ATOMIC DATA AND NUCLEAR DATA TABLES **70,** 63–92 (1998)
ARTICLE NO. DT980786

CALCULATED LEVEL ENERGIES, TRANSITION PROBABILITIES, AND LIFETIMES OF SILICON-LIKE IONS

C. KOHSTALL, S. FRITZSCHE, B. FRICKE, and W.-D. SEPP

Fachbereich Physik, Universität Kassel
Heinrich-Plett-Strasse 40, D-34132 Kassel, Germany

We present theoretical excitation energies and lifetimes for the 27 low-lying levels of silicon-like ions of S, Ar, Ca, Ti, Fe, Zn, and Kr ($16 \leq Z \leq 36$). Special attention has been paid to provide a complete tabulation of all electric-dipole (E1) allowed transitions from levels of the $3s3p^3$ and $3s^23p3d$ excited configurations to those of the $3s^23p^2$ ground-state configuration, including all weak and intercombination transitions. Large-scale multiconfiguration Dirac–Fock wave functions are applied to compute transition energies and probabilities. We further investigate the decay of the $3s^23p3d$ $J = 4$ level which is connected to the ground-state configuration only via forbidden M2 transitions but otherwise mainly decays via M1 to lower-lying levels of the same parity. For a few selected data, we compare our results with experiment and with previous computations. © 1998 Academic Press

0092-640X/98 $25.00

CONTENTS

INTRODUCTION

Many lines which are nowadays observed in astrophysical precision spectroscopy and the diagnostics of laboratory plasmas arise from spin-forbidden transitions. These lines have been shown to be very useful, for instance, in understanding density fluctuations and elementary processes which occur in both interstellar and laboratory plasmas. Often, however, the transition energies and probabilities of these lines as needed for a quantitative analysis of the spectra are not well known. This is mainly because compared to the much stronger resonance lines, these weak transitions are usually sensitive to the theoretical modeling and, until recently, have been a challenge for atomic structure theory.

In previous times, most atomic transition data of astrophysical interest have been obtained from a (basically) nonrelativistic theory in *LS* coupling which neglects the fine structure of the atomic levels. For example, the Opacity Project has led to a large amount of now accurately known energy terms, radiative transition data, and photoionization cross sections for most of the astrophysically abundant atoms and ions. These data have been very useful for modeling integral quantities like the total stellar opacities [1] (which is the aim of that Project). In spectroscopic applications, in contrast, one usually observes transitions between individual fine-structure levels for ions with a rather different degree of ionization. In this case, a more appropriate approach to determine theoretical transition energies and probabilities is to start with a relativistic theory from the beginning. This approach has been taken in the present work where we calculated energy levels and lifetimes associated with the two low-lying excited $3s3p^3$ and $3s^2 3p3d$ configurations for seven silicon-like ions of S, Ar, Ca, Ti, Fe, Zn, and Kr ($16 \le Z \le 36$). We also list the transition probabilities of all the electric-dipole (E1) allowed transitions from these excited levels to the five levels of the $3s^2 3p^2$ ground-state configuration. This study continues a similar work on phosphorus-like ions which was carried out recently [2]. Compared to that study, however, a major improvement has been achieved in the present computation of transition probabilities by taking into account relaxation effects in the electron density due to the decay of the excited levels.

To generate approximations to the atomic wave functions, we applied the structure package GRASP92 [3], an implementation of the multiconfiguration Dirac–Fock (MCDF) method. In this package, an atomic state with given parity P and angular momentum quantum numbers J, M is taken as a linear combination of configuration state functions (CSF) of the same symmetry,

$$\psi_\alpha(PJM) = \sum_{r=1}^{n_c} c_r(\alpha) |\gamma_r PJM\rangle, \qquad (1)$$

wherein the number of CSF, n_c, characterizes the size of the wave function expansion. In the standard implementation of the MCDF method, each CSF is built from antisymmetrized products of a common set of orthonormal Dirac orbitals which are represented on a numerical grid. Both the radial orbital functions and the expansion coefficients $\{c_r(\alpha),\ r = 1, \ldots, n_c\}$ are optimized self-consistently on the basis of the Dirac–Coulomb Hamiltonian, whereas contributions from (transverse) Breit interactions among the electrons are added later to the

Hamiltonian matrix only as a perturbation. The complete wave function expansion, that is, the coefficients $\{c_r(\alpha\}$ in (1), is obtained by diagonalizing the Dirac–Coulomb–Breit Hamiltonian matrix.

For generating appropriate wave functions for the 27 fine-structure states of the $3s^23p^2$, $3s3p^3$, and $3s^23p3d$ configurations, we divided these atomic states into six groups. A first group contains the five even-parity states with total angular momenta $J = 0$, 1, and 2 from the $3s^23p^2$ ground configuration. The five other groups are formed by the atomic levels with angular momenta $J = 0$, $J = 1$, and up to $J = 4$ of the $3s3p^3$ and $3s^23p3d$ excited configurations. For silicon-like sulfur, we also considered the $3s^23p4s$ levels which are intermixed with the other excited levels at the near-neutral end of the isoelectronic sequence. For each of these groups, we then optimized the occupied (spectroscopic) orbitals and all additional correlation orbitals independently. This separation of the atomic levels into different groups has been chosen as a compromise between achieving a rather accurate description of the atomic levels and still keeping the computation feasible for this large number of levels. By applying this scheme of separate optimization of the atomic states, however, a large part of the rearrangement effects of the electron density due to the individual transitions can be taken into account. Apart from the excited levels with $J = 0$, 1, 2, and 3 which mainly decay by allowed E1 transitions to the ground state configuration, we also investigated the forbidden M2 decay of the $3s^23p3d$ $J = 4$ level to the two ground states with $J = 2$ as well as the M1 and E2 transitions to lower-lying levels of the same (odd) parity.

The full set of CSF in Eq. (1) has been obtained by applying the active space method [4]. In this method, one starts from one or a few reference configurations chosen on the basis of the occupied spectroscopic orbitals. Then, the list of CSF of a given symmetry (PJM) is generated by exciting electrons from these reference configurations within an active set of orbitals. In the present study, we use the configurations $3s^23p^2$, $3s3p^3$, and $3s^23p3d$ as references and include all possible (up to quadruple) excitations of the four valence electrons within the $3l$ subshells as well as single (S) and double (D) excitations into the $4l$ and $5l$ shells. For a higher degree of ionization, such an expansion results in an accurate description of all considered levels, as is seen from the rather good agreement for the excitation energies compared to experiment [cf. Table I]. In contrast, a similar high precision of transition data at the near-neutral end of the sequence (and here particularly for the S III ion) might require one to consider also triple excitations of the valence electrons into the $4l$ subshells and, possibly, even core-valence excitations. Such an accuracy is, however, beyond the scope of this work and would be only feasible for studying a very few selected transitions but not a full transition array. An active space with SD excitations up to the $5l$ orbitals outside the neon-like core yields, for example, a maximum wave function expansion of 5063 CSF for the representation of the odd-parity levels with $J = 3$. Table A lists for each symmetry the number of CSF in Eq. (1); for illustration, we also compare the size of the wave function expansion in the current treatment (column 4) with an analogous expansion including only quadruple excitation within the valence shells (column 3). In the last column of this table we further display the number of determinants, n_D, as used in the computation of transition probabilities (see below). Because of the combinatorial increase of the size of the CSF basis as additional virtual orbital layers are included in the active space, we are not able to go beyond the $5l$ layer.

TABLE A
Number of CSF in Eq. (1) for the Calculation of Level Energies and Transition Probabilities

Parity	J	$3l$	$5l$	n_D
Even	0, 1, 2	144	5350	33854
Odd	0	20	1643	33364
	1	53	3475	24744
	2	65	4800	21709
	3	57	5063	17000
	4	38	4435	11952

Note. Our representations of the wave functions include up to quadruple excitations within the $3l$ subshells and single and double excitations to the $4l$ and $5l$ shells. For the computation of relaxed-orbital transition probabilities, the number of determinants, n_D, in the $5l$ representation is also displayed.

