D-22	4.44D-22
3	4	5.33D-22	3.74D-22	2.92D-22	2.44D-22	2.16D-22
3	5	1.11D-21	6.80D-22	4.20D-22	2.59D-22	1.92D-22
3	6	8.19D-21	6.01D-21	4.32D-21	2.93D-21	2.23D-21
3	7	5.23D-21	3.65D-21	2.67D-21	1.99D-21	1.65D-21
3	8	2.44D-20	2.05D-20	1.75D-20	1.47D-20	1.26D-20

FE+22(BE) IONIZATION POTENTIAL= 1950.00 EV

W. D. ROBB, UNPUBLISHED

U. FELDMAN, G. A. DOSCHEK C. C. CHENG, A. K. BHATIA, J. APPL. PHYS. 51, 190 (1980)

COMMENTS: ROBB USES THE R-MATRIX CLOSE-COUPLING APPROXIMATION WITH CONFIGURATION-INTERACTION WAVE FUNCTIONS. FELDMAN ET AL. USE THE DISTORTED WAVE APPROXIMATION WITH CONFIGURATION-INTERACTION WAVE FUNCTIONS. FINE-STRUCTURE RECOUPLING IS HANDLED IN BOTH CASES BY JAJOM. THE ATOMIC ENERGY LEVELS ARE CALCULATED BY FELDMAN ET AL. WHERE THE TWO CALCULATIONS OVERLAP, ONE FINDS A 30% AGREEMENT OR BETTER NEAR THRESHOLD. AN R-MATRIX CALCULATION FOR THE 1→3 TRANSITION BY SCOTT AND BURKE, J. PHYS. B 13, 4299 (1980), IS 30% LOWER THAN FELDMAN ET AL. NEAR THRESHOLD, BUT A SURPRISING 45% LOWER THAN ROBB'S RESULT.

ATOMIC STATE AND EXCITATION ENERGY

1	2S(2)	1 S 0.0	0.0	EV
2	2S(1)2P(1)	3 P 0.0	43.12	EV
3	2S(1)2P(1)	3 P 1.0	47.07	EV
4	2S(1)2P(1)	3 P 2.0	58.32	EV
5	2S(1)2P(1)	1 P 1.0	94.28	EV
6	2P(2)	3 P 0.0	118.39	EV
7	2P(2)	3 P 1.0	126.97	EV
8	2P(2)	3 P 2.0	133.05	EV
9	2P(2)	1 D 2.0	149.75	EV
10	2P(2)	1 S 0.0	176.95	EV

ROBB

CROSS SECTIONS IN CM**2 VS ENERGY

I	J	163.26 EV	204.08 EV	272.10 EV	680.25 EV	1360.50 EV	4081.50 EV	6802.50 EV
1	2	9.24D-21	7.21D-21	5.15D-21	1.58D-21	5.32D-22	5.92D-23	1.76D-23
1	3	1.05D-19	8.62D-20	6.69D-20	2.96D-20	1.55D-20	5.42D-21	3.34D-21
1	4	5.14D-20	4.00D-20	2.87D-20	8.81D-21	2.97D-21	3.31D-22	9.92D-23
1	5	2.30D-18	1.88D-18	1.44D-18	6.63D-19	3.88D-19	1.66D-19	1.11D-19
2	3	1.03D-19	8.03D-20	5.67D-20	1.64D-20	5.39D-21	5.84D-22	1.76D-22
2	4	7.23D-20	5.69D-20	4.16D-20	1.51D-20	7.08D-21	2.22D-21	1.31D-21
2	5	2.46D-20	1.89D-20	1.33D-20	3.77D-21	1.19D-21	1.17D-22	3.13D-23
3	4	9.43D-20	7.37D-20	5.31D-20	1.77D-20	7.33D-21	1.86D-21	1.03D-21
3	5	2.88D-20	2.03D-20	1.43D-20	4.24D-21	1.46D-21	2.28D-22	9.97D-23
4	5	2.64D-20	2.03D-20	1.4[illegible]D-20	4.08D-21	1.31D-21	1.45D-22	4.64D-23

FELDMAN ET AL.

CROSS SECTIONS IN CM**2 VS ENERGY

I	J	204.18 EV	408.15 EV	612.23 EV
1	6	5.86D-22	2.93D-22	1.95D-22
1	7	1.17D-21	2.93D-22	1.95D-22
1	8	2.35D-21	1.17D-21	7.82D-22
1	9	4.11D-21	2.05D-21	1.37D-21
1	10	2.35D-21	1.17D-21	7.82D-22
2	6	5.28D-21	2.35D-21	1.37D-21
2	7	8.01D-19	4.44D-19	3.22D-19
2	8	1.41D-20	6.16D-21	3.71D-21
2	9	3.52D-21	1.47D-21	7.82D-22
2	10	5.86D-22	2.93D-22	1.95D-22
3	6	2.84D-19	1.56D-19	1.12D-19
3	7	2.07D-19	1.14D-19	8.20D-20
3	8	3.43D-19	1.89D-19	1.37D-19
3	9	2.17D-20	1.10D-20	7.49D-21
3	10	1.17D-21	4.89D-22	2.61D-22
4	6	7.04D-22	2.93D-22	1.56D-22
4	7	2.22D-19	1.23D-19	8.84D-20
4	8	4.83D-19	3.23D-19	1.93D-19
4	9	1.55D-19	8.38D-20	5.99D-20
4	10	2.11D-21	8.80D-22	5.08D-22
5	6	2.05D-20	1.11D-20	7.88D-21
5	7	9.77D-21	4.20D-21	2.48D-21
5	8	3.14D-19	1.75D-19	1.26D-19
5	9	1.22D-18	6.83D-19	4.97D-19
5	10	4.81D-19	2.63D-19	1.89D-19
6	7	9.27D-20	3.90D-20	2.23D-20
6	8	8.74D-20	3.93D-20	2.42D-20
6	9	1.94D-20	7.92D-21	4.50D-21
6	10	3.52D-21	1.47D-21	7.82D-22
7	8	8.54D-20	3.72D-20	2.21D-20
7	9	4.95D-20	2.11D-20	1.22D-20
7	10	7.43D-21	3.03D-21	1.69D-21
8	9	6.73D-20	2.96D-20	1.76D-20
8	10	9.15D-21	3.99D-21	2.38D-21
9	10	2.24D-20	1.09D-20	7.19D-21

FE+21(8) IONIZATION POTENTIAL= 1799.00 EV

W.D.ROBB, UNPUBLISHED

M.E.MASON AND P.J.STOREY, M.N.R.A.S.191,631(1980)

COMMENTS: ROBB USES THE R-MATRIX CLOSE-COUPLING APPROXIMATION WITH CONFIGURATION-INTERACTION WAVE FUNCTIONS. MASON AND STOREY USE THE DISTORTED WAVE APPROXIMATION WITH CONFIGURATION-INTERACTION WAVE FUNCTIONS. FINE-STRUCTURE RECOUPLING IS HANDLED IN BOTH CASES BY JAJOM. THE ATOMIC ENERGY LEVELS ARE CALCULATED BY MASON AND STOREY. WHERE THE TWO CALCULATIONS OVERLAP, ONE FINDS A 10% AGREEMENT OR BETTER NEAR THRESHOLD. THE LEVEL ASSIGNMENTS FOR 8 AND 9 ARE THOSE GIVEN BY MASON AND STOREY.

ATOMIC STATE AND EXCITATION ENERGY

1	2S(2)2P(1)	2 P 0.5	0.0	EV
2	2S(2)2P(1)	2 P 1.5	14.89	EV
3	2S(1)2P(2)	4 P 0.5	50.28	EV
4	2S(1)2P(2)	4 P 1.5	57.34	EV
5	2S(1)2P(2)	4 P 2.5	64.37	EV
6	2S(1)2P(2)	2 D 1.5	92.42	EV
7	2S(1)2P(2)	2 D 2.5	95.36	EV
8	2S(1)2P(2)	2 S 0.5	106.88	EV
9	2S(1)2P(2)	2 P 0.5	122.46	EV
10	2S(1)2P(2)	2 P 1.5	124.53	EV
11	2S(2)3S(1)	2 S 0.5	1008.00	EV
12	2S(2)3D(1)	2 D 1.5	1056.00	EV
13	2S(2)3D(1)	2 D 2.5	1057.00	EV
14	2S(1)2P(1)3P(1)	4 D 0.5	1073.00	EV
15	2S(1)2P(1)3P(1)	4 D 1.5	1076.00	EV
16	2S(1)2P(1)3P(1)	4 S 1.5	1081.00	EV
17	2S(1)2P(1)3P(1)	4 D 2.5	1082.00	EV
18	2S(1)2P(1)3P(1)	2 P 0.5	1082.00	EV
19	2S(1)2P(1)3P(1)	4 P 0.5	1085.00	EV
20	2S(1)2P(1)3P(1)	2 P 1.5	1087.00	EV
21	2S(1)2P(1)3P(1)	4 D 3.5	1091.00	EV
22	2S(1)2P(1)3P(1)	4 P 1.5	1092.00	EV
23	2S(1)2P(1)3P(1)	4 P 2.5	1095.00	EV
24	2S(1)2P(1)3P(1)	2 D 1.5	1096.00	EV
25	2S(1)2P(1)3P(1)	2 D 2.5	1100.00	EV
26	2S(1)2P(1)3P(1)	2 S 0.5	1104.00	EV
27	2S(1)2P(1)3P(1)	2 D 1.5	1127.00	EV
28	2S(1)2P(1)3P(1)	2 P 0.5	1126.00	EV
29	2S(1)2P(1)3P(1)	2 D 2.5	1130.00	EV
30	2S(1)2P(1)3P(1)	2 P 1.5	1131.00	EV
31	2S(1)2P(1)3P(1)	2 S 0.5	1137.00	EV

ROBB

CROSS SECTIONS IN CM**2 VS ENERGY

I	J	102.04 EV	170.06 EV	272.10 EV	816.30 EV	1360.50 EV	5442.00 EV	10884.00 EV
1	2	1.94D-19	1.12D-19	6.58D-20	1.73D-20	8.93D-21	1.61D-21	7.04D-22
1	3	6.39D-20	4.08D-20	2.68D-20	9.97D-21	6.11D-21	1.68D-21	9.07D-22
1	4	3.45D-20	1.99D-20	1.18D-20	2.83D-21	1.29D-21	1.11D-22	3.76D-23
1	5	2.96D-20	1.70D-20	9.90D-21	2.33D-21	1.02D-21	5.72D-23	9.95D-24
1	6	1.44D-18	9.11D-19	6.05D-19	2.50D-19	1.68D-19	5.56D-20	3.13D-20
1	7	2.21D-20	1.27D-20	7.43D-21	1.77D-21	7.79D-22	4.45D-23	7.86D-24
1	8	1.57D-18	9.82D-19	6.51D-19	2.65D-19	1.76D-19	5.86D-20	3.31D-20
1	9	4.96D-20	3.12D-20	2.11D-20	9.38D-21	6.47D-21	2.29D-21	1.33D-21
1	10	3.05D-19	1.91D-19	1.27D-19	5.24D-20	3.49D-20	1.17D-20	6.65D-21
2	3	1.32D-20	8.37D-21	5.54D-21	2.04D-21	1.25D-21	3.43D-22	1.84D-22
2	4	2.67D-20	1.61D-20	1.00D-20	3.10D-21	1.72D-21	3.73D-22	1.92D-22
2	5	9.65D-20	6.05D-20	3.93D-20	1.41D-20	8.69D-21	2.42D-21	1.32D-21
2	6	2.63D-20	1.48D-20	8.40D-21	2.03D-21	9.94D-22	1.35D-22	6.08D-23
2	7	9.74D-19	6.12D-19	3.99D-19	1.61D-19	1.08D-19	3.55D-20	2.00D-20
2	8	5.86D-21	3.34D-21	1.96D-21	5.20D-22	2.60D-22	4.48D-23	2.31D-23
2	9	7.27D-19	4.57D-19	3.03D-19	1.24D-19	8.20D-20	2.68D-20	1.51D-20
2	10	1.63D-18	1.02D-18	6.77D-19	2.76D-19	1.84D-19	6.16D-20	3.46D-20