The separate optimization of the wave functions for each group of levels yields an appropriate representation of the atomic states but it also results in orbital functions for each group which are not quite orthogonal to the orbitals of any other group. This incomplete orthogonality of the orbital functions is usually considered as a relaxation effect in the electron cloud owing to the atomic transition. Even though a few case studies [5] have now confirmed the importance of this rearrangement of the density, to our knowledge these effects have not been taken into account before in the computation of any full transition array. In practice, the inclusion of this rearrangement requires incorporation of all nonvanishing overlaps of orbital functions of the same symmetry. A straightforward procedure to incorporate these overlaps is to expand the atomic states not in a CSF basis as displayed in Eq. (1) but rather in a determinant basis and to apply matrix expressions as first derived by Löwdin [6]. To enable such a computation of relaxation effects in radiative transition amplitudes, two new modules for the

TABLE B
Excitation Energies of Selected Levels of the $3s^23p^2$, $3s3p^3$, and $3s^23p3d$ Configurations for Ti IX and Fe XIII Ions

Level	J^P	Huang [1]	Fawcett [2]	This work	NIST [9]
			Ti IX Levels		
1	0+	0		0	0
2	1+	3123		3067	3119
3	2+	7319		7212	7282
4	2+	31424		28936	28555
5	0+	65132		61963	61100
6	2−	141474	144028	144183	
7	1−	200583	200341	200333	200209
8	2−	200760	200409	200421	200293
9	3−	201385	201062	201206	201000
10	0−	232329	230383	231291	230524
21	0−	366302	358360	361271	358427
22	2−	367647	358381	361646	
23	1−	374629	364185	368067	364414
24	2−	376037	365393	369297	365611
25	3−	376555	365957	369727	366074
			Fe XIII Levels		
1	0+	0		0	0
2	1+	9219		9185	9302
3	2+	18694		18453	18561
4	2+	50722		48382	48068
5	0+	95443		92410	91502
6	2−	210844	211682	213840	
7	1−	287962	286281	287811	287205
8	2−	288197	287401	287968	287360
9	3−	290884	290081	290866	290210
10	0−	331085	329157	330236	
21	2−	509628	499458	503735	498870
22	0−	509855	501899	504978	503340
23	1−	516570	506145	510683	506502
24	3−	520219	508689	513511	509176
25	2−	520013	508865	513578	509250

Note. Our results are compared with previous theoretical computations and available experimental data. All energies (in cm^{-1}) are displayed with respect to the $3s^23p^2$ $J = 0$ ground-state level. Level numbers are taken from Table I.

GRASP92 suite, CESD [7] and REOS [8] were developed by us during the past few years; these modules have also been applied in the present work. As demonstrated previously [5], the inclusion of relaxation effects typically leads to improved transition probabilities and has the further advantage that one does not need to apply such very large wave function expansions to achieve a certain accuracy.

In relativistic theory, the coupling of the radiation field to an atom or ion is often considered within two gauges, namely the Babushkin and the Coulomb gauge. In the nonrelativistic limit, these gauges correspond to the well-known length and velocity forms and for simplicity, we have chosen to use these more common nonrelativistic terms (instead of the relativistic designations) in displaying our results. Of course, by applying exact wave functions the results in both gauges should be identical. But, in practice, one often takes another viewpoint by considering the agreement of different gauges as a test of the quality of the approximation even though there exists no strict argument that agreement of the gauge forms could prove the accuracy of any individual result. For a full transition array, however, the overall agreement of results from different gauges seems to be a reasonable measure for accuracy in those cases where it is not easily possible to show the convergence of the results by systematically increasing the size of the CSF basis. In our tabulations below, we will therefore display the transition probabilities in both gauges, but usually the results in length gauge are accepted to be more reliable since they probe the wave functions in a similar (radial) region as does the optimization procedure on the total energy of the atom.

Results of our work are shown in three tabulations: In Table I, we present the level splittings of the $3s^23p^2$ ground-state configuration as well as excitation energies and lifetimes of the 22 levels from the $3s3p^3$ and $3s^23p3d$ configurations relative to the $3s^23p^2$ $J = 0$ ground state. These energies are compared with experimental data from the NIST Atomic Spectroscopic Database [9] and, in the case of Ar V, with the compilation of Bashkin and Stoner [10]. For the S III ion, we also display results for the $3s^23p4s$ levels. For the low-excitation levels, we typically find excellent agreement with experimental values (as far as available), whereas for levels with higher excitation a "systematic" shift of up to a maximum of about 5000 cm^{-1} occurs. This is a consequence of our limits in the CSF bases which become less appropriate for higher excited levels than for tightly bound states. For a few selected energy levels of two ions, Ti IX and Fe XIII, Table B further shows a comparison of our *ab initio* excitation energies with values from the NIST database and with previous computations. Even though the energies of the higher excited levels are slightly too large, our results are clearly in better agreement with experiment [9] than a previous (rather limited) MCDF calculation by Huang [11]. Our *ab initio* energies are even in satisfying agreement with the data by Fawcett [12] and by Biémont [13] who both adjusted their calculated energies semiempirically to experiment. In particular, Biémont [13] carried out a calculation in *LS* coupling near the neutral end of the isoelectronic sequence by applying a HXR (Hartree-extended-relativistic) method combined with an optimization of Slater integrals and a least-square fitting of experimental energy levels. We also note that no lifetimes had been given in the previous tabulations by Huang [11] and Fawcett [12]. Apart from the $3s^23p3d$ $J = 4$ excited level, all other lifetimes are

TABLE C
Comparison of Wavelengths and Weighted Oscillator Strengths for Selected Transitions of the Silicon-like Ions Ca VII, Ti IX, and Fe XIII

	Transition			Wavelengths (Å)				gf			
	Levels	J_F^P	J_I^P	Fawcett [12]	Biemont [13]	This work	NIST [9]	Fawcett [12]	Biemont [13]	This work	NIST [9]
Ca VII	4–7	2+	1−		723.02	725.65			0.00040	0.00030	
	5–20	0+	1−		418.00	414.90			0.00047	0.00033	
	3–14	2+	2−		405.31	408.72			0.00059	0.00051	
Ti IX	1–7	0+	1−	500.15	499.51	499.16	499.48	0.054	0.063	0.063	0.058
	3–7	2+	1−		518.26	517.81	518.33		0.00091	0.00098	0.00087
	1–11	0+	1−	434.64	433.60	432.09	433.57	0.058	0.062	0.062	0.057
	5–27	0+	1−	285.80	285.13	282.11	285.13	1.679	1.41	1.500	1.480
	4–26	2+	3−	267.19	267.90	265.25	267.94	4.031	3.715	3.950	3.801
	1–27	0+	1−		242.83	240.14	242.82		0.0028	0.0030	0.0036
Fe XIII	5–11	0+	1−		419.89	419.22	419.92		0.00186	0.00174	0.00165
	3–7	2+	1−		372.14	371.26	372.24		0.00081	0.00078	0.00072
	3–8	2+	2−		371.99	371.04	372.02		0.0049	0.0055	0.0052
	3–9	2+	3−	368.04	368.06	367.09	368.12	0.172	0.186	0.185	0.182
	1–7	0+	1−	349.03	348.14	347.45	348.18	0.067	0.072	0.072	0.069
	3–11	2+	1−	321.10	321.40	320.00	321.45	0.042	0.044	0.045	0.041
	2–12	1+	2−	311.76	311.58	310.17	311.55	0.033	0.0316	0.032	0.030
	5–27	0+	1−	208.99	208.70	206.74	208.68	1.263	1.072	1.130	1.096
	3–24	2+	3−	203.95	203.85	202.00	203.83	2.923	2.818	2.870	2.818
	4–26	2+	3−	195.82	196.51	194.77	196.52	2.902	2.692	2.810	2.766
	1–27	0+	1−		175.24	173.58	175.22		0.0052	0.0055	0.0060

Note. Level numbers in the designation of the transitions are taken from Table I.

governed by E1 decay although some of the excited levels require spin–flip (intercombination) transitions in order to decay to the ground-state levels.

Table II lists all E1 transition energies and probabilities of the $3s3p^3$ and $3s^23p3d$ excited levels to the five levels of the ground-state configuration. For the S III ion, we additionally include the transitions from the $3s^23p4s$ levels. A comparison of wavelengths and weighted oscillator strengths (gf, in length gauge) with computations by Fawcett [12], Biémont [13], and the NIST evaluated data compilation [9] is furthermore made in Table C for a few selected transitions of the three ions Ca VII, Ti IX, and Fe XIII. The tabulations by Fawcett only provided data for the resonance lines but not for the weaker intercombination transitions. As can be seen from the comparison in Table C, good agreement with the evaluated data [9] is found for wavelengths and even for most individual transition probabilities. Similarly as in a recent computation for several phosphorus-like ions [2], we list transition rates in both gauge forms in Table II to allow an estimate of the accuracy of this computation. The weighted oscillator strengths, however, are only shown in length gauge. To facilitate the analysis of experimental spectra and lifetime measurements, we list all transitions in ascending order of energy. We further display the level numbers (as taken from Table I) as well as the total angular momenta of the corresponding initial and final atomic states. Here, the levels of the ground configuration are of even parity, whereas all levels of the two excited configurations have odd parity.

Table III, finally, displays the different decay branches for the $3s^23p3d$ $J = 4$ level. This single $J = 4$ level among the other excited levels decays either via forbidden M2 transitions to the $J = 2$ ground levels or via M1 and E2 transitions to lower levels of the same parity. Most of these transitions are rather weak; we list only those with a rate $A > 0.1$ s^{-1} in this Table. For this long-lived $J = 4$ level, our intention is to provide mainly a fingerprint of allowed decay branches rather than an accurate prediction since most of these lines have not yet been identified by experiment.

In Table II, our results of the transition probabilities in the two gauges indicate an estimated accuracy of about 8% for all stronger lines and for ions with $Z \geq 20$. The same applies for the (corresponding) shorter lifetimes. Larger discrepancies remain, however, in a few cases, in particular for weak transitions and for lifetimes of long-lived levels. The decay of the $J = 4$ excited level is also estimated to be less accurate.

Recent years have seen the capability of systematic multiconfiguration Hartree–(Dirac–)Fock studies, in particular for light systems with a simple shell structure [14]. In contrast, open shells with three and more electrons still remain a challenge for accurate structure calculations. Nevertheless, we hope the present work will prove helpful in furthering experimental analysis and investigation of lifetimes of long-lived levels in this isoelectronic sequence.

Acknowledgment

We acknowledge support by the Deutsche Forschungsgemeinschaft in the framework of the Schwerpunktprogramm “Relativistische Effekte.”

References

1. M. J. Seaton, J. Phys. B **20,** 6363 (1987)
2. S. Fritzsche, C. Froese Fischer, and B. Fricke, Atomic Data and Nuclear Data Tables **68,** 149 (1998)
3. F. A. Parpia, C. Froese Fischer, and I. P. Grant, Comput. Phys. Commun. **94,** 249 (1996)
4. B. O. Roos, P. R. Taylor, and P. E. M. Siegbahn, Chem. Phys. **48,** 157 (1980)
5. S. Fritzsche, M. Finkbeiner, B. Fricke, and W.-D. Sepp, Phys. Scr. **52,** 258 (1995); S. Fritzsche and I. P. Grant, Phys. Scr. **50,** 473 (1994)
6. P. O. Löwdin, Phys. Rev. **97,** 1474 (1955)
7. S. Fritzsche and I. P. Grant, Comput. Phys. Commun. **103,** 277 (1997)
8. S. Fritzsche and C. Froese Fischer, Comput. Phys. Commun. **99,** 323 (1997)
9. J. R. Fuhr, W. C. Martin, A. Musgrove, J. Sugar, and W. L. Wiese, NIST Atomic Spectroscopic Database, available at http://physics.nist.gov/PhysRefData/contents.html (December 1997)
10. S. Bashkin and J. O. Stoner, *Atomic Energy Levels and Grotrian Diagrams*, North-Holland/American Elsevier, Amsterdam/New York, 1978 Vol. II, p. 241
11. K.-N. Huang, Atomic Data and Nuclear Data Tables **32,** 503 (1985)
12. B. C. Fawcett, Atomic Data and Nuclear Data Tables **36,** 129 (1986)
13. E. Biémont, J. Opt. Soc. Am. B **3,** 163 (1986); E. Biémont, Phys. Scr. **33,** 324 (1986)
14. C. Froese Fischer, Phys. Scr. **49,** 323 (1994); P. Jönsson, C. Froese Fischer, and J. Bieron, Phys. Rev. A **52,** 4262 (1995)

EXPLANATION OF TABLES

TABLE I. Excitation Energies and Lifetimes

Excitation energies of the $3s^23p^2$, $3s3p^3$, and $3s^23p3d$ excited levels are given relative to the $3s^23p^2$ $J = 0$ ground state. For the S III ion, the $3s^23p4s$ excited levels are also included. Energies are given as wave numbers (cm^{-1}) in ascending order and are compared with evaluated data [9, 10]. Numbers in brackets denote powers of ten. The ion is identified in the upper left corner.

No.	Level number (1 = ground state).
Designation	Designation of the state in *LS* coupling.
J^P	Total angular momentum and parity.
Energy	Wavenumber (in cm^{-1}) relative to the ground state.
Lifetime	Theoretical lifetimes (in s) of $J = 0, \ldots, 4$ excited levels. All levels with $J \leq 3$ decay by E1 transitions to the ground state configuration, whereas the $J = 4$ excited level decays via M2 transitions to the two $J = 2$ level of the ground state configuration, or via M1 and E2 to levels of the same parity. Lifetimes involving E1 (or E2) decays are displayed in both length and velocity gauges.

TABLE II. E1 Transition Energies, Probabilities, and Weighted Oscillator Strengths for $3s^23p^2$–$3s3p^3$ and $3s^23p^2$–$3s^23p3d$

Electric-dipole (E1) allowed transitions from the $3s3p^3$ and $3s^23p3d$ excited levels to the different levels of the $3s^23p^2$ ground-state configuration are listed in ascending order of the transition energy. For the S III ion, the transitions from the $3s^23p4s$ levels are also listed. Transitions are given as wavenumbers and as wavelengths. All final levels are of even parity and all initial levels are of odd parity. The ion is identified in the upper left corner.

Trans.	Level numbers of the lower and upper level from Table I.
J_F	Total angular momentum of the lower $3s^23p^2$ J_F even-parity level.
J_I	Total angular momentum of the upper $3s3p^3$ J_I or $3s^23p3d$ J_I excited odd-parity level.
Type	Multipolarity of the transition.
Wavenumber	Wavenumber of the transition (in cm^{-1}).
Wavelength	Wavelength of the transition (in Å).
A	Transition probability (in s^{-1}). Values are given for both length and velocity gauge.
gf	Weighted oscillator strength (dimensionless) in length gauge.

TABLE III. M1, E2, and M2 Transition Energies, Probabilities, and Weighted Oscillator Strengths for the $3s^23p3d$ $J = 4$ Level

M1 and E2 transitions of the $3s^23p3d$ $J = 4$ level to energetically lower-lying levels of the same (odd) parity and M2 transitions to the two $J = 2$ even-parity levels of the ground-state configuration. Transitions are listed in ascending order of the transition energies, given as wavenumbers and as wavelengths.

Trans.	Level numbers of the lower and upper level from Table I.
J_F	Total angular momentum of the lower $3s^23p^2$ $J_F = 2$ even-parity level, or of the $3s3p^3$ or $3s^23p3d$ J_F lower-lying odd-parity level.
J_I	Total angular momentum of the upper $3s3p^3$ $J_I = 4$ odd-parity level.
Type	Multipolarity of the transition.
Wavenumber	Wavenumber of the transition (in cm^{-1}).
Wavelength	Wavelength of the transition (in Å).
A	Transition probability (in s^{-1}). E2 transition probabilities are given in both length and velocity gauge, whereas there is only one gauge form (column "length") for magnetic transitions. Transitions with $A \leq 0.1$ s^{-1} are not listed.
gf	Weighted oscillator strength (dimensionless) in length gauge.

TABLE I. Excitation Energies and Lifetimes

See page 69 for Explanation of Tables

S III Levels				Energy (cm^{-1})		Lifetime (s)	
No.	Designation		J^P	Calc.	NIST [9]	Length	Velocity
1	$3s^23p^2$	$^3P_0$	0 +	0	0		
2	$3s^23p^2$	$^3P_1$	1 +	292	299		
3	$3s^23p^2$	$^3P_2$	2 +	817	833		
4	$3s^23p^2$	$^1D_2$	2 +	11597	11323		
5	$3s^23p^2$	$^1S_0$	0 +	27698	27161		
6	$3s3p^3$	$^5S_2$	2 −	57546	58672	5.30(–5)	4.16(–5)
7	$3s3p^3$	$^3D_1$	1 −	83540	84019	1.48(–8)	1.70(–8)
8	$3s3p^3$	$^3D_2$	2 −	83584	84047	1.50(–8)	1.67(–8)
9	$3s3p^3$	$^3D_3$	3 −	83647	84099	1.53(–8)	1.70(–8)
10	$3s3p^3$	$^3P_0$	0 −	98613	98772	3.48(–9)	3.53(–9)
11	$3s3p^3$	$^3P_1$	1 −	98648	98766	3.53(–9)	3.64(–9)
12	$3s3p^3$	$^3P_2$	2 −	98677	98745	3.64(–9)	3.70(–9)
13	$3s^23p3d$	$^1D_2$	2 −	104100	104160	7.40(–9)	8.43(–9)
14	$3s^23p3d$	$^3F_2$	2 −	122295	122118	9.73(–7)	9.89(–7)
15	$3s^23p3d$	$^3F_3$	3 −	122537	122404	6.89(–7)	6.73(–7)
16	$3s^23p3d$	$^3F_4$	4 −	122742	122799	6.78(–1)	5.45(–1)
17	$3s3p^3$	$^1P_1$	1 −	138445	136844	1.56(–10)	1.57(–10)
18	$3s3p^3$	$^3S_1$	1 −	140264	138067	7.41(–11)	7.43(–11)
19	$3s^23p3d$	$^3P_0$	0 −	143826	143097	8.93(–11)	8.84(–11)
20	$3s^23p3d$	$^3P_2$	2 −	144171	143125	8.61(–11)	8.57(–11)
21	$3s^23p3d$	$^3P_1$	1 −	144191	143117	8.84(–11)	8.83(–11)
22	$3s^23p4s$	$^3P_0$	0 −	148119	146697	1.94(–9)	1.92(–9)
23	$3s^23p4s$	$^3P_1$	1 −	148345	146738	8.96(–10)	8.89(–10)
24	$3s^23p4s$	$^3P_2$	2 −	148757	147147	3.93(–10)	3.92(–10)
25	$3s^23p3d$	$^3D_3$	3 −	148927	147746	6.89(–11)	6.83(–11)
26	$3s^23p3d$	$^3D_1$	1 −	148987	147551	7.03(–11)	7.03(–11)
27	$3s^23p3d$	$^3D_2$	2 −	149205	147692	8.09(–11)	8.07(–11)
28	$3s^23p4s$	$^1P_1$	1 −	149992	148399	3.47(–10)	3.22(–10)
29	$3s3p^3$	$^1D_2$	2 −	154257	151979	7.27(–11)	7.26(–11)
30	$3s^23p3d$	$^1F_3$	3 −	159201	157810	7.04(–11)	7.00(–11)
31	$3s^23p3d$	$^1P_1$	1 −	168972	164141	7.73(–11)	7.74(–11)