MASON AND STOREY

CROSS SECTIONS IN CM**2 VS ENERGY

I	J	1156.00 EV	1497.00 EV	2041.00 EV
1	11	5.74D-22	4.64D-22	3.96D-22
1	12	2.68D-20	2.42D-20	2.15D-20
1	13	4.47D-21	2.58D-21	1.33D-21
1	14	4.50D-22	3.68D-22	3.08D-22
1	15	5.02D-22	3.32D-22	2.17D-22
1	16	1.26D-21	1.17D-21	1.10D-21
1	17	5.07D-22	2.96D-22	1.47D-22
1	18	1.60D-21	1.76D-21	1.88D-21
1	19	2.95D-22	2.20D-22	1.67D-22
1	20	2.78D-21	3.06D-21	3.28D-21
1	22	1.60D-22	1.64D-22	1.67D-22
1	23	8.80D-23	4.80D-23	2.35D-23

continued

1	24	4.81D-22	5.44D-22	5.95D-22
1	25	5.17D-24	4.00D-24	2.93D-24
1	26	3.47D-22	3.84D-22	4.13D-24
1	27	1.50D-22	1.00D-22	6.49D-23
1	28	3.67D-22	3.88D-22	4.02D-22
1	29	1.86D-22	1.12D-22	5.86D-23
1	30	2.38D-22	2.44D-22	2.61D-22
1	31	1.71D-22	1.64D-22	1.58D-22
2	11	5.69D-22	4.58D-22	3.93D-22
2	12	5.28D-21	3.91D-21	2.90D-21
2	13	2.54D-20	2.23D-20	1.74D-20
2	14	1.81D-23	2.00D-23	1.91D-23
2	15	1.91D-22	1.76D-22	1.66D-22
2	16	2.23D-22	2.32D-22	2.38D-22
2	17	2.77D-22	1.96D-22	1.39D-22
2	18	1.06D-22	1.00D-22	9.24D-23
2	19	5.69D-23	4.40D-23	3.52D-23
2	20	1.14D-22	8.20D-23	5.72D-23
2	21	5.67D-22	3.28D-22	1.60D-22
2	22	5.46D-22	4.78D-22	4.31D-22
2	23	1.02D-21	9.52D-22	8.83D-22
2	24	1.26D-21	1.31D-21	1.35D-21
2	25	2.93D-21	3.15D-21	3.34D-21
2	26	9.03D-22	9.86D-22	1.05D-21
2	27	3.96D-22	3.62D-22	3.43D-22
2	28	3.86D-22	3.82D-22	3.84D-22
2	29	4.04D-22	3.64D-22	3.50D-22
2	30	8.38D-22	8.50D-22	8.71D-22
2	31	1.16D-22	7.60D-23	4.99D-23

FE+20(C) IONIZATION POTENTIAL= 1689.00 EV

W.D.ROBB, UNPUBLISHED

H.E.MASON, G.A.DOSCHEK, U.FELDMAN, A.K.BHATIA, ASTR.ASTPHYS.73,74(1979)

COMMENTS: ROBB USES THE R-MATRIX CLOSE-COUPLING APPROXIMATION WITH CONFIGURATION-INTERACTION WAVE FUNCTIONS. MASON ET AL. USE THE DISTORTED WAVE APPROXIMATION WITH CONFIGURATION-INTERACTION WAVE FUNCTIONS. FINE-STRUCTURE RECOUPLING IS HANDLED IN BOTH CASES BY JAJOM. THE ATOMIC ENERGY LEVELS ARE CALCULATED BY MASON ET AL. FOR TRANSITIONS WITHIN THE GROUND CONFIGURATION $2s^2\ 2p^2$, THE TWO CALCULATIONS AGREE TO 10% OR BETTER NEAR THRESHOLD. WHERE THE TWO CALCULATIONS OVERLAP FOR TRANSITIONS OUTSIDE THE GROUND CONFIGURATION, THERE ARE SOME SHARP DISAGREEMENTS. FOR EXAMPLE, ROBB'S 4-12 RESULT NEAR THRESHOLD IS A FACTOR OF 10 LARGER THAN MASON ET AL.

ATOMIC STATE AND EXCITATION ENERGY

1	2S(2)2P(2)	3 P	0.0	0.0 EV
2	2S(2)2P(2)	3 P	1.0	8.99 EV
3	2S(2)2P(2)	3 P	2.0	14.34 EV
4	2S(2)2P(2)	1 D	2.0	30.13 EV
5	2S(2)2P(2)	1 S	0.0	44.99 EV
6	2S(1)2P(3)	5 S	2.0	57.87 EV
7	2S(1)2P(3)	3 D	1.0	94.95 EV
8	2S(1)2P(3)	3 D	2.0	95.09 EV
9	2S(1)2P(3)	3 D	3.0	98.75 EV
10	2S(1)2P(3)	3 P	0.0	112.15 EV
11	2S(1)2P(3)	3 P	1.0	113.40 EV
12	2S(1)2P(3)	3 P	2.0	115.73 EV
13	2S(1)2P(3)	3 S	1.0	135.24 EV
14	2S(1)2P(3)	1 D	2.0	139.51 EV
15	2S(1)2P(3)	1 P	1.0	155.98 EV
16	2S(2)2P(1)3S(1)	3 P	0.0	952.29 EV
17	2S(2)2P(1)3S(1)	3 P	1.0	953.45 EV
18	2S(2)2P(1)3S(1)	3 P	2.0	966.05 EV
19	2S(2)2P(1)3S(1)	1 P	1.0	969.18 EV
20	2S(2)2P(1)3D(1)	3 F	2.0	1004.00 EV
21	2S(2)2P(1)3D(1)	3 F	3.0	1009.00 EV
22	2S(2)2P(1)3D(1)	1 D	2.0	1010.00 EV
23	2S(2)2P(1)3D(1)	3 D	1.0	1012.00 EV
24	2S(2)2P(1)3D(1)	3 F	4.0	1019.00 EV
25	2S(2)2P(1)3D(1)	3 D	2.0	1020.00 EV
26	2S(2)2P(1)3D(1)	3 D	3.0	1023.00 EV
27	2S(2)2P(1)3D(1)	3 P	2.0	1024.00 EV
28	2S(2)2P(1)3D(1)	3 P	1.0	1024.00 EV
29	2S(2)2P(1)3D(1)	3 P	0.0	1024.00 EV
30	2S(2)2P(1)3D(1)	1 F	3.0	1032.00 EV
31	2S(2)2P(1)3D(1)	1 P	1.0	1031.00 EV

ROBB

CROSS SECTIONS IN CM**2 VS ENERGY

I	J	115.64 EV	136.05 EV	204.08 EV	272.10 EV	680.25 EV	1360.50 EV	2721.00 EV
1	2	1.99D-19	1.51D-19	9.50D-20	6.69D-20	1.92D-20	6.11D-21	1.55D-21
1	3	1.90D-19	1.42D-19	9.09D-20	6.60D-20	2.29D-20	1.00D-20	4.53D-21
1	4	3.48D-20	2.89D-20	1.79D-20	1.26D-20	3.52D-21	1.08D-21	2.66D-22
1	5	7.06D-21	4.72D-21	2.90D-21	2.02D-21	5.33D-22	1.50D-22	3.36D-23
1	7	1.52D-18	1.31D-18	8.91D-19	6.86D-19	3.15D-19	1.86D-19	1.11D-19
1	8	3.23D-20	2.70D-20	1.72D-20	1.23D-20	3.77D-21	1.27D-21	3.34D-22
1	9	2.56D-22	1.94D-22	1.13D-22	7.57D-23	2.30D-23	6.84D-24	1.95D-24
1	10	7.87D-22	6.56D-22	4.11D-22	2.90D-22	8.32D-23	2.62D-23	6.47D-24
1	11	8.81D-20	7.56D-20	5.24D-20	4.13D-20	2.55D-20	2.08D-20	1.58D-20
1	12	4.94D-21	4.12D-21	2.62D-21	1.87D-21	5.75D-22	1.93D-22	4.97D-23
1	13	8.92D-19	7.67D-19	5.29D-19	4.06D-19	1.72D-19	8.80D-20	4.57D-20
2	3	1.85D-19	1.38D-19	8.74D-20	6.25D-20	1.96D-20	7.45D-21	2.76D-21
2	4	1.01D-19	7.91D-20	4.97D-20	3.52D-20	1.04D-20	3.61D-21	1.15D-21
2	5	1.68D-20	1.35D-20	8.39D-21	5.85D-21	1.59D-21	4.72D-22	1.07D-22
2	7	1.10D-19	9.53D-20	6.37D-20	4.81D-20	1.98D-20	1.04D-20	5.45D-21
2	8	1.16D-18	1.00D-18	6.86D-19	5.29D-19	2.45D-19	1.43D-19	8.31D-20
2	9	9.14D-21	7.62D-21	4.85D-21	3.47D-21	1.06D-21	3.55D-22	9.46D-23
2	10	3.18D-19	2.75D-19	1.89D-19	1.45D-19	6.51D-20	3.72D-20	2.16D-20
2	11	2.15D-19	1.86D-19	1.27D-19	9.88D-20	5.62D-20	4.22D-20	3.03D-20
2	12	3.90D-20	3.28D-20	2.27D-20	1.74D-20	7.68D-21	4.11D-21	2.24D-21
2	13	9.45D-19	8.12D-19	5.61D-19	4.31D-19	1.85D-19	9.76D-20	5.22D-20
3	4	1.35D-19	1.07D-19	6.80D-20	4.88D-20	3.90D-20	6.11D-21	2.38D-21
3	5	1.68D-20	1.47D-20	9.28D-21	6.62D-21	5.20D-21	8.16D-22	3.31D-22
3	7	1.36D-20	1.16D-20	7.94D-21	6.04D-21	6.00D-21	1.10D-21	4.84D-22
3	8	1.30D-20	1.08D-20	6.78D-21	4.84D-21	3.71D-21	5.05D-22	1.40D-22
3	9	7.04D-19	6.09D-19	4.13D-19	3.17D-19	3.62D-19	8.37D-20	4.86D-20
3	10	2.38D-21	1.99D-21	1.26D-21	8.97D-22	6.84D-22	9.06D-23	2.33D-23
3	11	3.31D-19	2.87D-19	1.96D-19	1.50D-19	1.52D-19	2.92D-20	1.36D-20
3	12	6.69D-19	5.79D-19	3.96D-19	3.04D-19	3.43D-19	7.88D-20	4.57D-20
4	5	4.55D-20	3.77D-20	2.50D-20	1.86D-20	7.42D-21	3.82D-21	2.01D-21
4	7	1.55D-20	1.31D-20	8.50D-21	6.21D-21	2.08D-21	7.92D-22	2.73D-22
4	8	1.64D-20	1.37D-20	8.70D-21	6.23D-21	1.91D-21	6.44D-22	1.74D-22
4	9	2.32D-19	2.01D-19	1.37D-19	1.06D-19	4.89D-20	2.78D-20	1.57D-20
4	10	6.06D-22	5.07D-22	3.21D-22	2.30D-22	6.93D-23	2.27D-23	5.70D-24
4	11	1.09D-19	9.40D-20	6.42D-20	4.90D-20	1.98D-20	9.43D-21	4.38D-21
4	12	2.24D-19	1.94D-19	1.33D-19	1.02D-19	4.68D-20	2.66D-20	1.51D-20
4	13	1.30D-19	1.12D-19	7.76D-20	6.06D-20	3.07D-20	1.59D-14	1.25D-20
5	7	1.70D-19	1.50D-19	1.07D-19	8.62D-20	4.42D-20	2.63D-20	1.53D-20

continued

5	8	3.22D-21	2.69D-21	1.71D-21	1.22D-21	3.73D-22	1.22D-22	3.17D-23
5	9	7.99D-23	6.41D-23	3.77D-23	2.49D-23	6.47D-24	1.84D-24	4.62D-25
5	10	1.53D-20	1.28D-20	8.15D-21	5.85D-21	1.79D-21	5.98D-22	1.57D-22
5	11	4.67D-20	3.95D-20	2.63D-20	1.98D-20	8.45D-21	4.52D-21	2.49D-21
5	12	4.50D-20	3.77D-20	2.40D-20	1.72D-20	5.28D-21	1.77D-21	4.62D-22
5	13	9.51D-20	8.18D-20	5.67D-20	4.40D-20	1.97D-20	1.06D-20	5.63D-21
7	8	1.38D-19	1.15D-19	7.17D-20	5.04D-20	1.42D-20	4.43D-21	1.12D-21
7	9	3.79D-20	3.17D-20	2.03D-20	1.45D-20	4.80D-21	1.98D-21	8.36D-22
7	10	1.18D-20	9.76D-21	6.06D-21	4.24D-21	1.17D-21	3.56D-22	8.55D-23
7	11	7.93D-20	6.66D-20	4.30D-20	3.11D-20	1.08D-20	4.81D-21	2.23D-21
7	12	3.83D-20	3.23D-20	2.09D-20	1.54D-20	5.74D-21	2.76D-21	1.37D-21
7	13	1.75D-20	1.46D-20	9.19D-21	6.51D-21	1.95D-21	6.95D-22	2.33D-22
8	9	1.13D-19	9.41D-20	5.94D-20	4.22D-20	1.30D-20	4.80D-21	1.73D-21
8	10	3.54D-20	2.99D-20	1.98D-20	1.46D-20	5.74D-21	2.92D-21	1.53D-21
8	11	1.86D-20	1.57D-20	1.01D-20	7.33D-21	2.59D-21	1.17D-21	5.51D-22
8	12	5.71D-20	4.77D-20	3.06D-20	2.21D-20	7.53D-21	3.27D-21	1.47D-21
8	13	1.39D-20	1.15D-20	7.19D-21	5.06D-21	1.44D-21	4.56D-22	1.21D-22
9	10	9.05D-24	7.44D-24	4.73D-24	3.10D-24	7.84D-25	2.39D-25	5.86D-26
9	11	2.97D-20	3.03D-20	1.99D-20	1.48D-20	5.78D-21	2.94D-21	1.53D-21
9	12	8.75D-20	7.40D-20	4.83D-20	3.54D-20	1.32D-20	6.36D-21	3.16D-21
9	13	1.35D-20	1.13D-20	7.09D-21	5.02D-21	1.50D-21	5.19D-22	1.66D-22
10	11	1.54D-19	1.28D-19	7.98D-20	5.59D-20	1.57D-20	4.90D-21	1.22D-21
10	12	7.84D-20	6.50D-20	4.16D-20	3.01D-20	1.04D-20	4.56D-21	2.07D-21
10	13	1.64D-20	1.35D-20	8.39D-21	5.85D-21	1.61D-21	4.91D-22	1.21D-22
11	12	1.15D-19	9.47D-20	5.88D-20	4.13D-20	1.16D-20	3.61D-21	8.90D-22
11	13	1.27D-20	1.05D-20	6.57D-21	4.63D-21	1.35D-21	4.63D-22	1.48D-22
12	13	9.02D-21	7.50D-21	4.64D-21	3.24D-21	8.80D-22	2.62D-22	6.11D-23