TABLE I. Excitation Energies and Lifetimes

See page 69 for Explanation of Tables

Ar V Levels				Energy (cm^{-1})		Lifetime (s)	
No.	Designation		J^P	Calc.	Exp. [10]	Length	Velocity
1	$3s^23p^2$	$^3P_0$	0 +	0	0		
2	$3s^23p^2$	$^3P_1$	1 +	750	765		
3	$3s^23p^2$	$^3P_2$	2 +	2000	2032		
4	$3s^23p^2$	$^1D_2$	2 +	16636	16301		
5	$3s^23p^2$	$^1S_0$	0 +	38592	37914		
6	$3s3p^3$	$^5S_2$	2 −	84647		7.70(−6)	6.85(−6)
7	$3s3p^3$	$^3D_1$	1 −	121313	121632	3.96(−9)	4.32(−9)
8	$3s3p^3$	$^3D_2$	2 −	121358	121678	4.04(−9)	4.35(−9)
9	$3s3p^3$	$^3D_3$	3 −	121540	121810	4.15(−9)	4.36(−9)
10	$3s3p^3$	$^3P_0$	0 −	141910	141773	1.18(−9)	1.19(−9)
11	$3s3p^3$	$^3P_1$	1 −	141963		1.20(−9)	1.23(−9)
12	$3s3p^3$	$^3P_2$	2 −	141983	141764	1.24(−9)	1.27(−9)
13	$3s^23p3d$	$^1D_2$	2 −	154470	154210	1.20(−9)	1.28(−9)
14	$3s^23p3d$	$^3F_2$	2 −	186856		1.35(−7)	1.34(−7)
15	$3s^23p3d$	$^3F_3$	3 −	187549		1.52(−7)	1.49(−7)
16	$3s^23p3d$	$^3F_4$	4 −	188375		1.34(−1)	1.07(−1)
17	$3s3p^3$	$^1P_1$	1 −	194939	191537	4.59(−11)	4.58(−11)
18	$3s3p^3$	$^3S_1$	1 −	198043	195356	8.12(−11)	8.13(−11)
19	$3s^23p3d$	$^3P_2$	2 −	219592	217578	5.51(−11)	5.42(−11)
20	$3s^23p3d$	$^3P_1$	1 −	220252	218286	5.48(−11)	5.40(−11)
21	$3s^23p3d$	$^3P_0$	0 −	220352	218642	5.46(−11)	5.35(−11)
22	$3s^23p3d$	$^3D_2$	2 −	225020	224505	4.15(−11)	4.08(−11)
23	$3s^23p3d$	$^3D_1$	1 −	226542	224216	3.47(−11)	3.40(−11)
24	$3s3p^3$	$^1D_2$	2 −	226888		3.49(−11)	3.41(−11)
25	$3s^23p3d$	$^3D_3$	3 −	226985	224717	3.51(−11)	3.43(−11)
26	$3s^23p3d$	$^1F_3$	3 −	248074	245310	3.24(−11)	3.18(−11)
27	$3s^23p3d$	$^1P_1$	1 −	256305	252113	4.18(−11)	4.15(−11)

TABLE I. Excitation Energies and Lifetimes

See page 69 for Explanation of Tables

Ca VII Levels				Energy (cm^{-1})		Lifetime (s)	
No.	Designation		J^P	Calc.	NIST [9]	Length	Velocity
1	$3s^23p^2$	$^3P_0$	0 +	0	0		
2	$3s^23p^2$	$^3P_1$	1 +	1600	1625		
3	$3s^23p^2$	$^3P_2$	2 +	4029	4071		
4	$3s^23p^2$	$^1D_2$	2 +	22243	21864		
5	$3s^23p^2$	$^1S_0$	0 +	49777	48981		
6	$3s3p^3$	$^5S_2$	2 −	113430		1.74(−6)	1.58(−6)
7	$3s3p^3$	$^3D_1$	1 −	160050	160158	1.96(−9)	2.11(−9)
8	$3s3p^3$	$^3D_2$	2 −	160120	160220	2.01(−9)	2.13(−9)
9	$3s3p^3$	$^3D_3$	3 −	160499	160529	2.10(−9)	2.17(−9)
10	$3s3p^3$	$^3P_0$	0 −	185818	185357	6.52(−10)	6.52(−10)
11	$3s3p^3$	$^3P_1$	1 −	185885	185393	6.61(−10)	6.72(−10)
12	$3s3p^3$	$^3P_2$	2 −	185933	185412	6.91(−10)	6.97(−10)
13	$3s3p^3$	$^1D_2$	2 −	204293	203616	5.36(−10)	5.57(−10)
14	$3s^23p3d$	$^3F_2$	2 −	248693		3.22(−8)	3.15(−8)
15	$3s3p^3$	$^3S_1$	1 −	249554	245241	3.18(−11)	3.15(−11)
16	$3s^23p3d$	$^3F_3$	3 −	250110		4.50(−8)	4.38(−8)
17	$3s^23p3d$	$^3F_4$	4 −	251959		5.56(−2)	3.85(−2)
18	$3s3p^3$	$^1P_1$	1 −	255935	252490	5.40(−11)	5.37(−11)
19	$3s^23p3d$	$^3P_2$	2 −	289107	286224	3.77(−11)	3.68(−11)
20	$3s^23p3d$	$^3P_1$	1 −	290799	288160	3.88(−11)	3.76(−11)
21	$3s^23p3d$	$^3P_0$	0 −	291383	289004	3.88(−11)	3.78(−11)
22	$3s^23p3d$	$^1D_2$	2 −	293219		3.06(−11)	2.98(−11)
23	$3s^23p3d$	$^3D_1$	1 −	298293	295138	2.47(−11)	2.40(−11)
24	$3s^23p3d$	$^3D_2$	2 −	298936	295772	2.50(−11)	2.42(−11)
25	$3s^23p3d$	$^3D_3$	3 −	299239	296132	2.51(−11)	2.43(−11)
26	$3s^23p3d$	$^1F_3$	3 −	328520	324885	2.29(−11)	2.23(−11)
27	$3s^23p3d$	$^1P_1$	1 −	337699	333501	2.97(−11)	2.93(−11)

TABLE I. Excitation Energies and Lifetimes

See page 69 for Explanation of Tables

Ti IX Levels				Energy (cm^{-1})		Lifetime (s)	
No.	Designation		J^P	Calc.	NIST [9]	Length	Velocity
1	$3s^23p^2$	$^3P_0$	0 +	0	0		
2	$3s^23p^2$	$^3P_1$	1 +	3067	3119		
3	$3s^23p^2$	$^3P_2$	2 +	7213	7282		
4	$3s^23p^2$	$^1D_2$	2 +	28937	28555		
5	$3s^23p^2$	$^1S_0$	0 +	61964	61100		
6	$3s3p^3$	$^5S_2$	2 −	144183		5.19(–07)	4.77(–07)
7	$3s3p^3$	$^3D_1$	1 −	200334	200209	1.20(–09)	1.27(–09)
8	$3s3p^3$	$^3D_2$	2 −	200421	200293	1.24(–09)	1.30(–09)
9	$3s3p^3$	$^3D_3$	3 −	201206	201000	1.33(–09)	1.35(–09)
10	$3s3p^3$	$^3P_0$	0 −	231291	230524	4.27(–10)	4.26(–10)
11	$3s3p^3$	$^3P_1$	1 −	231428	230645	4.33(–10)	4.39(–10)
12	$3s3p^3$	$^3P_2$	2 −	231551	230754	4.60(–10)	4.62(–10)
13	$3s3p^3$	$^1D_2$	2 −	255054	254028	3.27(–10)	3.35(–10)
14	$3s3p^3$	$^3S_1$	1 −	305006	299944	2.44(–11)	2.40(–11)
15	$3s^23p3d$	$^3F_2$	2 −	309358		1.03(–08)	1.00(–08)
16	$3s^23p3d$	$^3F_3$	3 −	311929		1.60(–08)	1.55(–08)
17	$3s3p^3$	$^1P_1$	1 −	315189	311087	3.86(–11)	3.81(–11)
18	$3s^23p3d$	$^3F_4$	4 −	315435		2.83(–2)	2.48(–2)
19	$3s^23p3d$	$^3P_2$	2 −	356331	352632	2.78(–11)	2.69(–11)
20	$3s^23p3d$	$^3P_1$	1 −	359880	356962	2.94(–11)	2.85(–11)
21	$3s^23p3d$	$^3P_0$	0 −	361271	358427	3.02(–11)	2.93(–11)
22	$3s^23p3d$	$^1D_2$	2 −	361646		2.49(–11)	2.41(–11)
23	$3s^23p3d$	$^3D_1$	1 −	368067	364414	1.98(–11)	1.90(–11)
24	$3s^23p3d$	$^3D_2$	2 −	369298	365611	2.00(–11)	1.92(–11)
25	$3s^23p3d$	$^3D_3$	3 −	369727	366074	1.99(–11)	1.91(–11)
26	$3s^23p3d$	$^1F_3$	3 −	405927	401771	1.84(–11)	1.78(–11)
27	$3s^23p3d$	$^1P_1$	1 −	416432	411820	2.35(–11)	2.29(–11)

TABLE I. Excitation Energies and Lifetimes

See page 69 for Explanation of Tables

Fe XIII Levels				Energy (cm^{-1})		Lifetime (s)	
No.	Designation		J^P	Calc.	NIST [9]	Length	Velocity
1	$3s^23p^2$	$^3P_0$	$0+$	0	0		
2	$3s^23p^2$	$^3P_1$	$1+$	9185	9303		
3	$3s^23p^2$	$^3P_2$	$2+$	18453	18561		
4	$3s^23p^2$	$^1D_2$	$2+$	48382	48068		
5	$3s^23p^2$	$^1S_0$	$0+$	92411	91508		
6	$3s3p^3$	$^5S_2$	$2-$	213840		7.36(−8)	6.92(−8)
7	$3s3p^3$	$^3D_1$	$1-$	287812	287205	5.77(−10)	6.08(−10)
8	$3s3p^3$	$^3D_2$	$2-$	287969	287360	6.26(−10)	6.54(−10)
9	$3s3p^3$	$^3D_3$	$3-$	290867	290210	7.12(−10)	7.13(−10)
10	$3s3p^3$	$^3P_0$	$0-$	330237		2.32(−10)	2.30(−10)
11	$3s3p^3$	$^3P_1$	$1-$	330947	329647	2.33(−10)	2.35(−10)
12	$3s3p^3$	$^3P_2$	$2-$	331582	330279	2.58(−10)	2.60(−10)
13	$3s3p^3$	$^1D_2$	$2-$	363968	362330	1.78(−10)	1.82(−10)
14	$3s3p^3$	$^3S_1$	$1-$	421683	415462	1.65(−11)	1.60(−11)
15	$3s^23p3d$	$^3F_2$	$2-$	431406		1.79(−9)	1.73(−9)
16	$3s^23p3d$	$^3F_3$	$3-$	438079		3.02(−9)	2.90(−9)
17	$3s3p^3$	$^1P_1$	$1-$	443287	438050	2.27(−11)	2.22(−11)
18	$3s^23p3d$	$^3F_4$	$4-$	447852		9.17(−3)	8.34(−3)
19	$3s^23p3d$	$^3P_2$	$2-$	490912	486358	1.87(−11)	1.79(−11)
20	$3s^23p3d$	$^3P_1$	$1-$	498950	494942	1.78(−11)	1.71(−11)
21	$3s^23p3d$	$^1D_2$	$2-$	503736	498870	1.66(−11)	1.59(−11)
22	$3s^23p3d$	$^3P_0$	$0-$	504979	503340	2.07(−11)	1.99(−11)
23	$3s^23p3d$	$^3D_1$	$1-$	510684	506502	1.52(−11)	1.45(−11)
24	$3s^23p3d$	$^3D_3$	$3-$	513511	509176	1.43(−11)	1.36(−11)
25	$3s^23p3d$	$^3D_2$	$2-$	513579	509250	1.49(−11)	1.42(−11)
26	$3s^23p3d$	$^1F_3$	$3-$	561801	556870	1.34(−11)	1.29(−11)
27	$3s^23p3d$	$^1P_1$	$1-$	576100	570690	1.61(−11)	1.68(−11)

TABLE I. Excitation Energies and Lifetimes

See page 69 for Explanation of Tables

Zn XVII Levels				Energy (cm^{-1})		Lifetime (s)	
No.	Designation		J^P	Calc.	NIST [9]	Length	Velocity
1	$3s^23p^2$	$^3P_0$	0 +	0	0		
2	$3s^23p^2$	$^3P_1$	1 +	22711	22956		
3	$3s^23p^2$	$^3P_2$	2 +	38677	38841		
4	$3s^23p^2$	$^1D_2$	2 +	82668	82594		
5	$3s^23p^2$	$^1S_0$	0 +	137563	136755		
6	$3s3p^3$	$^5S_2$	2 −	299133	299300	1.49(–8)	1.40(–8)
7	$3s3p^3$	$^3D_1$	1 −	388760		3.09(–10)	3.22(–10)
8	$3s3p^3$	$^3D_2$	2 −	389484		3.76(–10)	3.83(–10)
9	$3s3p^3$	$^3D_3$	3 −	397955	397116	4.59(–10)	4.55(–10)
10	$3s3p^3$	$^3P_0$	0 −	446533		1.44(–10)	1.43(–10)
11	$3s3p^3$	$^3P_1$	1 −	449003		1.39(–10)	1.40(–10)
12	$3s3p^3$	$^3P_2$	2 −	450571	450203	1.62(–10)	1.63(–10)
13	$3s3p^3$	$^1D_2$	2 −	491294		1.32(–10)	1.33(–10)
14	$3s3p^3$	$^3S_1$	1 −	552135	544971	1.16(–11)	1.20(–11)
15	$3s^23p3d$	$^3F_2$	2 −	560469		4.85(–10)	4.65(–10)
16	$3s^23p3d$	$^3F_3$	3 −	574342		8.09(–10)	7.69(–10)
17	$3s3p^3$	$^1P_1$	1 −	593537	587436	1.50(–11)	1.46(–11)
18	$3s^23p3d$	$^3F_4$	4 −	596567		2.25(–3)	2.15(–3)
19	$3s^23p3d$	$^3P_2$	2 −	633105	628170	1.41(–11)	1.34(–11)
20	$3s^23p3d$	$^3D_1$	1 −	644131	639464	1.17(–11)	1.12(–11)
21	$3s^23p3d$	$^1D_2$	2 −	660111	654590	1.12(–11)	1.06(–11)
22	$3s^23p3d$	$^3P_0$	0 −	662806	659108	1.51(–11)	1.45(–11)
23	$3s^23p3d$	$^3P_1$	1 −	668730	664389	1.25(–11)	1.19(–11)
24	$3s^23p3d$	$^3D_3$	3 −	670618	665946	1.10(–11)	1.05(–11)
25	$3s^23p3d$	$^3D_2$	2 −	673856	669159	1.23(–11)	1.16(–11)
26	$3s^23p3d$	$^1F_3$	3 −	729846	724701	1.05(–11)	1.01(–11)
27	$3s^23p3d$	$^1P_1$	1 −	749399	743614	1.28(–11)	1.22(–11)

TABLE I. Excitation Energies and Lifetimes

See page 69 for Explanation of Tables

Kr XXIII Levels				Energy (cm^{-1})		Lifetime (s)	
No.	Designation		J^P	Calc.	NIST [9]	Length	Velocity
1	$3s^23p^2$	$^3P_0$	0 +	0	0		
2	$3s^23p^2$	$^3P_1$	1 +	67813	68369		
3	$3s^23p^2$	$^3P_2$	2 +	94093	94397		
4	$3s^23p^2$	$^1D_2$	2 +	184934	185490		
5	$3s^23p^2$	$^1S_0$	0 +	255023	254520		
6	$3s3p^3$	$^5S_2$	2 −	469132		2.04(−9)	1.94(−9)
7	$3s3p^3$	$^3D_1$	1 −	576820		1.21(−10)	1.23(−10)
8	$3s3p^3$	$^3D_2$	2 −	585518		2.17(−10)	2.21(−10)
9	$3s3p^3$	$^3D_3$	3 −	612182		2.81(−10)	2.78(−10)
10	$3s3p^3$	$^3P_0$	0 −	674889		7.77(−11)	7.72(−11)
11	$3s3p^3$	$^3P_2$	2 −	681798		9.37(−11)	9.48(−11)
12	$3s3p^3$	$^3P_1$	1 −	683862		6.45(−11)	6.46(−11)
13	$3s3p^3$	$^1D_2$	2 −	744697		1.53(−10)	1.55(−10)
14	$3s^23p3d$	$^3F_2$	2 −	788033		9.69(−11)	9.40(−11)
15	$3s3p^3$	$^3S_1$	1 −	794163	785644	7.86(−12)	7.61(−12)
16	$3s^23p3d$	$^3F_3$	3 −	814755		1.73(−10)	1.63(−10)
17	$3s^23p3d$	$^3F_4$	4 −	875730		8.79(−4)	8.33(−4)
18	$3s^23p3d$	$^3P_2$	2 −	878158	872750	9.95(−12)	9.41(−12)
19	$3s3p^3$	$^1P_1$	1 −	880805		9.12(−12)	8.75(−12)
20	$3s^23p3d$	$^3D_1$	1 −	895951	888210	7.18(−12)	6.88(−12)
21	$3s^23p3d$	$^3D_2$	2 −	944509	938520	6.86(−12)	6.50(−12)
22	$3s^23p3d$	$^3P_0$	0 −	949900	945520	9.71(−12)	9.31(−12)
23	$3s^23p3d$	$^3D_3$	3 −	955335	950580	7.91(−12)	7.45(−12)
24	$3s^23p3d$	$^3P_1$	1 −	961100	956580	8.80(−12)	8.41(−12)
25	$3s^23p3d$	$^1D_2$	2 −	974031	968860	9.08(−12)	8.59(−12)
26	$3s^23p3d$	$^1F_3$	3 −	1031977	1026920	7.86(−12)	7.47(−12)
27	$3s^23p3d$	$^1P_1$	1 −	1063838		8.88(−12)	8.44(−12)