MASON ET AL.
CROSS SECTIONS IN CM**2 VS ENERGY

I	J	272.10 Ev	690.25 Ev	1360.50 Ev
1	6	1.28D-20	3.87D-21	1.32D-21
2	6	1.63D-20	5.04D-21	1.79D-21
2	14	8.36D-21	2.52D-21	9.38D-22
2	15	2.77D-20	1.27D-20	7.36D-21
3	6	2.18D-20	6.80D-21	2.43D-21
3	14	1.28D-19	5.88D-20	3.40D-20
3	15	5.42D-21	1.58D-21	5.28D-22
4	6	2.02D-21	5.98D-22	2.11D-22
4	14	6.88D-19	3.21D-19	1.87D-19
4	15	3.84D-19	1.77D-19	1.02D-19
5	15	7.48D-19	3.50D-19	2.03D-19

CROSS SECTIONS IN CM**2 VS ENERGY

I	J	1088.00 EV	1361.00 EV	2041.00 EV
1	16	2.31D-22	1.50D-22	6.45D-23
1	17	9.24D-22	8.71D-22	8.45D-22
1	18	6.60D-23	4.40D-23	1.76D-23
1	19	5.50D-23	5.28D-23	5.28D-23
1	20	3.14D-21	1.83D-21	6.28D-22
1	21	3.32D-21	2.24D-21	1.18D-21
1	22	5.12D-21	3.03D-21	1.08D-21
1	23	4.83D-20	4.54D-20	3.98D-20
1	24	2.97D-22	1.76D-22	5.86D-23
1	25	3.19D-22	1.85D-22	6.45D-23
1	26	4.62D-22	2.82D-22	1.17D-22
1	27	1.76D-22	1.06D-22	3.52D-23
1	28	2.20D-22	1.50D-22	7.62D-23
1	29	8.80D-23	5.28D-23	1.76D-23
1	30	5.17D-22	2.99D-22	9.97D-23
1	31	5.28D-22	4.13D-22	2.99D-22
2	16	2.09D-22	2.20D-22	2.54D-22
2	17	4.25D-22	3.40D-22	2.29D-22
2	18	4.44D-22	4.11D-22	4.01D-22
2	19	2.09D-22	1.52D-22	9.19D-23
2	20	1.88D-21	1.27D-21	6.72D-22
2	21	2.19D-21	1.31D-21	4.95D-22
2	22	1.85D-20	1.68D-20	1.43D-20
2	23	4.63D-21	3.80D-21	2.85D-21
2	24	1.38D-21	9.09D-22	4.54D-22
2	25	1.27D-20	1.18D-20	1.03D-20
2	26	1.72D-21	1.05D-21	4.22D-22
2	27	4.06D-21	3.49D-21	2.77D-21
2	28	9.18D-21	8.54D-21	7.41D-21
2	29	4.08D-21	3.82D-21	3.32D-21
2	30	1.26D-21	7.36D-22	2.62D-22
2	31	9.57D-22	6.39D-22	3.32D-22
3	16	1.03D-22	6.69D-23	2.82D-23
3	17	3.94D-22	3.47D-22	3.19D-22
3	18	5.39D-22	5.10D-22	5.13D-22
3	19	2.42D-22	1.65D-22	8.21D-23

continued

3	20	3.020-21	2.260-21	1.470-21
3	21	9.130-21	7.960-21	6.480-21
3	22	2.670-21	2.060-21	1.410-21
3	23	9.190-22	6.190-22	3.280-22
3	24	1.830-21	1.150-21	5.060-22
3	25	2.820-21	2.080-21	1.330-21
3	26	2.470-20	2.300-20	2.000-20
3	27	1.000-20	9.140-21	7.790-21
3	28	3.150-21	2.770-21	2.270-21
3	29	1.800-22	1.020-22	3.400-23
3	30	3.190-21	2.780-21	2.020-21
3	31	6.840-22	4.080-22	1.560-22
4	16	2.640-23	1.760-23	7.040-24
4	17	9.020-23	6.690-23	4.460-23
4	18	6.250-22	4.500-22	2.720-22
4	19	5.010-22	5.050-22	5.490-22
4	20	1.120-21	9.030-22	6.620-22
4	21	1.320-21	8.900-22	4.770-22
4	22	1.550-21	1.350-21	1.060-21
4	23	2.820-22	1.690-22	6.570-23
4	24	3.480-21	2.060-21	7.480-22
4	25	4.130-21	3.320-21	2.430-21
4	26	4.140-21	2.990-21	1.820-21
4	27	6.560-21	5.600-21	4.450-21
4	28	1.630-21	1.190-21	7.470-22
4	29	2.950-22	1.690-22	5.750-23
4	30	3.700-20	3.480-20	3.080-20
4	31	1.280-21	1.010-21	7.050-22
5	16	2.200-23	1.760-23	5.860-24
5	17	7.700-23	6.160-23	4.110-23
5	18	5.830-22	3.780-22	1.640-22
5	19	5.940-22	6.510-22	7.800-22
5	20	2.970-22	1.670-22	5.860-23
5	21	7.040-22	4.050-22	1.410-22
5	22	3.960-22	2.200-22	7.620-23
5	23	4.510-22	3.690-22	2.520-22
5	24	3.060-21	1.780-21	6.160-22
5	25	1.230-21	6.950-22	2.290-22
5	26	1.550-21	8.800-22	2.870-22
5	27	2.650-21	1.560-21	5.510-22
5	28	2.310-21	1.450-21	6.450-22
5	29	8.800-22	5.280-22	1.940-22
5	30	1.660-21	1.290-21	8.620-22
5	31	4.650-20	4.420-20	3.940-20

FE+19(N) IONIZATION POTENTIAL= 1582.00 EV

W.D.ROBB, UNPUBLISHED

COMMENTS: ROBB USES THE R-MATRIX CLOSE COUPLING APPROXIMATION WITH CONFIGURATION-INTERACTION WAVE FUNCTIONS. FINE-STRUCTURE RECOUPLING IS HANDLED BY JAJOM. THE ATOMIC ENERGY LEVELS ARE TAKEN FROM THE CONFIGURATION-INTERACTION CALCULATION OF BHATIA AND MASON, ASTRON. ASTROPHYS. 83, 380 (1980). FOR TRANSITIONS WITHIN THE GROUND CONFIGURATION $2s^2 2p^3$, ROBB'S RESULTS AGREE TO 40% OR BETTER NEAR THRESHOLD WITH THE DISTORTED WAVE CALCULATION OF BHATIA AND MASON. FOR OTHER TRANSITIONS OUTSIDE THE GROUND CONFIGURATION FACTORS OF 10 TO 20 DISAGREEMENT ARE FOUND.

ATOMIC STATE AND EXCITATION ENERGY

1	2S(2)2P(3)	4 S 1.5	0.0 EV
2	2S(2)2P(3)	2 D 1.5	17.43 EV
3	2S(2)2P(3)	2 D 2.5	22.19 EV
4	2S(2)2P(3)	2 P 0.5	31.94 EV
5	2S(2)2P(3)	2 P 1.5	39.66 EV
6	2S(1)2P(4)	4 P 2.5	92.89 EV
7	2S(1)2P(4)	4 P 1.5	101.02 EV
8	2S(1)2P(4)	4 P 0.5	103.72 EV
9	2S(1)2P(4)	2 D 1.5	129.87 EV
10	2S(1)2P(4)	2 D 2.5	131.98 EV
11	2S(1)2P(4)	2 S 0.5	148.51 EV
12	2S(1)2P(4)	2 P 1.5	155.43 EV
13	2S(1)2P(4)	2 P 0.5	167.09 EV

CROSS SECTIONS IN CM**2 VS ENERGY

I	J	149.66 Ev	204.08 Ev	340.13 Ev	680.25 Ev	1360.50 Ev	4081.50 Ev	6802.50 Ev
1	2	6.80D-20	4.71D-20	2.47D-20	9.15D-21	2.75D-21	2.48D-22	6.73D-23
1	3	8.76D-20	6.08D-20	3.23D-20	1.23D-20	3.96D-21	5.07D-22	2.01D-22
1	4	2.10D-20	1.45D-20	7.65D-21	2.92D-21	9.87D-22	1.83D-22	9.50D-23
1	5	4.74D-20	3.30D-20	1.74D-20	6.64D-21	2.22D-21	3.46D-22	1.61D-22
1	8	3.32D-19	2.49D-19	1.57D-19	8.62D-20	4.93D-20	2.05D-20	1.35D-20
1	7	5.28D-19	3.94D-19	2.49D-19	1.40D-19	1.10D-19	3.66D-20	2.46D-20
1	6	8.88D-19	6.66D-19	4.21D-19	2.34D-19	1.35D-19	5.62D-20	3.70D-20
1	9	8.58D-20	6.45D-20	4.02D-20	2.03D-20	9.90D-21	3.14D-21	1.84D-21
1	10	3.56D-21	2.58D-21	1.49D-21	6.73D-22	2.79D-22	6.76D-23	3.52D-23
1	11	2.16D-20	1.61D-20	1.02D-20	5.61D-21	2.75D-21	9.24D-22	5.54D-22
1	13	4.02D-20	3.01D-20	1.88D-20	9.46D-21	4.29D-21	1.06D-21	5.23D-22
1	12	1.98D-20	1.42D-20	8.12D-21	4.00D-21	2.44D-21	1.40D-21	1.06D-21
2	3	1.12D-19	7.83D-20	4.25D-20	1.73D-20	6.53D-21	1.40D-21	7.30D-22
2	4	4.38D-20	3.15D-20	1.82D-20	8.71D-21	4.27D-21	1.45D-21	8.71D-22
2	5	2.64D-20	1.85D-20	1.03D-20	4.44D-21	1.90D-21	5.31D-22	3.01D-22
2	8	1.21D-20	9.35D-21	7.31D-21	6.64D-21	5.83D-21	3.60D-21	2.65D-21
2	7	6.92D-20	5.18D-20	3.18D-20	1.56D-20	7.15D-21	1.91D-21	1.01D-21
2	6	4.06D-20	3.03D-20	1.99D-20	1.24D-20	8.03D-21	3.89D-21	2.72D-21
2	9	4.56D-19	3.45D-19	2.23D-19	1.38D-19	9.43D-20	4.99D-20	3.54D-20
2	10	1.32D-20	9.35D-21	5.14D-21	2.10D-21	7.28D-22	1.00D-22	4.27D-23
2	11	7.82D-22	6.76D-22	2.08D-21	8.05D-21	1.30D-20	1.15D-20	9.10D-21
2	13	4.38D-19	3.31D-19	2.13D-19	1.31D-19	9.57D-20	5.81D-20	4.31D-20
2	12	6.66D-19	5.03D-19	3.18D-19	1.65D-19	8.05D-20	2.51D-20	1.45D-20
3	4	2.95D-20	2.11D-20	1.20D-20	5.51D-21	2.60D-21	8.55D-22	5.10D-22
3	5	7.38D-20	5.30D-20	3.03D-20	1.41D-20	6.66D-21	2.17D-21	1.28D-21
3	8	9.24D-22	6.49D-22	3.51D-22	1.36D-22	4.37D-23	4.35D-24	1.24D-24
3	7	5.82D-21	4.14D-21	2.35D-21	1.06D-21	4.65D-22	1.42D-22	9.06D-23
3	6	4.07D-20	3.02D-20	1.88D-20	9.94D-21	5.19D-21	1.90D-21	1.21D-21
3	9	2.13D-19	1.61D-19	1.00D-19	4.99D-20	2.26D-20	5.62D-21	2.80D-21
3	10	8.32D-19	6.29D-19	4.00D-19	2.21D-19	1.27D-19	5.38D-20	3.55D-20
3	11	2.72D-22	1.90D-22	9.85D-23	3.78D-23	1.28D-23	1.66D-24	6.10D-25
3	13	1.22D-21	8.66D-22	4.64D-22	1.81D-22	5.88D-23	5.82D-24	1.68D-24
3	12	6.96D-19	5.27D-19	3.38D-19	1.94D-19	1.17D-19	5.38D-20	3.67D-20
4	5	8.08D-20	5.63D-20	3.06D-20	1.24D-20	4.57D-21	9.19D-22	4.64D-22
4	8	1.64D-20	1.21D-20	7.71D-21	4.49D-21	2.70D-21	1.23D-21	8.51D-22
4	7	1.44D-20	1.02D-20	5.72D-21	2.38D-21	8.71D-22	1.48D-22	6.89D-23
4	6	4.40D-21	3.11D-21	1.68D-21	6.62D-22	2.16D-22	2.21D-23	6.35D-24
4	9	4.20D-19	3.17D-19	2.01D-19	1.06D-19	5.54D-20	1.98D-20	1.22D-20
4	10	1.78D-20	1.26D-20	6.91D-21	2.75D-21	9.10D-22	9.63D-23	2.82D-23
4	11	9.72D-20	7.42D-20	5.35D-20	4.84D-20	4.71D-20	3.24D-20	2.45D-20
4	13	7.20D-19	5.45D-19	3.45D-19	1.75D-19	8.14D-20	2.21D-20	1.16D-20
4	12	8.44D-20	6.36D-20	4.26D-20	2.97D-20	2.34D-20	1.43D-20	1.06D-20
5	8	8.18D-21	5.59D-21	2.90D-21	1.16D-21	4.13D-22	6.97D-23	3.31D-23
5	7	7.78D-20	5.82D-20	3.63D-20	1.87D-20	9.35D-21	3.06D-21	1.83D-21
5	6	4.88D-20	3.62D-20	2.22D-20	1.10D-20	5.21D-21	1.53D-21	8.71D-22
5	9	9.90D-20	7.45D-20	4.69D-20	2.43D-20	1.20D-20	3.80D-21	2.23D-21
5	10	4.94D-19	3.65D-19	1.96D-19	1.10D-19	6.40D-20	2.70D-20	1.78D-20
5	11	6.72D-19	5.07D-19	3.20D-19	1.62D-19	7.50D-20	1.99D-20	1.03D-20
5	13	7.32D-20	5.56D-20	4.00D-20	3.88D-20	4.11D-20	3.04D-20	2.33D-20
5	12	1.29D-19	9.76D-20	6.36D-20	3.79D-20	2.40D-20	1.16D-20	8.05D-21
7	8	6.88D-20	4.74D-20	2.48D-20	9.37D-21	2.99D-21	3.61D-22	1.33D-22
6	8	2.63D-20	1.80D-20	1.00D-20	4.57D-21	2.08D-21	6.16D-22	3.48D-22
8	9	5.96D-20	4.13D-20	2.18D-20	8.17D-21	2.56D-21	3.06D-22	1.21D-22

continued

8	10	4.240D-20	2.930D-20	1.540D-20	5.760D-21	1.790D-21	1.940D-22	6.980D-23
8	11	1.590D-20	1.090D-20	5.580D-21	1.950D-21	5.370D-22	3.770D-23	8.970D-24
8	13	4.920D-21	3.340D-21	1.700D-21	5.890D-22	1.660D-22	1.270D-23	7.870D-24
8	16	1.120D-20	7.710D-21	3.990D-21	1.430D-21	4.190D-22	4.110D-23	1.430D-23
7	7	8.580D-20	5.990D-20	3.170D-20	1.280D-20	4.790D-21	9.870D-22	4.810D-22
7	9	5.280D-20	3.650D-20	1.910D-20	6.990D-21	2.080D-21	1.830D-22	5.150D-23
7	10	4.820D-20	3.340D-20	1.760D-20	6.600D-21	2.080D-21	2.460D-22	9.150D-23
7	11	1.510D-20	1.040D-20	5.350D-21	1.900D-21	5.390D-22	4.220D-23	1.120D-23
7	13	5.480D-21	3.780D-21	1.970D-21	7.210D-22	2.240D-22	2.980D-23	1.290D-23
7	16	1.220D-20	8.420D-21	4.360D-21	1.580D-21	4.660D-22	4.260D-23	1.270D-23
6	9	1.880D-20	1.310D-20	6.920D-21	2.610D-21	8.330D-22	1.080D-22	4.340D-23
6	10	6.820D-20	4.730D-20	2.490D-20	9.300D-21	2.900D-21	3.540D-22	1.390D-22
6	11	5.800D-21	3.990D-21	2.050D-21	7.150D-22	1.950D-22	1.360D-23	3.610D-24
6	13	9.280D-21	6.390D-21	3.300D-21	1.180D-21	3.400D-22	3.350D-23	1.230D-23
6	16	1.690D-20	1.170D-20	6.160D-21	2.270D-21	6.940D-22	6.990D-23	2.180D-23
4	10	6.260D-20	4.380D-20	2.380D-20	9.760D-21	3.850D-21	9.530D-22	5.190D-22
4	11	3.600D-20	2.620D-20	1.560D-20	7.830D-21	4.050D-21	1.470D-21	8.840D-22
4	13	1.980D-20	1.380D-20	7.450D-21	2.970D-21	1.080D-21	2.180D-22	1.120D-22
4	16	4.760D-20	3.310D-20	1.770D-20	6.910D-21	2.420D-21	4.470D-22	2.230D-22
10	11	3.590D-20	2.590D-20	1.520D-20	7.460D-21	3.750D-21	1.320D-21	7.920D-22
10	13	2.510D-20	1.770D-20	9.740D-21	4.110D-21	1.670D-21	4.320D-22	2.430D-22
10	16	3.480D-20	2.610D-20	1.270D-20	4.660D-21	1.400D-21	1.390D-22	4.550D-23
11	13	3.010D-20	2.080D-20	1.080D-20	3.880D-21	1.130D-21	9.500D-23	2.520D-23
11	16	3.560D-20	2.460D-20	1.290D-20	4.770D-21	1.480D-21	1.890D-22	7.850D-23
12	13	5.560D-20	3.930D-20	2.190D-20	9.590D-21	4.110D-21	1.170D-21	6.640D-22

FE+18(0) IONIZATION POTENTIAL= 1456.00 EV

W.D.ROBB, UNPUBLISHED

COMMENTS: ROBB USES THE R-MATRIX CLOSE-COUPLING APPROXIMATION WITH CONFIGURATION-INTERACTION WAVE FUNCTIONS. FINE-STRUCTURE RECOUPLING IS HANDLED BY JAJOM. THE ATOMIC ENERGY LEVELS ARE TAKEN FROM THE ANALYSIS OF ATOMIC SPECTRA BY READER AND SUGAR, J. PHYS. CHEM. REF. DATA 4, 353 (1975).

ATOMIC STATE AND EXCITATION ENERGY

1	2S(2)2P(4)	3 P 2.0	0.0 EV
2	2S(2)2P(4)	3 P 0.0	9.33 EV
3	2S(2)2P(4)	3 P 1.0	11.09 EV
4	2S(2)2P(4)	1 D 2.0	21.05 EV
5	2S(2)2P(4)	1 S 0.0	40.44 EV
6	2S(1)2P(5)	3 P 2.0	114.61 EV
7	2S(1)2P(5)	3 P 1.0	122.08 EV
8	2S(1)2P(5)	3 P 0.0	127.68 EV
9	2S(1)2P(5)	1 P 1.0	157.26 EV

CROSS SECTIONS IN CM**2 VS ENERGY

I	J	142.85 EV	238.09 EV	680.25 EV	3401.00 EV	6122.00 EV	8843.00 EV
1	2	3.97D-21	2.32D-21	7.53D-22	1.48D-22	8.25D-23	5.60D-23
1	3	7.54D-20	4.22D-20	1.14D-20	1.36D-21	6.76D-22	4.39D-22
1	4	9.22D-20	5.08D-20	1.28D-20	1.15D-21	5.32D-22	3.38D-22
1	5	2.58D-20	1.44D-20	4.01D-21	5.90D-22	3.18D-22	2.13D-22
1	6	8.86D-19	5.53D-19	2.25D-19	6.27D-20	3.91D-20	2.90D-20
1	7	3.59D-19	2.25D-19	9.04D-20	2.50D-20	1.56D-20	1.16D-20
1	8	4.94D-22	2.72D-22	6.93D-23	3.61D-24	9.34D-25	3.82D-25
1	9	6.90D-20	4.31D-20	1.67D-20	4.29D-21	2.66D-21	1.97D-21
2	3	1.55D-19	8.45D-20	1.99D-20	8.76D-22	2.09D-22	8.03D-23
2	4	1.67D-19	9.45D-20	2.73D-20	4.15D-21	2.19D-21	1.46D-21
2	5	8.80D-22	4.73D-22	1.01D-22	4.22D-24	1.66D-24	1.13D-24
2	6	7.62D-22	3.98D-22	8.71D-23	3.04D-24	8.03D-25	3.61D-25
2	7	8.30D-19	5.18D-19	2.22D-19	7.14D-20	4.65D-20	3.52D-20
2	8	1.32D-20	7.44D-21	1.92D-21	9.75D-23	2.38D-23	9.35D-24
2	9	3.32D-19	2.09D-19	7.64D-20	1.24D-20	6.12D-21	3.90D-21
3	4	1.16D-19	6.32D-20	1.49D-20	7.69D-22	2.44D-22	1.26D-22
3	5	1.97D-20	1.07D-20	2.46D-21	1.01D-22	2.32D-23	8.75D-24
3	6	5.47D-19	3.44D-19	1.43D-19	4.01D-20	2.50D-20	1.85D-20
3	7	3.21D-19	2.01D-19	8.15D-20	2.28D-20	1.41D-20	1.05D-20
3	8	4.33D-19	2.70D-19	1.10D-19	3.07D-20	1.92D-20	1.43D-20
3	9	2.59D-20	1.53D-20	4.89D-21	8.15D-22	4.63D-22	3.32D-22
4	5	2.63D-20	1.55D-20	5.31D-21	1.17D-21	6.57D-22	4.44D-22
4	6	1.19D-19	7.43D-20	2.99D-20	7.60D-21	4.65D-21	3.38D-21
4	7	1.53D-20	8.54D-21	2.20D-21	1.35D-22	4.26D-23	2.18D-23
4	8	5.97D-21	3.35D-21	8.59D-22	4.20D-23	1.01D-23	3.92D-24
4	9	1.09D-18	6.89D-19	2.84D-19	8.09D-20	5.08D-20	3.76D-20
5	6	4.00D-20	2.25D-20	5.82D-21	2.95D-22	7.25D-23	2.84D-23
5	7	4.55D-19	2.87D-19	1.11D-19	2.16D-20	1.17D-20	7.93D-21
5	8	8.71D-22	4.86D-22	1.20D-22	5.42D-24	1.29D-24	4.98D-25
5	9	3.32D-19	2.12D-19	9.76D-20	3.77D-20	2.54D-20	1.95D-20
6	7	9.40D-20	5.18D-20	1.36D-20	1.51D-21	7.31D-22	4.71D-22
6	8	2.13D-20	1.19D-20	3.52D-21	5.78D-22	3.10D-22	2.07D-22
6	9	4.39D-20	2.37D-20	5.42D-21	2.34D-22	6.57D-23	3.11D-23
7	8	5.81D-20	3.15D-20	7.27D-21	3.11D-22	7.43D-23	2.88D-23
7	9	5.00D-20	2.71D-20	8.33D-21	4.12D-22	1.64D-22	9.74D-23
8	9	5.38D-20	2.90D-20	6.47D-21	2.39D-22	5.18D-23	1.85D-23

FE+17(F) IONIZATION POTENTIAL= 1358.00 Ev

W.D.ROBB, LA-8267-MS,MARCH(1980)

J.B.MANN, LA-8267-MS,MARCH(1980)

COMMENTS: ROBB USES THE R-MATRIX CLOSE-COUPLING APPROXIMATION WITH CONFIGURATION-INTERACTION WAVE FUNCTIONS. MANN USES THE DISTORTED WAVE APPROXIMATION WITH CONFIGURATION-INTERACTION WAVE FUNCTIONS. ONLY LS TERM VALUES ARE AVAILABLE. MANN'S RESULTS ARE SPLINE INTERPOLATED FROM THE ORIGINAL DATA FOR EASE IN PRESENTATION. THE ATOMIC ENERGY LEVELS ARE CALCULATED BY ROBB AND MANN.