TABLE II. E1 Transition Energies, Probabilities, and Weighted Oscillator Strengths for $3s^23p^2$–$3s3p^3$ and $3s^23p^2$–$3s^23p3d$

See page 69 for Explanation of Tables

S III Emission Lines				Wavenumber	Wavelength	A (1/s)		
Trans.	J_F	J_I	Type	1/cm	Å	Length	Velocity	gf
4 – 6	2	2	E1	45949	2176.33	4.43	6.14	1.57(−8)
5 – 7	0	1	E1	55842	1790.76	1.17(+3)	1.98(+3)	1.69(−6)
3 – 6	2	2	E1	56730	1762.75	1.38(+4)	1.76(+4)	3.22(−5)
2 – 6	1	2	E1	57254	1746.59	5.01(+3)	6.35(+3)	1.14(−5)
5 – 11	0	1	E1	70950	1409.44	3.29(+4)	5.17(+4)	2.94(−5)
4 – 7	2	1	E1	71942	1390.01	5.26(+4)	5.90(+4)	4.57(−5)
4 – 8	2	2	E1	71986	1389.16	5.36(+3)	8.03(+3)	7.76(−6)
4 – 9	2	3	E1	72049	1387.94	6.60(+4)	6.95(+4)	1.33(−4)
3 – 7	2	1	E1	82723	1208.86	1.34(+6)	1.12(+6)	8.83(−4)
3 – 8	2	2	E1	82767	1208.21	1.34(+7)	1.17(+7)	1.46(−2)
3 – 9	2	3	E1	82830	1207.29	6.51(+7)	5.86(+7)	9.95(−2)
2 – 7	1	1	E1	83247	1201.24	2.61(+7)	2.24(+7)	1.69(−2)
2 – 8	1	2	E1	83292	1200.60	5.30(+7)	4.80(+7)	5.73(−2)
1 – 7	0	1	E1	83540	1197.04	3.99(+7)	3.48(+7)	2.57(−2)
4 – 11	2	1	E1	87050	1148.76	9.97(+4)	1.00(+5)	5.92(−5)
4 – 12	2	2	E1	87079	1148.38	1.36(+5)	1.11(+5)	1.35(−4)
4 – 13	2	2	E1	92503	1081.05	1.34(+8)	1.17(+8)	1.17(−1)
3 – 11	2	1	E1	97831	1022.17	1.09(+8)	1.05(+8)	5.14(−2)
3 – 12	2	2	E1	97860	1021.87	2.09(+8)	2.04(+8)	1.63(−1)
2 – 10	1	0	E1	98321	1017.08	2.86(+8)	2.82(+8)	1.18(−6)
2 – 11	1	1	E1	98356	1016.72	7.79(+7)	7.53(+7)	3.62(−2)
2 – 12	1	2	E1	98384	1016.42	6.53(+7)	6.48(+7)	5.06(−2)
1 – 11	0	1	E1	98648	1013.71	9.54(+7)	9.31(+7)	4.40(−2)
3 – 13	2	2	E1	103284	968.208	2.27(+5)	2.94(+5)	1.60(−4)
2 – 13	1	2	E1	103808	963.313	4.70(+5)	4.19(+5)	3.27(−4)
4 – 14	2	2	E1	110697	903.365	4.92(+5)	5.02(+5)	3.01(−4)
5 – 17	0	1	E1	110747	902.956	5.41(+6)	2.57(+6)	1.98(−3)
4 – 15	2	3	E1	110940	901.388	5.15(+5)	5.30(+5)	4.39(−4)
5 – 18	0	1	E1	112567	888.361	3.69(+5)	2.03(+5)	1.31(−4)
5 – 21	0	1	E1	116493	858.419	1.47(+5)	2.98(+5)	4.87(−5)
5 – 23	0	1	E1	120648	828.859	6.60(+6)	8.17(+6)	2.04(−3)
5 – 26	0	1	E1	121289	824.475	5.71(+4)	8.73(+4)	1.74(−5)
3 – 14	2	2	E1	121478	823.195	1.41(+5)	1.34(+5)	7.19(−5)
3 – 15	2	3	E1	121721	821.553	9.34(+5)	9.53(+5)	6.62(−4)
2 – 14	1	2	E1	122003	819.654	3.92(+5)	3.72(+5)	1.97(−4)
1 – 28	0	1	E1	122295	817.696	1.87(+8)	2.37(+8)	5.64(−2)
4 – 17	2	1	E1	126847	788.349	5.68(+9)	5.66(+9)	1.58
4 – 18	2	1	E1	128667	777.200	3.45(+8)	3.43(+8)	9.38(−2)
4 – 20	2	2	E1	132573	754.299	4.14(+4)	4.09(+4)	1.76(−5)
4 – 21	2	1	E1	132593	754.186	1.34(+7)	1.30(+7)	3.43(−3)
4 – 23	2	1	E1	136748	731.273	1.75(+8)	1.84(+8)	4.21(−2)
4 – 24	2	2	E1	137160	729.075	1.29(+7)	1.30(+7)	5.15(−3)
4 – 25	2	3	E1	137330	728.174	2.82(+6)	2.93(+6)	1.57(−3)
4 – 26	2	1	E1	137389	727.858	1.96(+5)	2.13(+5)	4.67(−5)
4 – 27	2	2	E1	137608	726.702	3.03(+6)	3.10(+6)	1.20(−3)
3 – 17	2	1	E1	137628	726.596	4.90(+8)	4.90(+8)	1.16(−1)
2 – 17	1	1	E1	138153	723.836	1.67(+8)	1.66(+8)	3.95(−2)
1 – 28	2	1	E1	138395	722.570	2.64(+9)	2.81(+9)	6.21(−1)
1 – 17	0	1	E1	138445	722.309	3.52(+7)	3.39(+7)	8.27(−3)
3 – 18	2	1	E1	139448	717.115	6.80(+9)	6.77(+9)	1.57

TABLE II. E1 Transition Energies, Probabilities, and Weighted Oscillator Strengths for $3s^2 3p^2$–$3s3p^3$ and $3s^2 3p^2$–$3s^2 3p3d$

See page 69 for Explanation of Tables

S III Emission Lines				Wavenumber	Wavelength	A (1/s)		
Trans.	J_F	J_I	Type	1/cm	Å	Length	Velocity	gf
2 − 18	1	1	E1	139972	714.427	4.67(+9)	4.65(+9)	1.07
1 − 18	0	1	E1	140264	712.939	1.68(+9)	1.68(+9)	3.85(−1)
5 − 31	0	1	E1	141275	707.841	1.25(+10)	1.24(+10)	2.81
1 − 29	2	2	E1	142661	700.963	1.37(+10)	1.38(+10)	5.06
3 − 20	2	2	E1	143354	697.573	8.03(+9)	8.06(+9)	2.92
3 − 21	2	1	E1	143374	697.477	4.97(+9)	4.98(+9)	1.08
2 − 19	1	0	E1	143534	696.701	1.11(+10)	1.13(+10)	8.14(−1)
2 − 20	1	2	E1	143879	695.029	3.58(+9)	3.59(+9)	1.29
2 − 21	1	1	E1	143899	694.933	2.34(+9)	2.35(+9)	5.09(−1)
1 − 21	0	1	E1	144191	693.526	3.96(+9)	3.96(+9)	8.56(−1)
3 − 23	2	1	E1	147528	677.836	7.79(+7)	7.76(+7)	1.61(−2)
4 − 30	2	3	E1	147604	677.489	1.41(+10)	1.42(+10)	6.83
2 − 22	1	0	E1	147628	676.462	5.15(+8)	5.21(+8)	3.53(−2)
3 − 24	2	2	E1	147941	675.947	3.53(+8)	3.58(+8)	1.21(−1)
2 − 23	1	1	E1	148053	675.433	3.30(+7)	3.30(+7)	6.77(−3)
3 − 25	2	3	E1	148110	675.172	1.45(+10)	1.46(+10)	6.94
3 − 26	2	1	E1	148170	674.900	6.08(+8)	6.10(+8)	1.24(−1)
1 − 23	0	1	E1	148345	674.103	8.23(+8)	8.20(+8)	1.68(−1)
3 − 27	2	2	E1	148389	673.906	4.12(+9)	4.13(+9)	1.40
2 − 24	1	2	E1	148466	673.557	2.17(+9)	2.17(+9)	7.39(−1)
2 − 26	1	1	E1	148695	672.518	6.47(+9)	6.48(+9)	1.31
2 − 27	1	2	E1	148913	671.531	8.22(+9)	8.24(+9)	2.77
1 − 26	0	1	E1	148987	671.200	7.13(+9)	7.12(+9)	1.44
1 − 28	2	1	E1	149176	670.351	2.65(+6)	2.70(+6)	5.37(−4)
1 − 28	1	1	E1	149700	668.001	1.23(+7)	1.24(+7)	2.47(−3)
1 − 28	0	1	E1	149992	666.701	3.74(+7)	3.68(+7)	7.36(−3)
1 − 29	2	2	E1	153442	651.714	6.23(+6)	6.11(+6)	1.99(−3)
1 − 29	1	2	E1	153966	649.493	7.93(+6)	7.88(+6)	2.51(−3)
4 − 31	2	1	E1	157375	635.426	4.62(+8)	4.89(+8)	8.38(−2)
3 − 30	2	3	E1	158384	631.375	4.26(+6)	4.20(+6)	1.78(−3)
3 − 31	2	1	E1	168155	594.688	5.96(+5)	5.83(+5)	9.48(−5)
2 − 31	1	1	E1	168680	592.838	4.74(+5)	4.85(+5)	7.49(−5)
1 − 31	0	1	E1	168972	591.814	1.39(+6)	1.19(+6)	2.18(−4)