ATOMIC STATE AND EXCITATION ENERGY

1	2S(2)2P(5)	2 P	0.0 Ev
2	2S(1)2P(6)	2 S	118.90 Ev
3	2S(2)2P(4)3S(1)	4 P	781.20 Ev
4	2S(2)2P(4)3S(1)	2 P	781.20 Ev
5	2S(2)2P(4)3S(1)	2 D	781.20 Ev
6	2S(2)2P(4)3S(1)	2 S	781.20 Ev
7	2S(2)2P(4)[3P]3D(1)	4 F	857.30 Ev
8	2S(2)2P(4)[3P]3D(1)	2 F	857.30 Ev
9	2S(2)2P(4)[3P]3D(1)	4 D	857.30 Ev
10	2S(2)2P(4)[3P]3D(1)	2 D	857.30 Ev
11	2S(2)2P(4)[3P]3D(1)	4 P	857.30 Ev
12	2S(2)2P(4)[3P]3D(1)	2 P	857.30 Ev
13	2S(2)2P(4)[1D]3D(1)	2 G	857.30 Ev
14	2S(2)2P(4)[1D]3D(1)	2 F	857.30 Ev
15	2S(2)2P(4)[1D]3D(1)	2 D	857.30 Ev
16	2S(2)2P(4)[1D]3D(1)	2 P	857.30 Ev
17	2S(2)2P(4)[1D]3D(1)	2 S	857.30 Ev
18	2S(2)2P(4)[1S]3D(1)	2 D	857.30 Ev
19	2S(1)2P(5)3P(1)	4 D	932.10 Ev
20	2S(1)2P(5)3P(1)	2 D	932.10 Ev
21	2S(1)2P(5)3P(1)	4 P	932.10 Ev
22	2S(1)2P(5)3P(1)	2 P	932.10 Ev
23	2S(1)2P(5)3P(1)	4 S	932.10 Ev
24	2S(1)2P(5)3P(1)	2 S	932.10 Ev
25	2S(1)2P(5)3P(1)	2 D	932.10 Ev
26	2S(1)2P(5)3P(1)	2 P	932.10 Ev
27	2S(1)2P(5)3P(1)	2 S	932.10 Ev

CROSS SECTIONS IN CM**2 VS ENERGY

ROBB

I	J	135.49 Ev	544.35 Ev	952.01 Ev	1360.00 Ev	4080.00 Ev	6801.00 Ev	9520.00 Ev
1	2	6.74D-19	2.06D-19	1.33D-19	1.01D-19	4.21D-20	2.78D-20	2.10D-20

MANN

CROSS SECTIONS IN CM**2 VS ENERGY

I	J	1360.50 Ev	2721.00 Ev	4081.50 Ev	6802.50 Ev	13605.00 Ev	27210.00 Ev	68025.00 Ev
1	3	9.72D-22	5.40D-22	4.37D-22	3.44D-22	2.39D-22	1.56D-22	8.27D-23
1	4	1.24D-21	1.26D-21	1.17D-21	9.83D-22	6.99D-22	4.59D-22	2.43D-22
1	5	1.28D-21	1.07D-21	9.57D-22	7.91D-22	5.60D-22	3.67D-22	1.94D-22
1	6	2.55D-22	2.13D-22	1.91D-22	1.58D-22	1.12D-22	7.33D-23	3.88D-23
1	7	4.15D-21	1.12D-21	6.76D-22	4.25D-22	2.52D-22	1.50D-22	7.30D-23
1	8	8.50D-21	6.04D-21	4.93D-21	3.71D-21	2.41D-21	1.49D-21	7.53D-22
1	9	4.04D-21	6.84D-22	2.58D-22	9.41D-23	3.85D-23	2.06D-23	9.61D-24
1	10	1.25D-20	9.17D-21	7.56D-21	5.76D-21	3.78D-21	2.36D-21	1.20D-21
1	11	7.78D-21	5.24D-21	4.25D-21	3.21D-21	2.09D-21	1.30D-21	6.61D-22
1	12	2.50D-21	1.32D-21	1.02D-21	7.53D-22	4.89D-22	3.05D-22	1.55D-22
1	13	2.63D-21	8.73D-22	5.45D-22	3.28D-22	1.71D-22	8.91D-23	3.69D-23
1	14	2.77D-21	1.36D-21	1.02D-21	7.38D-22	4.66D-22	2.84D-22	1.41D-22
1	15	4.42D-20	3.51D-20	2.93D-20	2.25D-20	1.49D-20	9.32D-21	4.75D-21
1	16	3.19D-20	2.52D-20	2.10D-20	1.62D-20	1.07D-20	6.69D-21	3.41D-21
1	17	7.62D-21	5.81D-21	4.82D-21	3.69D-21	2.44D-21	1.53D-21	7.79D-22
1	18	1.51D-20	1.14D-20	9.48D-21	7.25D-21	4.78D-21	2.99D-21	1.52D-21
1	19	1.59D-21	1.27D-21	1.15D-21	9.60D-22	6.92D-22	4.61D-22	2.48D-22
1	20	1.94D-21	2.05D-21	1.92D-21	1.64D-21	1.19D-21	7.91D-22	4.25D-22
1	21	1.65D-21	1.63D-21	1.52D-21	1.29D-21	9.31D-22	6.21D-22	3.34D-22
1	22	1.62D-21	1.80D-21	1.70D-21	1.45D-21	1.05D-21	7.01D-22	3.77D-22
1	23	1.34D-22	2.97D-23	1.40D-23	7.27D-24	4.22D-24	2.69D-24	1.43D-24
1	24	7.52D-22	8.57D-22	8.13D-22	6.95D-22	5.04D-22	3.36D-22	1.81D-22
1	25	1.32D-21	1.29D-21	1.20D-21	1.02D-21	7.35D-22	4.90D-22	2.63D-22
1	26	1.04D-21	1.07D-21	1.01D-21	8.56D-22	6.20D-22	4.13D-22	2.22D-22
1	27	7.73D-23	2.75D-23	1.91D-23	1.40D-23	9.64D-24	6.36D-24	3.41D-24

FE+16(NE) IONIZATION POTENTIAL= 1266.00 EV

J.B.MANN, LA-6267-MS,MARCH(1980)

COMMENTS: MANN USES THE DISTORTED WAVE APPROXIMATION WITH CONFIGURATION-INTERACTION WAVE FUNCTIONS. ONLY LS TERM VALUES ARE AVAILABLE. MANN'S RESULTS ARE SPLINE INTERPOLATED FROM THE ORIGINAL DATA FOR EASE IN PRESENTATION. THE ATOMIC ENERGY LEVELS ARE CALCULATED BY MANN. MANN'S RESULTS ARE IN GOOD AGREEMENT WITH A DISTORTED WAVE APPROXIMATION CALCULATION OF FLOWER, J. PHYS. B 4, 697 (1971), EXCEPT FOR THE 1-11 TRANSITION.

ATOMIC STATE AND EXCITATION ENERGY

1	2S(2)2P(6)	1	S	0.0 EV
2	2S(2)2P(5)3S(1)	1	P	730.60 EV
3	2S(2)2P(5)3S(1)	3	P	730.60 EV
4	2S(2)2P(5)3P(1)	3	D	765.70 EV
5	2S(2)2P(5)3P(1)	3	P	765.70 EV
6	2S(2)2P(5)3P(1)	3	S	765.70 EV
7	2S(2)2P(5)3P(1)	1	D	765.70 EV
8	2S(2)2P(5)3P(1)	1	P	765.70 EV
9	2S(2)2P(5)3P(1)	1	S	765.70 EV
10	2S(2)2P(5)3D(1)	3	F	810.70 EV
11	2S(2)2P(5)3D(1)	3	D	810.70 EV
12	2S(2)2P(5)3D(1)	3	P	810.70 EV
13	2S(2)2P(5)3D(1)	1	F	810.70 EV
14	2S(2)2P(5)3D(1)	1	D	810.70 EV
15	2S(2)2P(5)3D(1)	1	P	810.70 EV
16	2S(1)2P(6)3S(1)	3	S	860.70 EV
17	2S(1)2P(6)3S(1)	1	S	866.80 EV
18	2S(1)2P(6)3P(1)	1	P	895.90 EV
19	2S(1)2P(6)3P(1)	3	P	895.90 EV
20	2S(1)2P(6)3D(1)	1	D	940.20 EV
21	2S(1)2P(6)3D(1)	3	D	940.20 EV

CROSS SECTIONS IN CM**2 VS ENERGY

I	J	1360.50 EV	2721.00 EV	4081.50 EV	6802.50 EV	13605.00 EV	27210.00 EV	68025.00 EV
1	2	3.21D-21	3.24D-21	2.96D-21	2.44D-21	1.71D-21	1.12D-21	5.86D-22
1	3	3.77D-21	2.94D-21	2.56D-21	2.06D-21	1.44D-21	9.33D-22	4.90D-22
1	4	6.01D-21	1.85D-21	1.08D-21	6.18D-22	3.14D-22	1.60D-22	6.26D-23
1	5	7.00D-21	3.29D-21	2.21D-21	1.36D-21	7.01D-22	3.55D-22	1.40D-22
1	6	2.03D-21	3.97D-22	1.42D-22	3.63D-23	5.30D-24	7.26D-25	5.20D-26
1	7	2.95D-21	1.54D-21	1.10D-21	7.19D-22	3.88D-22	2.01D-22	7.88D-23
1	8	8.48D-22	1.62D-22	4.55D-23	1.00D-23	1.20D-24	1.39D-25	8.90D-27
1	9	4.67D-20	2.46D-20	1.66D-20	1.00D-20	5.01D-21	2.50D-21	9.94D-22
1	10	7.85D-21	1.83D-21	9.68D-22	5.19D-22	2.51D-22	1.32D-22	5.45D-23
1	11	3.74D-20	2.77D-20	2.29D-20	1.75D-20	1.14D-20	7.13D-21	3.61D-21
1	12	8.06D-21	1.53D-21	6.72D-22	3.19D-22	1.68D-22	1.00D-22	5.05D-23
1	13	2.94D-21	1.36D-21	9.42D-22	6.00D-22	3.20D-22	1.68D-22	6.94D-23
1	14	1.25D-21	1.53D-22	4.18D-23	7.80D-24	8.34D-25	9.49D-26	6.27D-27
1	15	1.20D-19	9.67D-20	8.10D-20	6.22D-20	4.10D-20	2.57D-20	1.30D-20
1	16	6.24D-22	1.02D-22	3.47D-23	8.52D-24	1.22D-24	1.67D-25	1.19D-26
1	17	1.43D-20	7.95D-21	5.47D-21	3.36D-21	1.70D-21	8.52D-22	3.41D-22
1	18	4.39D-21	5.45D-21	5.27D-21	4.58D-21	3.35D-21	2.24D-21	1.21D-21
1	19	1.88D-21	9.09D-22	7.20D-22	5.72D-22	4.07D-22	2.71D-22	1.46D-22
1	20	1.70D-20	1.34D-20	1.05D-20	7.21D-21	3.96D-21	2.05D-21	8.16D-22
1	21	5.47D-21	8.80D-22	2.97D-22	8.03D-23	1.87D-23	6.72D-24	2.35D-24

FE+15(NA) IONIZATION POTENTIAL= 489.30 EV

D.R.FLOWER AND H.NUSSBAUMER, ASTRON.ASTROPHYS.42,265(1975)

COMMENTS: FLOWER AND NUSSBAUMER USE THE DISTORTED WAVE APPROXIMATION WITH CONFIGURATION-INTERACTION WAVE FUNCTIONS. FINE-STRUCTURE RECOUPLING IS HANDLED BY JAJOM. THE ATOMIC ENERGY LEVELS ARE CALCULATED BY FLOWER AND NUSSBAUMER. FLOWER AND NUSSBAUMER'S LS TERM RECULTS ARE 10% AGREEMENT OR BETTER NEAR THRESHOLD WITH THE DISTORTED WAVE APPROXIMATION CALCULATION OF BLAHA AND DAVIS, J. QUANT. SPECTROSC. RADIAT. TRANSFER 19, 227 (1978).

ATOMIC STATE AND EXCITATION ENERGY

1	3S(1)	2 S 0.5	0.0 EV
2	3P(1)	2 P 0.5	34.36 EV
3	3P(1)	2 P 1.5	36.96 EV
4	3D(1)	2 D 1.5	83.74 EV
5	3D(1)	2 D 2.5	84.11 EV

CROSS SECTIONS IN CM**2 VS ENERGY

I	J	88.43 EV	108.84 EV
1	2	8.32D-18	6.76D-18
1	3	1.65D-17	1.33D-17
1	4	8.80D-19	7.15D-19
1	5	1.29D-18	1.04D-18
2	3	1.42D-18	1.15D-18
2	4	1.20D-17	9.90D-18
2	5	3.32D-19	2.58D-19
3	4	1.39D-18	1.15D-18
3	5	1.09D-17	8.99D-18
4	5	8.46D-19	6.32D-19

FE+14(MG) IONIZATION POTENTIAL= 457.00 EV

A.K.BHATIA AND S.O.KASTNER, SOLAR PHYS.65,181(1980)

A.K.BHATIA AND S.O.KASTNER, J.Q.S.R.T.24,53(1980)

COMMENTS: BHATIA AND KASTNER USE THE DISTORTED WAVE APPROXIMATION WITH CONFIGURATION-INTERACTION WAVE FUNCTIONS. FINE-STRUCTURE RECOUPLING IS HANDLED BY JAJOM. THE ATOMIC ENERGY LEVELS ARE CALCULATED BY BHATIA AND KASTNER. BHATIA AND KASTNER'S LS TERM RESULTS ARE IN FAIR AGREEMENT NEAR THRESHOLD WITH A DISTORTED WAVE APPROXIMATION CALCULATION OF FLOWER AND JORDAN, ASTRON. ASTROPHYS. 14, 473 (1971).

ATOMIC STATE AND EXCITATION ENERGY

1	3S(2)	1 S 0.0	0.0 EV
2	3S(1)3P(1)	3 P 0.0	28.79 EV
3	3S(1)3P(1)	3 P 1.0	29.51 EV
4	3S(1)3P(1)	3 P 2.0	31.20 EV
5	3S(1)3P(1)	1 P 1.0	44.08 EV
6	3P(2)	3 P 0.0	68.84 EV
7	3P(2)	1 D 2.0	69.30 EV
8	3P(2)	3 P 1.0	70.04 EV
9	3P(2)	3 P 2.0	72.08 EV
10	3P(2)	1 S 0.0	82.35 EV
11	3S(1)3D(1)	3 D 1.0	84.60 EV
12	3S(1)3D(1)	3 D 2.0	84.75 EV
13	3S(1)3D(1)	3 D 3.0	84.99 EV
14	3S(1)3D(1)	1 D 2.0	95.67 EV

CROSS SECTIONS IN CM**2 VS ENERGY

I	J	108.84 EV	217.68 EV	326.52 EV
1	2	3.85D-20	1.32D-20	4.40D-21
1	3	2.58D-19	1.21D-19	6.67D-20
1	4	1.92D-19	6.65D-20	2.20D-20
1	5	2.65D-17	1.52D-17	9.89D-18
1	7	8.65D-19	4.25D-19	1.87D-19
1	9	1.48D-19	7.31D-20	3.26D-20
1	10	3.19D-20	1.32D-20	6.23D-21
1	11	9.68D-20	3.35D-20	1.39D-20

continued

1	12	1.62D-19	5.61D-20	2.27D-20
1	13	2.25D-19	7.86D-20	3.08D-20
1	14	1.80D-18	8.52D-19	3.78D-19
2	3	2.93D-19	1.00D-19	3.08D-20
2	4	9.69D-19	4.38D-19	1.75D-19
2	5	4.84D-20	1.59D-20	5.13D-21
2	6	2.86D-20	9.35D-21	3.30D-21
2	7	1.32D-19	4.56D-20	1.47D-20
2	8	1.27D-17	7.07D-18	4.52D-18
2	9	1.32D-20	4.40D-21	1.47D-21
2	11	9.37D-18	5.17D-18	3.18D-18
2	12	1.11D-19	3.79D-20	1.17D-20
2	13	1.62D-19	7.20D-20	2.71D-20
2	14	5.28D-20	1.76D-20	5.86D-21
3	4	8.43D-19	3.67D-19	1.53D-19
3	5	5.86D-20	2.05D-20	6.84D-21
3	6	4.34D-18	2.42D-18	1.55D-18
3	7	1.10D-18	5.88D-19	3.73D-19
3	8	3.23D-18	1.79D-18	1.14D-18
3	9	4.33D-18	2.40D-18	1.57D-18
3	10	1.80D-20	8.98D-21	5.25D-21
3	11	2.39D-18	1.31D-18	8.05D-19
3	12	7.10D-18	3.92D-18	2.49D-18
3	13	1.61D-19	6.62D-20	2.35D-20
3	14	1.04D-19	4.49D-20	2.28D-20
4	5	5.28D-20	1.78D-20	5.57D-21
4	6	6.38D-21	2.20D-21	7.33D-22
4	7	1.42D-18	7.73D-19	4.91D-19
4	8	3.29D-18	1.83D-18	1.18D-18
4	9	8.36D-18	4.63D-18	2.97D-18
4	10	9.46D-21	3.19D-21	1.25D-21
4	11	1.64D-19	8.23D-20	4.54D-20
4	12	1.54D-18	8.37D-19	5.20D-19
4	13	8.10D-18	4.47D-18	2.95D-18
4	14	5.37D-20	1.78D-20	5.50D-21
5	6	5.61D-20	2.13D-20	7.82D-21
5	7	7.33D-18	4.07D-18	2.74D-18
5	8	4.73D-20	1.67D-20	5.74D-21
5	9	1.25D-18	6.85D-19	4.53D-19
5	10	7.22D-18	3.96D-18	2.53D-18
5	11	6.82D-20	2.38D-20	7.94D-21
5	12	1.06D-19	3.68D-20	1.19D-20
5	13	1.33D-19	4.53D-20	1.36D-20
5	14	2.33D-17	1.29D-17	8.26D-18
6	7	4.67D-19	1.94D-19	8.14D-20
6	8	3.46D-19	1.15D-19	4.11D-20
6	9	7.20D-19	3.19D-19	1.35D-19
6	10	1.09D-20	3.24D-21	1.14D-21
6	11	7.90D-21	2.42D-21	7.33D-22
6	12	9.04D-21	3.41D-21	1.43D-21
6	13	6.27D-22	2.14D-22	7.33D-23
6	14	5.51D-20	2.14D-20	8.80D-21
7	8	1.49D-19	5.65D-20	2.25D-20
7	9	4.13D-19	1.75D-19	7.55D-20
7	10	3.72D-19	1.73D-19	7.23D-20
7	11	2.22D-20	6.71D-21	1.69D-21
7	12	3.76D-20	1.14D-20	2.86D-21
7	13	5.32D-20	1.62D-20	3.96D-21
7	14	7.32D-20	2.83D-20	1.00D-20
8	9	7.99D-19	3.39D-19	1.36D-19
8	10	1.44D-20	4.40D-21	1.71D-21
8	11	6.05D-21	2.20D-21	8.19D-22
8	12	6.89D-21	2.20D-21	6.72D-22
8	13	4.47D-21	1.69D-21	7.09D-22
8	14	3.23D-20	1.06D-20	4.03D-21
9	10	1.01D-19	4.41D-20	1.89D-20
9	11	5.12D-21	1.65D-21	4.47D-22
9	12	1.07D-20	3.41D-21	1.03D-21
9	13	2.24D-20	7.92D-21	3.15D-21
9	14	3.72D-20	1.25D-20	4.69D-21
10	11	3.33D-21	1.10D-21	4.40D-22
10	12	5.97D-21	2.09D-21	8.43D-22
10	13	7.43D-21	2.47D-21	9.90D-22
10	14	1.39D-18	6.32D-19	2.63D-19
11	12	7.37D-19	2.79D-19	1.06D-19
11	13	2.44D-19	8.14D-20	2.61D-20
11	14	1.74D-19	5.19D-20	1.25D-20
12	13	5.94D-19	2.19D-19	8.36D-20
12	14	1.73D-19	5.18D-20	1.25D-20
13	14	1.73D-19	5.15D-20	1.24D-20

FE+13(AL) IONIZATION POTENTIAL= 392.20 EV

M.E.MASON, M.N.R.A.S.170,651(1975)

COMMENTS: MASON USES THE DISTORTED WAVE APPROXIMATION WITH CONFIGURATION-INTERACTION WAVE FUNCTIONS. FINE-STRUCTURE RECOUPLING IS HANDLED BY JAJOM. THE ATOMIC ENERGY LEVELS ARE CALCULATED BY MASON. MASON'S RESULTS ARE IN FAIR AGREEMENT WITH AN EARLIER CLOSE-COUPLING APPROXIMATION BY PETRINI, ASTRON. ASTROPHYS. 9, 392 (1970).

ATOMIC STATE AND EXCITATION ENERGY

1	3S(2)3P(1)	2	P	0.5	0.0 EV
2	3S(2)3P(1)	2	P	1.5	2.20 EV
3	3S(1)3P(2)	4	P	0.5	25.35 EV
4	3S(1)3P(2)	4	P	1.5	26.22 EV
5	3S(1)3P(2)	4	P	2.5	27.35 EV
6	3S(1)3P(2)	2	D	1.5	35.77 EV
7	3S(1)3P(2)	2	D	2.5	35.96 EV
8	3S(1)3P(2)	2	S	0.5	44.80 EV
9	3S(1)3P(2)	2	P	0.5	49.13 EV
10	3S(1)3P(2)	2	P	1.5	50.31 EV
11	3S(2)3D(1)	2	D	1.5	59.14 EV
12	3S(2)3D(1)	2	D	2.5	59.47 EV

CROSS SECTIONS IN CM**2 VS ENERGY

I	J	81.63 EV
1	2	1.68D-18
1	3	1.30D-19
1	4	9.97D-20
1	5	7.55D-20
1	6	6.82D-18
1	7	1.88D-19
1	8	8.08D-18
1	9	1.22D-17
1	10	8.77D-18
1	11	2.05D-17
1	12	3.01D-19
2	3	3.12D-20
2	4	7.73D-20
2	5	2.26D-19
2	6	3.61D-19
2	7	5.44D-18
2	8	1.19D-18
2	9	6.19D-18
2	10	2.14D-17
2	11	2.87D-18
2	12	1.94D-17

FE+12(SI) IONIZATION POTENTIAL= 361.00 EV

D.R.FLOWER AND G.PINEAU DES FORETS, ASTRON.ASTROPHYS.24,181(1973)

D.R.FLOWER AND H.NUSSBAUMER, ASTRON.ASTROPHYS.31,353(1974)

COMMENTS: FLOWER AND PINEAU DES FORETS USE THE DISTORTED WAVE APPROXIMATION WITH CONFIGURATION-INTERACTION WAVE FUNCTIONS. FINE-STRUCTURE RECOUPLING IS HANDLED BY JAJOM. FLOWER AND NUSSBAUMER EXTENDED THE FLOWER AND PINEAU DES FORETS RESULTS BY INCLUDING MORE CONFIGURATIONS. THE ATOMIC ENERGY LEVELS ARE CALCULATED BY FLOWER AND NUSSBAUMER.

ATOMIC STATE AND EXCITATION ENERGY

1	3S(2)3P(2)	3 P	0.0	0.0 EV
2	3S(2)3P(2)	3 P	1.0	1.16 EV
3	3S(2)3P(2)	3 P	2.0	2.30 EV
4	3S(2)3P(2)	1 D	2.0	6.20 EV
5	3S(2)3P(2)	1 S	0.0	11.31 EV
6	3S(1)3P(3)	5 S	2.0	24.00 EV
7	3S(1)3P(3)	3 D	1.0	33.50 EV
8	3S(1)3P(3)	3 D	2.0	33.50 EV
9	3S(1)3P(3)	3 D	3.0	33.85 EV
10	3S(1)3P(3)	3 P	0.0	38.71 EV
11	3S(1)3P(3)	3 P	1.0	38.80 EV
12	3S(1)3P(3)	3 P	2.0	38.88 EV
13	3S(1)3P(3)	1 D	2.0	43.29 EV
14	3S(1)3P(3)	3 S	1.0	50.05 EV
15	3S(2)3P(1)3D(1)	3 F	2.0	52.58 EV
16	3S(1)3P(3)	1 P	1.0	53.06 EV
17	3S(2)3P(1)3D(1)	3 F	3.0	53.36 EV
18	3S(2)3P(1)3D(1)	3 F	4.0	54.53 EV
19	3S(2)3P(1)3D(1)	3 P	2.0	59.60 EV
20	3S(2)3P(1)3D(1)	3 P	1.0	60.76 EV
21	3S(2)3P(1)3D(1)	1 D	2.0	61.14 EV
22	3S(2)3P(1)3D(1)	3 P	0.0	61.51 EV
23	3S(2)3P(1)3D(1)	3 D	1.0	62.30 EV
24	3S(2)3P(1)3D(1)	3 D	3.0	62.64 EV
25	3S(2)3P(1)3D(1)	3 D	2.0	62.64 EV
26	3S(2)3P(1)3D(1)	1 F	3.0	68.95 EV
27	3S(2)3P(1)3D(1)	1 P	1.0	70.34 EV

CROSS SECTIONS IN CM**2 VS ENERGY

I	J	69.39 EV
1	2	6.04D-19
1	3	1.91D-18
1	4	1.76D-19
1	5	1.90D-20
1	6	1.33D-19
1	7	5.97D-18
1	8	2.16D-19
1	9	2.41D-20
1	10	2.24D-20
1	11	3.57D-18
1	12	7.42D-20
1	13	1.54D-19
1	14	7.93D-18
1	15	1.79D-19
1	16	7.04D-19
1	17	2.81D-19
1	18	6.04D-20
1	19	1.85D-19
1	20	2.64D-17
1	21	5.35D-20
1	22	1.03D-20
1	23	6.04D-18
1	24	1.83D-19
1	25	8.45D-20
1	26	1.22D-19
1	27	2.04D-19
2	3	1.50D-18
2	4	3.08D-19
2	5	2.89D-20
2	6	1.70D-19
2	7	6.67D-19
2	8	4.21D-18
2	9	9.66D-20
2	10	1.51D-18
2	11	2.02D-18
2	12	9.37D-19
2	13	2.89D-19

Continued

2	14	7.30D-16
2	15	2.44D-19
2	16	1.54D-18
2	17	1.51D-19
2	18	1.83D-19
2	19	6.44D-18
2	20	1.33D-19
2	21	6.27D-18
2	22	3.21D-18
2	23	8.11D-18
2	24	2.07D-19
2	25	8.85D-18
2	26	1.36D-19
2	27	6.61D-20
3	4	5.86D-19
3	5	6.52D-20
3	6	1.63D-19
3	7	1.97D-20
3	8	1.28D-19
3	9	3.30D-18
3	10	1.55D-20
3	11	7.45D-19
3	12	3.93D-18
3	13	2.75D-19
3	14	9.11D-18
3	15	1.70D-19
3	16	2.09D-19
3	17	3.45D-19
3	18	2.20D-19
3	19	4.24D-18
3	20	1.19D-18
3	21	3.00D-20
3	22	1.52D-20
3	23	1.53D-18
3	24	1.88D-17
3	25	7.14D-18
3	26	7.87D-19
3	27	4.14D-21
4	5	1.20D-18
4	6	6.90D-21
4	7	1.50D-19
4	8	1.15D-19
4	9	4.07D-19
4	10	6.90D-21
4	11	7.93D-20
4	12	4.38D-19
4	13	6.42D-18
4	14	2.10D-19
4	15	2.73D-19
4	16	9.28D-18
4	17	2.39D-19
4	18	2.92D-19
4	19	5.49D-18
4	20	1.42D-19
4	21	1.03D-17
4	22	2.55D-20
4	23	2.52D-19
4	24	8.69D-19
4	25	1.05D-18
4	26	1.73D-17
5	7	6.04D-20
5	8	6.90D-21
5	9	8.62D-21
5	10	9.14D-20
5	11	4.48D-19
5	12	3.16D-19
5	13	7.24D-20
5	14	1.00D-18
5	15	8.28D-20
5	16	1.11D-17
5	17	1.48D-19
5	18	2.55D-19
5	19	1.00D-19
5	20	4.24D-19
5	21	1.38D-19
5	22	3.62D-20
5	23	1.69D-19
5	24	7.76D-20
5	25	9.49D-20
5	26	4.07D-19
5	27	3.59D-17

FE.11(P) IONIZATION POTENTIAL= 330.80 EV

D.R.FLOWER, ASTRON.ASTROPHYS.54.103(1977)

COMMENTS: FLOWER USES THE DISTORTED WAVE APPROXIMATION WITH CONFIGURATION-INTERACTION WAVE FUNCTIONS. FINE STRUCTURE RECOUPLING IS HANDLED BY JAJOM. THE ATOMIC ENERGY LEVELS ARE CALCULATED BY FLOWER, THE PARENT COUPLINGS FOR THE $3s^2 3p^2 3D$ CONFIGURATION ARE NOT IDENTIFIED.