TABLE II. E1 Transition Energies, Probabilities, and Weighted Oscillator Strengths for $3s^23p^2$–$3s3p^3$ and $3s^23p^2$–$3s^23p3d$

See page 69 for Explanation of Tables

Ar V Emission Lines				Wavenumber	Wavelength	A (1/s)		
Trans.	J_F	J_I	Type	1/cm	Å	Length	Velocity	gf
4 – 6	2	2	E1	68011	1470.36	1.00(+4)	1.05(+5)	1.02(–4)
3 – 6	2	2	E1	82647	1210.97	9.35(+4)	1.05(+5)	1.02(–4)
5 – 7	0	1	E1	82720	1208.89	1.84(+4)	1.35(+4)	1.21(–5)
2 – 6	1	2	E1	83898	1191.93	3.61(+4)	4.03(+4)	3.84(–5)
5 – 11	0	1	E1	103371	967.391	2.76(+5)	3.17(+5)	1.16(–4)
4 – 7	2	1	E1	104677	955.322	3.03(+5)	3.46(+5)	1.24(–4)
4 – 8	2	2	E1	104721	954.915	1.03(+5)	9.91(+4)	7.06(–5)
4 – 9	2	3	E1	104904	953.254	7.22(+5)	7.25(+5)	6.88(–4)
3 – 7	2	1	E1	119313	838.133	4.21(+6)	3.78(+6)	1.33(–3)
3 – 8	2	2	E1	119357	837.820	4.39(+7)	4.02(+7)	2.31(–2)
3 – 9	2	3	E1	119540	836.541	2.39(+8)	2.28(+8)	1.76(–1)
2 – 7	1	1	E1	120563	829.439	9.32(+7)	8.50(+7)	2.88(–2)
2 – 8	1	2	E1	120608	829.132	2.03(+8)	1.89(+8)	1.04(–1)
1 – 7	0	1	E1	121313	824.314	1.54(+8)	1.41(+8)	4.71(–2)
4 – 11	2	1	E1	125327	797.914	9.30(+5)	9.18(+5)	2.66(–4)
4 – 12	2	2	E1	125346	797.789	3.66(+5)	3.45(+5)	1.74(–4)
4 – 13	2	2	E1	137834	725.510	8.27(+8)	7.79(+8)	3.26(–1)
3 – 11	2	1	E1	139963	714.476	3.08(+8)	3.00(+8)	7.07(–2)
3 – 12	2	2	E1	139983	714.375	6.21(+8)	6.09(+8)	2.37(–1)
2 – 10	1	0	E1	141161	708.410	8.44(+8)	8.39(+8)	6.35(–2)
2 – 11	1	1	E1	141213	708.148	2.44(+8)	2.38(+8)	5.50(–2)
2 – 12	1	2	E1	141233	708.049	1.79(+8)	1.76(+8)	6.72(–2)
1 – 11	0	1	E1	141963	704.409	2.77(+8)	2.72(+8)	6.19(–2)
3 – 13	2	2	E1	152470	655.866	1.05(+5)	7.11(+4)	3.40(–5)
2 – 13	1	2	E1	153721	650.530	1.76(+6)	1.73(+6)	5.61(–4)
5 – 17	0	1	E1	156347	639.603	5.98(+7)	5.80(+7)	1.10(–2)
5 – 18	0	1	E1	159451	627.153	6.56(+8)	6.39(+8)	1.16(–1)
4 – 14	2	2	E1	170219	587.477	4.26(+6)	4.31(+6)	1.10(–3)
4 – 15	2	3	E1	170912	585.095	1.82(+6)	1.85(+6)	6.56(–4)
4 – 17	2	1	E1	178303	560.843	7.55(+8)	7.52(+8)	1.06(–1)
4 – 18	2	1	E1	181407	551.248	9.42(+9)	9.41(+9)	1.28
5 – 20	0	1	E1	181660	550.478	8.06(+5)	6.80(+5)	1.09(–4)
3 – 14	2	2	E1	184856	540.963	9.31(+5)	9.41(+5)	2.04(–4)
3 – 15	2	3	E1	185548	538.943	4.74(+6)	4.85(+6)	1.44(–3)
2 – 14	1	2	E1	186106	537.328	2.17(+6)	2.19(+6)	4.70(–4)
5 – 23	0	1	E1	187949	532.058	7.19(+5)	7.55(+5)	9.15(–5)
3 – 17	2	1	E1	192939	518.299	1.16(+10)	1.17(+10)	1.40
2 – 17	1	1	E1	194189	514.961	6.89(+9)	6.91(+9)	8.22(–1)
1 – 17	0	1	E1	194939	512.981	2.38(+9)	2.39(+9)	2.82(–1)
3 – 18	2	1	E1	196043	510.093	9.87(+8)	9.89(+8)	1.15(–1)
2 – 18	1	1	E1	197294	506.859	9.61(+8)	9.64(+8)	1.11(–1)
1 – 18	0	1	E1	198042	504.941	2.85(+8)	2.88(+8)	3.27(–2)
4 – 19	2	2	E1	202956	492.718	1.73(+8)	1.76(+8)	3.15(–2)
4 – 20	2	1	E1	203616	491.120	3.81(+7)	3.88(+7)	4.13(–3)
4 – 22	2	2	E1	208384	479.884	2.40(+10)	2.44(+10)	4.14
4 – 23	2	1	E1	209905	476.405	4.68(+6)	4.70(+6)	4.78(–4)
4 – 24	2	2	E1	210252	475.620	5.11(+6)	5.32(+6)	8.67(–4)
4 – 25	2	3	E1	210349	475.401	3.78(+7)	3.90(+7)	8.97(–3)
3 – 19	2	2	E1	217592	459.576	1.12(+10)	1.14(+10)	1.78
5 – 27	0	1	E1	217713	459.321	2.35(+10)	2.37(+10)	2.23

TABLE II. E1 Transition Energies, Probabilities, and Weighted Oscillator Strengths for $3s^23p^2$–$3s3p^3$ and $3s^23p^2$–$3s^23p3d$

See page 69 for Explanation of Tables

Ar V Emission Lines				Wavenumber	Wavelength	A (1/s)		
Trans.	J_F	J_I	Type	1/cm	Å	Length	Velocity	gf
3 − 20	2	1	E1	218252	458.185	7.16(+9)	7.27(+9)	6.76(−1)
2 − 19	1	2	E1	218842	456.950	6.70(+9)	6.81(+9)	1.04
2 − 20	1	1	E1	219503	455.575	3.17(+9)	3.22(+9)	2.96(−1)
2 − 10	1	0	E1	219603	455.368	1.83(+10)	1.86(+10)	5.69(−1)
1 − 20	0	1	E1	220253	454.024	7.84(+9)	7.96(+9)	7.27(−1)
3 − 22	2	2	E1	223020	448.391	6.57(+7)	6.65(+7)	9.91(−3)
2 − 22	1	2	E1	224271	445.890	1.61(+7)	1.64(+7)	2.40(−3)
3 − 23	2	1	E1	224541	445.352	1.31(+9)	1.34(+9)	1.17(−1)
3 − 24	2	2	E1	224888	444.666	9.38(+9)	9.59(+9)	1.39
3 − 25	2	3	E1	224985	444.474	2.84(+10)	2.91(+10)	5.88
2 − 23	1	1	E1	225792	442.885	1.33(+10)	1.36(+10)	1.17
2 − 24	1	2	E1	226138	442.207	1.92(+10)	1.96(+10)	2.81
1 − 23	0	1	E1	226542	441.420	1.41(+10)	1.44(+10)	1.23
4 − 27	2	3	E1	231438	432.082	3.07(+10)	3.13(+10)	6.02
4 − 27	2	1	E1	239668	417.243	2.76(+8)	2.96(+8)	2.16(−2)
3 − 27	2	3	E1	246074	406.382	5.99(+7)	6.09(+7)	1.03(−2)
3 − 27	2	1	E1	254305	393.229	5.76(+4)	2.46(+4)	4.00(−6)
2 − 27	1	1	E1	255555	391.305	3.87(+6)	3.94(+6)	2.66(−4)
1 − 27	0	1	E1	256305	390.160	9.46(+6)	1.08(+7)	6.47(−4)

TABLE II. E1 Transition Energies, Probabilities, and Weighted Oscillator Strengths for $3s^23p^2$–$3s3p^3$ and $3s^23p^2$–$3s^23p3d$