ATOMIC STATE AND EXCITATION ENERGY

1	3S(2)3P(3)	4	S	1.5	0.0 Ev
2	3S(2)3P(3)	2	D	1.5	5.70 Ev
3	3S(2)3P(3)	2	D	2.5	6.27 Ev
4	3S(2)3P(3)	2	P	0.5	9.03 Ev
5	3S(2)3P(3)	2	P	1.5	9.80 Ev
6	3S(1)3P(4)	4	P	2.5	32.87 Ev
7	3S(1)3P(4)	4	P	1.5	33.96 Ev
8	3S(1)3P(4)	4	P	0.5	34.48 Ev
9	3S(1)3P(4)	2	D	1.5	41.78 Ev
10	3S(1)3P(4)	2	D	2.5	41.97 Ev
11	3S(1)3P(4)	2	P	1.5	48.30 Ev
12	3S(1)3P(4)	2	P	0.5	48.79 Ev
13	3S(1)3P(4)	2	S	0.5	50.52 Ev
14	3S(2)3P(2)3D(1)	4	F	1.5	52.56 Ev
15	3S(2)3P(2)3D(1)	4	F	2.5	53.01 Ev
16	3S(2)3P(2)3D(1)	4	F	3.5	53.64 Ev
17	3S(2)3P(2)3D(1)	4	F	4.5	54.45 Ev
18	3S(2)3P(2)3D(1)	2	F	2.5	54.94 Ev
19	3S(2)3P(2)3D(1)	4	D	0.5	55.32 Ev
20	3S(2)3P(2)3D(1)	4	D	3.5	55.39 Ev
21	3S(2)3P(2)3D(1)	4	D	1.5	55.45 Ev
22	3S(2)3P(2)3D(1)	4	D	2.5	55.98 Ev
23	3S(2)3P(2)3D(1)	2	F	3.5	57.11 Ev
24	3S(2)3P(2)3D(1)	2	G	3.5	61.36 Ev
25	3S(2)3P(2)3D(1)	2	G	4.5	61.71 Ev
26	3S(2)3P(2)3D(1)	2	P	1.5	64.49 Ev
27	3S(2)3P(2)3D(1)	4	P	2.5	64.81 Ev
28	3S(2)3P(2)3D(1)	4	P	1.5	65.24 Ev
29	3S(2)3P(2)3D(1)	4	P	0.5	65.36 Ev
30	3S(2)3P(2)3D(1)	2	P	0.5	65.86 Ev
31	3S(2)3P(2)3D(1)	2	D	1.5	65.96 Ev
32	3S(2)3P(2)3D(1)	2	D	2.5	67.36 Ev
33	3S(2)3P(2)3D(1)	2	D	2.5	70.62 Ev
34	3S(2)3P(2)3D(1)	2	D	1.5	70.68 Ev
35	3S(2)3P(2)3D(1)	2	P	0.5	72.24 Ev
36	3S(2)3P(2)3D(1)	2	P	1.5	72.94 Ev
37	3S(2)3P(2)3D(1)	2	D	2.5	73.30 Ev
38	3S(2)3P(2)3D(1)	2	F	3.5	73.74 Ev
39	3S(2)3P(2)3D(1)	2	S	0.5	74.45 Ev
40	3S(2)3P(2)3D(1)	2	F	2.5	76.91 Ev
41	3S(2)3P(2)3D(1)	2	D	1.5	77.05 Ev

CROSS SECTIONS IN CM**2 VS ENERGY

I	J	89.79 EV
1	2	1.70D-19
1	3	2.63D-19
1	4	3.33D-20
1	5	6.33D-20
1	6	3.70D-18
1	7	2.53D-18
1	8	1.30D-18
1	9	1.00D-20
1	10	1.67D-20
1	11	2.20D-19
1	12	8.33D-20
1	13	4.33D-20
1	14	1.10D-19
1	15	1.57D-19
1	16	1.90D-19
1	17	2.33D-19
1	18	8.33D-20
1	19	2.00D-20
1	20	6.00D-20
1	21	7.66D-20
1	22	1.23D-19
1	23	5.00D-20
1	24	1.00D-21

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1 25     3.33D-22
1 26     3.33D-19
1 27     2.20D-17
1 28     1.32D-17
1 29     5.03D-18
1 30     2.63D-18
1 31     1.80D-18
1 32     5.00D-19
1 33     3.00D-20
1 34     3.33D-21
1 35     1.67D-20
1 36     2.67D-20
1 37     1.10D-19
1 38     1.03D-19
1 39     3.00D-21
1 40     8.66D-20
1 41     2.67D-20
2  3     6.33D-19
2  4     9.66D-19
2  5     6.00D-19
2  6     1.20D-19
2  7     5.66D-20
2  8     2.67D-20
2  9     3.43D-18
2 10     2.27D-19
2 11     4.33D-19
2 12     2.17D-18
2 13     1.00D-19
2 14     1.53D-19
2 15     1.43D-19
2 16     1.13D-19
2 17     1.67D-21
2 18     1.27D-19
2 19     7.66D-20
2 20     1.40D-19
2 21     4.33D-20
2 22     6.66D-20
2 23     6.00D-20
2 24     1.20D-19
2 25     1.40D-19
2 26     3.57D-18
2 27     1.87D-19
2 28     4.67D-19
2 29     1.63D-18
2 30     3.97D-18
2 31     7.66D-19
2 32     2.63D-19
2 33     1.17D-18
2 34     1.17D-17
2 35     8.00D-20
2 36     3.33D-19
2 37     2.06D-17
2 38     8.66D-20
2 39     4.33D-19
2 40     9.66D-20
2 41     1.57D-19
3  4     5.11D-19
3  5     1.49D-18
3  6     1.22D-19
3  7     3.11D-20
3  8     6.66D-21
3  9     1.69D-19
3 10     3.29D-18
3 11     3.04D-18
3 12     1.33D-20
3 13     1.11D-20
3 14     6.66D-21
3 15     4.89D-20
3 16     1.00D-19
3 17     1.41D-19
3 18     1.36D-19
3 19     1.33D-20
3 20     1.60D-19
3 21     8.44D-20
3 22     9.11D-20
3 23     1.27D-19
3 24     1.53D-19
3 25     1.51D-19
3 26     7.66D-18
3 27     2.44D-19
3 28     8.22D-20
3 29     2.67D-20
3 30     2.22D-20
3 31     1.09D-18
3 32     3.24D-18
3 33     9.89D-18
3 34     8.89D-19
3 35     4.22D-20
3 36     6.22D-19
3 37     1.64D-18
3 38     2.03D-17
3 39     2.67D-20
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continued

3	40	1.42D-19
3	41	4.67D-20
4	5	5.20D-19
4	6	3.33D-20
4	7	8.66D-20
4	8	9.33D-20
4	9	4.60D-19
4	10	1.73D-19
4	11	2.87D-19
4	12	2.20D-18
4	13	1.00D-18
4	14	4.67D-20
4	15	6.00D-20
4	16	7.33D-20
4	17	6.00D-20
4	18	6.00D-20
4	19	5.33D-20
4	20	8.66D-20
4	21	8.00D-20
4	22	6.00D-20
4	23	1.33D-20
4	24	1.07D-19
4	25	7.33D-20
4	26	3.33D-19
4	27	2.67D-20
4	28	6.00D-20
4	29	2.07D-19
4	30	3.47D-19
4	31	9.33D-20
4	32	2.87D-19
4	33	6.00D-20
4	34	8.46D-19
4	35	1.09D-17
4	36	5.66D-18
4	37	1.20D-19
4	38	1.00D-19
4	39	2.07D-18
4	40	8.66D-20
4	41	2.10D-17
5	6	8.66D-20
5	7	1.13D-19
5	8	4.00D-20
5	9	6.00D-20
5	10	8.66D-19
5	11	1.93D-19
5	12	8.33D-20
5	13	2.80D-18
5	14	1.00D-20
5	15	2.00D-20
5	16	4.00D-20
5	17	9.66D-20
5	18	1.67D-20
5	19	4.00D-20
5	20	3.67D-20
5	21	4.67D-20
5	22	9.66D-20
5	23	2.07D-19
5	24	1.07D-19
5	25	1.37D-19
5	26	2.13D-19
5	27	5.66D-20
5	28	7.66D-20
5	29	6.33D-19
5	30	9.00D-19
5	31	1.63D-19
5	32	3.33D-19
5	33	1.27D-18
5	34	1.00D-19
5	35	1.47D-18
5	36	9.20D-18
5	37	1.03D-19
5	38	1.50D-19
5	39	5.53D-18
5	40	2.09D-17
5	41	2.40D-18

FE+10(5) IONIZATION POTENTIAL= 290.30 Ev

M.E.MASON, M.N.R.A.S.,170,651(1975)

COMMENTS. MASON USES THE DISTORTED WAVE APPROXIMATION WITH CONFIGURATION-INTERACTION WAVE FUNCTIONS. FINE-STRUCTURE RECOUPLING IS HANDLED BY JAJOM. THE ATOMIC ENERGY LEVELS ARE CALCULATED BY MASON. THE PARENT COUPLINGS FOR THE $3S^2 3P^3 3D$ CONFIGURATION ARE NOT IDENTIFIED.

ATOMIC STATE AND EXCITATION ENERGY

1	3S(2)3P(4)	3 P	2.0	0.0 Ev
2	3S(2)3P(4)	3 P	1.0	1.44 Ev
3	3S(2)3P(4)	3 P	0.0	1.63 Ev
4	3S(2)3P(4)	1 D	2.0	4.94 Ev
5	3S(2)3P(4)	1 S	0.0	9.28 Ev
6	3S(1)3P(5)	3 P	2.0	34.08 Ev
7	3S(1)3P(5)	3 P	1.0	35.20 Ev
8	3S(1)3P(5)	3 P	0.0	35.86 Ev
9	3S(1)3P(5)	1 P	1.0	44.05 Ev
10	3S(2)3P(3)3D(1)	5 D	0.0	46.77 Ev
11	3S(2)3P(3)3D(1)	5 D	1.0	46.80 Ev
12	3S(2)3P(3)3D(1)	5 D	2.0	46.84 Ev
13	3S(2)3P(3)3D(1)	5 D	3.0	46.90 Ev
14	3S(2)3P(3)3D(1)	5 D	4.0	47.03 Ev
15	3S(2)3P(3)3D(1)	3 D	2.0	50.72 Ev
16	3S(2)3P(3)3D(1)	3 D	3.0	50.98 Ev
17	3S(2)3P(3)3D(1)	3 D	1.0	51.15 Ev
18	3S(2)3P(3)3D(1)	3 F	2.0	51.85 Ev
19	3S(2)3P(3)3D(1)	3 F	3.0	52.23 Ev
20	3S(2)3P(3)3D(1)	3 F	4.0	52.76 Ev
21	3S(2)3P(3)3D(1)	1 S	0.0	52.91 Ev
22	3S(2)3P(3)3D(1)	3 G	3.0	54.94 Ev
23	3S(2)3P(3)3D(1)	3 G	4.0	55.14 Ev
24	3S(2)3P(3)3D(1)	3 G	5.0	55.39 Ev
25	3S(2)3P(3)3D(1)	1 D	2.0	56.56 Ev
26	3S(2)3P(3)3D(1)	1 D	2.0	57.60 Ev
27	3S(2)3P(3)3D(1)	3 D	1.0	59.63 Ev
28	3S(2)3P(3)3D(1)	3 P	0.0	59.97 Ev
29	3S(2)3P(3)3D(1)	3 F	3.0	60.04 Ev
30	3S(2)3P(3)3D(1)	3 F	4.0	60.15 Ev
31	3S(2)3P(3)3D(1)	3 F	2.0	60.16 Ev
32	3S(2)3P(3)3D(1)	3 P	1.0	60.30 Ev
33	3S(2)3P(3)3D(1)	3 D	2.0	60.54 Ev
34	3S(2)3P(3)3D(1)	3 P	2.0	61.41 Ev
35	3S(2)3P(3)3D(1)	3 F	3.0	61.49 Ev
36	3S(2)3P(3)3D(1)	1 F	3.0	65.39 Ev
37	3S(2)3P(3)3D(1)	3 S	1.0	65.74 Ev
38	3S(2)3P(3)3D(1)	3 P	2.0	66.12 Ev
39	3S(2)3P(3)3D(1)	3 P	1.0	66.71 Ev
40	3S(2)3P(3)3D(1)	3 P	0.0	69.39 Ev
41	3S(2)3P(3)3D(1)	1 P	1.0	69.81 Ev
42	3S(2)3P(3)3D(1)	3 D	3.0	70.20 Ev
43	3S(2)3P(3)3D(1)	3 D	2.0	71.05 Ev
44	3S(2)3P(3)3D(1)	3 D	1.0	71.67 Ev
45	3S(2)3P(3)3D(1)	1 D	2.0	74.81 Ev
46	3S(2)3P(3)3D(1)	1 F	3.0	75.81 Ev
47	3S(2)3P(3)3D(1)	1 P	1.0	79.60 Ev

CROSS SECTIONS IN CM**2 VS ENERGY

I = 1 108.84 Ev

1	2	5.92D-19
1	3	2.43D-19
1	4	2.70D-19
1	5	1.65D-20
1	6	2.87D-18
1	7	9.70D-19
1	8	9.02D-21
1	9	1.46D-19
1	10	1.43D-20
1	11	5.12D-20
1	12	9.37D-20
1	13	1.33D-19
1	14	1.84D-19
1	15	1.24D-19
1	16	1.33D-19
1	17	3.85D-20
1	19	3.63D-20

continued

1	19	6.69D-20
1	20	9.81D-20
1	21	1.87D-20
1	22	4.49D-20
1	23	7.61D-20
1	24	1.65D-19
1	25	8.27D-20
1	26	7.52D-20
1	27	5.26D-20
1	28	5.28D-21
1	29	4.71D-20
1	30	3.78D-20
1	31	1.14D-20
1	32	2.14D-19
1	33	5.63D-20
1	34	4.69D-19
1	35	1.74D-19
1	36	8.20D-20
1	37	3.87D-18
1	38	1.37D-17
1	39	3.62D-18
1	40	2.66D-21
1	41	1.35D-19
1	42	2.00D-17
1	43	2.29D-18
1	44	1.44D-19
1	45	6.07D-20
1	46	9.39D-20
1	47	1.06D-20
2	3	1.33D-19
2	4	2.28D-19
2	5	2.82D-20
2	6	1.74D-18
2	7	1.03D-18
2	8	1.24D-18
2	9	1.08D-19
2	10	2.31D-20
2	11	6.01D-20
2	12	9.71D-20
2	13	1.21D-19
2	14	1.04D-19
2	15	2.64D-20
2	16	1.19D-19
2	17	7.15D-20
2	18	7.88D-20
2	19	5.17D-20
2	20	5.02D-20
2	21	2.31D-20
2	22	1.11D-19
2	23	1.23D-19
2	24	4.33D-20
2	25	6.41D-20
2	26	1.02D-19
2	27	4.44D-20
2	28	2.16D-20
2	29	4.18D-20
2	30	6.63D-20
2	31	5.64D-20
2	32	8.80D-21
2	33	3.37D-19
2	34	2.44D-19
2	35	9.13D-20
2	36	3.34D-20
2	37	2.36D-18
2	38	4.67D-18
2	39	4.82D-18
2	40	5.77D-18
2	41	7.30D-19
2	42	6.45D-20
2	43	1.86D-17
2	44	5.65D-18
2	45	1.49D-18
2	46	6.19D-20
2	47	2.82D-20
3	4	2.82D-19
3	5	1.98D-20
3	6	1.36D-19
3	7	3.66D-18
3	8	3.30D-20
3	9	1.18D-19
3	10	3.85D-20
3	11	9.02D-20
3	12	7.26D-20
3	13	6.82D-20
3	14	1.26D-19
3	15	1.18D-19
3	16	4.29D-20
3	17	3.96D-20
3	18	5.06D-20
3	19	8.03D-20
3	20	9.90D-21

continued

3	21	1.87D-20
3	22	8.69D-20
3	25	5.72D-20
3	26	1.20D-19
3	27	4.28D-19
3	29	9.24D-20
3	30	2.31D-20
3	31	7.70D-20
3	32	4.51D-20
3	33	2.09D-20
3	34	3.30D-20
3	35	1.11D-19
3	36	3.30D-20
3	37	1.94D-18
3	38	1.87D-20
3	39	1.26D-17
3	40	9.90D-21
3	41	4.55D-18
3	42	6.93D-20
3	43	3.08D-20
3	44	2.46D-17
3	45	3.74D-20
3	46	6.60D-20
3	47	2.51D-19
4	5	7.82D-19
4	6	2.00D-19
4	7	6.80D-20
4	8	2.57D-20
4	9	3.17D-18
4	10	2.20D-22
4	11	8.80D-22
4	12	1.32D-21
4	13	1.54D-21
4	14	1.76D-21
4	15	4.77D-20
4	16	6.42D-20
4	17	3.19D-20
4	18	1.10D-19
4	19	1.69D-19
4	20	2.19D-19
4	21	5.94D-21
4	24	7.63D-20
4	23	9.39D-20
4	24	1.32D-19
4	25	1.51D-19
4	26	3.46D-19
4	27	5.41D-20
4	28	7.04D-21
4	29	7.28D-20
4	30	8.03D-20
4	31	6.51D-20
4	32	4.38D-20
4	33	6.86D-20
4	34	5.98D-20
4	35	9.57D-20
4	36	1.16D-19
4	37	1.14D-19
4	38	2.01D-19
4	39	1.63D-18
4	40	7.70D-21
4	41	9.23D-18
4	42	5.45D-20
4	43	6.31D-19
4	44	2.16D-19
4	45	1.02D-17
4	46	2.21D-17
4	47	8.38D-20
5	6	1.35D-19
5	7	3.52D-19
5	8	6.05D-20
5	9	1.72D-19
5	10	1.10D-21
5	11	2.20D-21
5	12	1.10D-21
5	15	6.60D-21
5	16	6.60D-21
5	17	4.40D-21
5	18	1.54D-20
5	19	3.30D-20
5	20	5.72D-20
5	22	1.10D-21
5	25	2.20D-21
5	26	4.51D-20
5	27	2.75D-20
5	28	5.72D-20
5	29	1.75D-19
5	30	2.76D-19
5	31	3.08D-20
5	32	1.70D-19
5	33	5.83D-20

continued

5	34	2.86D-19
5	35	6.27D-20
5	36	2.85D-19
5	37	3.74D-20
5	38	4.40D-21
5	39	1.21D-20
5	40	7.70D-21
5	41	1.82D-18
5	42	2.64D-20
5	43	2.20D-20
5	44	7.81D-20
5	45	2.64D-20
5	46	1.44D-19
5	47	3.78D-17

FE+9(CL) IONIZATION POTENTIAL= 262.10 EV

H.E.MASON, M.N.R.A.S.170,651(1975)

COMMENTS: MASON USES THE DISTORTED WAVE APPROXIMATION WITH CONFIGURATION-INTERACTION WAVE FUNCTIONS. FINE-STRUCTURE IS HANDLED BY JAJOM. THE ATOMIC ENERGY LEVELS ARE CALCULATED BY MASON; THE PARENT COUPLINGS FOR THE $3s^2 3p^4 3d$ CONFIGURATION ARE NOT IDENTIFIED.

ATOMIC STATE AND EXCITATION ENERGY

1	3S(2)3P(5)	2	P	1.5	0.0 EV
2	3S(2)3P(5)	2	P	0.5	1.81 EV
3	3S(1)3P(6)	2	S	0.5	34.75 EV
4	3S(2)3P(4)3D(1)	4	D	2.5	47.25 EV
5	3S(2)3P(4)3D(1)	4	D	3.5	47.26 EV
6	3S(2)3P(4)3D(1)	4	D	1.5	47.39 EV
7	3S(2)3P(4)3D(1)	4	D	0.5	47.55 EV
8	3S(2)3P(4)3D(1)	4	F	4.5	50.92 EV
9	3S(2)3P(4)3D(1)	4	F	3.5	51.49 EV
10	3S(2)3P(4)3D(1)	2	P	0.5	51.78 EV
11	3S(2)3P(4)3D(1)	4	F	2.5	51.92 EV
12	3S(2)3P(4)3D(1)	4	F	1.5	52.12 EV
13	3S(2)3P(4)3D(1)	2	P	1.5	52.71 EV
14	3S(2)3P(4)3D(1)	4	P	0.5	53.25 EV
15	3S(2)3P(4)3D(1)	2	D	1.5	53.35 EV
16	3S(2)3P(4)3D(1)	4	P	1.5	53.89 EV
17	3S(2)3P(4)3D(1)	2	F	3.5	54.16 EV
18	3S(2)3P(4)3D(1)	4	P	2.5	54.16 EV
19	3S(2)3P(4)3D(1)	2	D	2.5	54.45 EV
20	3S(2)3P(4)3D(1)	2	G	4.5	55.22 EV
21	3S(2)3P(4)3D(1)	2	G	3.5	55.33 EV
22	3S(2)3P(4)3D(1)	2	F	2.5	55.81 EV
23	3S(2)3P(4)3D(1)	2	F	2.5	59.58 EV
24	3S(2)3P(4)3D(1)	2	F	3.5	60.04 EV
25	3S(2)3P(4)3D(1)	2	D	1.5	63.93 EV
26	3S(2)3P(4)3D(1)	2	D	2.5	64.45 EV
27	3S(2)3P(4)3D(1)	2	S	0.5	70.62 EV
28	3S(2)3P(4)3D(1)	2	P	1.5	71.22 EV
29	3S(2)3P(4)3D(1)	2	P	0.5	71.96 EV
30	3S(2)3P(4)3D(1)	2	D	2.5	73.26 EV
31	3S(2)3P(4)3D(1)	2	D	1.5	74.80 EV

CROSS SECTIONS IN CM**2 VS ENERGY

I	J	74.83 EV
1	2	1.08D-18
1	3	2.41D-18
1	4	3.19D-19
1	5	4.75D-19
1	6	1.79D-19
1	7	7.12D-20
1	8	3.37D-19
1	9	2.16D-19
1	10	1.04D-19
1	11	1.38D-19
1	12	8.92D-20
1	13	2.34D-19
1	14	6.72D-20
1	15	2.91D-19
1	16	1.00D-19
1	17	3.16D-19
1	18	2.71D-19
1	19	2.24D-19
1	20	3.14D-19
1	21	1.62D-19
1	22	1.33D-19
1	23	5.84D-20
1	24	1.91D-19
1	25	1.36D-19

continued

1	26	9.04D-20
1	27	1.17D-17
1	28	1.66D-17
1	29	5.50D-19
1	30	2.94D-19
1	31	1.59D-18
2	3	2.55D-18
2	4	1.89D-19
2	5	1.42D-19
2	6	1.98D-19
2	7	1.35D-19
2	8	7.36D-20
2	9	1.75D-19
2	10	1.23D-19
2	11	1.91D-19
2	12	1.38D-19
2	13	2.47D-19
2	14	9.04D-20
2	15	1.50D-19
2	16	2.07D-19
2	17	1.02D-19
2	18	9.28D-20
2	19	4.77D-19
2	20	3.84D-19
2	21	4.19D-19
2	22	2.37D-19
2	23	1.67D-19
2	24	2.12D-19
2	25	1.90D-19
2	26	2.04D-19
2	27	3.55D-18
2	28	1.96D-18
2	29	1.74D-17
2	30	1.25D-19
2	31	3.97D-17

FE+8(AR) IONIZATION POTENTIAL= 233.60 EV

D.H.FLOWER, ASTRON.ASTROPHYS,56,451(1977)

COMMENTS: FLOWER USES THE DISTORTED WAVE APPROXIMATION WITH CONFIGURATION-INTERACTION WAVE FUNCTIONS. FINE-STRUCTURE RECOUPLING IS HANDLED BY JAJOM. THE ATOMIC ENERGY LEVELS ARE CALCULATED BY FLOWER.

ATOMIC STATE AND EXCITATION ENERGY

1	3P(6)	1 S 0.0	0.0 EV
2	3P(5)3D(1)	3 P 0.0	49.78 EV
3	3P(5)3D(1)	3 P 1.0	50.11 EV
4	3P(5)3D(1)	3 P 2.0	50.77 EV
5	3P(5)3D(1)	3 F 4.0	52.27 EV
6	3P(5)3D(1)	3 F 3.0	52.68 EV
7	3P(5)3D(1)	3 F 2.0	53.21 EV
8	3P(5)3D(1)	3 D 3.0	56.35 EV
9	3P(5)3D(1)	1 D 2.0	56.57 EV
10	3P(5)3D(1)	3 D 1.0	56.90 EV
11	3P(5)3D(1)	3 D 2.0	57.23 EV
12	3P(5)3D(1)	1 F 3.0	57.50 EV
13	3P(5)3D(1)	1 P 1.0	75.16 EV

CROSS SECTIONS IN CM**2 VS ENERGY

1 J 74.83 EV

1	2	2.24D-19
1	3	6.56D-19
1	4	1.09D-18
1	5	4.80D-19
1	6	6.88D-19
1	7	8.96D-19
1	8	2.24D-19
1	9	2.08D-19
1	10	2.24D-19
1	11	5.28D-19
1	12	7.84D-19
1	13	5.89D-17