See page 69 for Explanation of Tables

Ca VII Emission Lines				Wavenumber	Wavelength	A (1/s)		
Trans.	J_F	J_I	Type	1/cm	Å	Length	Velocity	gf
4 – 6	2	2	E1	91187	1096.65	1.17(+3)	1.34(+3)	1.05(–6)
3 – 6	2	2	E1	109401	914.066	4.02(+5)	4.45(+5)	2.52(–4)
5 – 7	0	1	E1	110273	906.844	1.02(+5)	6.78(+4)	3.79(–5)
2 – 6	1	2	E1	111830	894.214	1.68(+5)	1.84(+5)	1.01(–4)
5 – 11	0	1	E1	136108	734.712	1.22(+6)	1.28(+6)	2.96(–4)
4 – 7	2	1	E1	137807	725.653	1.24(+6)	1.38(+6)	2.95(–4)
4 – 8	2	2	E1	137877	725.285	5.72(+5)	5.54(+5)	2.25(–4)
4 – 9	2	3	E1	138256	723.297	3.72(+6)	3.76(+6)	2.04(–3)
3 – 7	2	1	E1	156021	640.938	6.60(+6)	6.01(+6)	1.22(–3)
3 – 8	2	2	E1	156091	640.650	7.13(+7)	6.60(+7)	2.19(–2)
3 – 9	2	3	E1	156470	639.099	4.70(+8)	4.56(+8)	2.01(–1)
2 – 7	1	1	E1	158450	631.115	1.74(+8)	1.60(+8)	3.12(–2)
2 – 8	1	2	E1	158520	630.836	4.23(+8)	4.01(+8)	1.26(–1)
1 – 7	0	1	E1	160050	624.805	3.26(+8)	3.04(+8)	5.73(–2)
4 – 11	2	1	E1	163642	611.090	4.04(+6)	3.94(+6)	6.78(–4)
4 – 12	2	2	E1	163690	610.911	8.26(+5)	8.04(+5)	2.31(–4)
3 – 11	2	1	E1	181857	549.884	5.24(+8)	5.12(+8)	7.12(–2)
3 – 12	2	2	E1	181905	549.739	1.14(+9)	1.13(+9)	2.60(–1)
4 – 13	2	2	E1	182050	549.299	1.85(+9)	1.78(+9)	4.19(–1)
2 – 10	1	0	E1	184218	542.834	1.53(+9)	1.53(+9)	6.76(–2)
2 – 11	1	1	E1	184285	542.638	4.84(+8)	4.76(+8)	6.41(–2)
2 – 12	1	2	E1	184333	542.497	2.95(+8)	2.95(+8)	6.52(–2)
1 – 11	0	1	E1	185885	537.967	4.98(+8)	4.92(+8)	6.49(–2)
5 – 15	0	1	E1	199776	500.560	1.12(+8)	1.10(+8)	1.26(–2)
3 – 13	2	2	E1	200265	499.339	2.74(+6)	2.42(+6)	5.12(–4)
2 – 13	1	2	E1	202693	493.357	5.65(+6)	5.60(+6)	1.03(–3)
5 – 18	0	1	E1	206157	485.067	1.51(+9)	1.49(+9)	1.59(–1)
4 – 14	2	2	E1	226450	441.598	1.93(+7)	1.97(+7)	2.82(–3)
4 – 15	2	1	E1	227311	439.926	7.75(+8)	7.78(+8)	6.74(–2)
4 – 16	2	3	E1	227867	438.853	4.79(+6)	4.83(+6)	9.68(–4)
4 – 18	2	1	E1	233691	427.915	1.42(+10)	1.43(+10)	1.17
5 – 20	0	1	E1	241022	414.900	4.31(+6)	4.44(+6)	3.33(–4)
3 – 14	2	2	E1	244664	408.723	4.09(+6)	4.18(+6)	5.12(–4)
3 – 15	2	1	E1	245525	407.290	1.70(+10)	1.72(+10)	1.27
3 – 16	2	3	E1	246082	406.369	1.74(+7)	1.79(+7)	3.01(–3)
2 – 14	1	2	E1	247093	404.706	7.59(+6)	7.76(+6)	9.32(–4)
2 – 15	1	1	E1	247954	403.301	9.91(+9)	1.00(+10)	7.24(–1)
5 – 23	0	1	E1	248515	402.390	4.03(+6)	4.66(+6)	2.93(–4)
1 – 15	0	1	E1	249554	400.715	3.49(+9)	3.53(+9)	2.52(–1)
3 – 18	2	1	E1	251906	396.973	1.05(+9)	1.06(+9)	7.45(–2)
2 – 18	1	1	E1	254334	393.183	1.38(+9)	1.39(+9)	9.60(–2)
1 – 18	0	1	E1	255934	390.725	3.46(+8)	3.52(+8)	2.38(–2)
4 – 19	2	2	E1	266864	374.723	2.94(+9)	3.02(+9)	3.09(–1)
4 – 20	2	1	E1	268556	372.362	1.16(+8)	1.19(+8)	7.25(–3)
4 – 22	2	2	E1	270976	369.036	3.06(+10)	3.14(+10)	3.13
4 – 23	2	1	E1	276049	362.254	2.76(+7)	2.83(+7)	1.63(–3)
4 – 24	2	2	E1	276693	361.412	5.89(+7)	6.04(+7)	5.77(–3)
4 – 25	2	3	E1	276996	361.016	1.59(+8)	1.66(+8)	2.18(–2)
3 – 19	2	2	E1	285078	350.781	1.35(+10)	1.38(+10)	1.25
3 – 20	2	1	E1	286770	348.711	9.42(+9)	9.65(+9)	5.15(–1)

TABLE II. E1 Transition Energies, Probabilities, and Weighted Oscillator Strengths for $3s^23p^2$–$3s3p^3$ and $3s^23p^2$–$3s^23p3d$

See page 69 for Explanation of Tables

Ca VII Emission Lines				Wavenumber	Wavelength	A (1/s)		
Trans.	J_F	J_I	Type	1/cm	Å	Length	Velocity	gf
2 − 19	1	2	E1	287507	347.818	9.97(+9)	1.02(+10)	9.04(−1)
5 − 27	0	1	E1	287921	347.317	3.34(+10)	3.39(+10)	1.81
3 − 22	2	2	E1	289190	345.793	6.91(+8)	7.07(+8)	6.19(−2)
2 − 20	1	1	E1	289299	345.783	3.35(+9)	3.42(+9)	1.80(−1)
2 − 21	1	0	E1	289784	345.085	2.57(+10)	2.64(+10)	4.59(−1)
1 − 20	0	1	E1	290799	343.880	1.29(+10)	1.33(+10)	6.90(−1)
2 − 22	1	2	E1	291619	342.913	1.28(+9)	1.32(+9)	1.13(−1)
3 − 23	2	1	E1	294264	339.831	2.43(+9)	2.50(+9)	1.26(−1)
3 − 24	2	2	E1	294907	339.090	1.48(+10)	1.52(+10)	1.27
3 − 25	2	3	E1	295211	338.741	3.96(+10)	4.09(+10)	4.77
2 − 23	1	1	E1	296692	337.050	1.99(+10)	2.05(+10)	1.01
2 − 24	1	2	E1	297335	336.321	2.50(+10)	2.58(+10)	2.12
1 − 23	0	1	E1	298293	335.241	1.79(+10)	1.85(+10)	9.08(−1)
4 − 26	2	3	E1	306277	326.502	4.32(+10)	4.44(+10)	4.83
4 − 27	2	1	E1	315455	317.002	1.24(+8)	1.31(+8)	5.61(−3)
3 − 26	2	3	E1	324492	308.174	2.47(+8)	2.53(+8)	2.46(−2)
3 − 27	2	1	E1	333670	299.697	8.49(+2)	1.26(+4)	3.43(−8)
2 − 27	1	1	E1	336098	297.532	1.27(+7)	1.30(+7)	5.09(−4)
1 − 27	0	1	E1	337699	296.122	4.24(+7)	4.48(+7)	1.67(−3)

TABLE II. E1 Transition Energies, Probabilities, and Weighted Oscillator Strengths for $3s^2 3p^2$–$3s3p^3$ and $3s^2 3p^2$–$3s^2 3p3d$

See page 69 for Explanation of Tables

Ti IX Emission Lines				Wavenumber	Wavelength	A (1/s)		
Trans.	J_F	J_I	Type	1/cm	Å	Length	Velocity	gf
4 – 6	2	2	E1	115247	867.702	8.96(+3)	1.00(+4)	5.06(–6)
3 – 6	2	2	E1	136971	730.084	1.30(+6)	1.42(+6)	5.22(–4)
5 – 7	0	1	E1	138370	722.701	3.80(+5)	2.81(+5)	8.92(–5)
2 – 6	1	2	E1	141116	708.636	6.06(+5)	6.55(+5)	2.28(–4)
5 – 11	0	1	E1	169465	590.094	3.88(+6)	4.01(+6)	6.07(–4)
4 – 7	2	1	E1	171397	583.440	4.10(+6)	4.50(+6)	6.28(–4)
4 – 8	2	2	E1	171485	583.142	1.98(+6)	1.93(+6)	5.04(–4)
4 – 9	2	3	E1	172270	580.485	1.35(+7)	1.36(+7)	4.77(–3)
3 – 7	2	1	E1	193121	517.810	8.09(+6)	7.43(+6)	9.76(–4)
3 – 8	2	2	E1	193208	517.576	8.43(+7)	7.79(+7)	1.69(–2)
3 – 9	2	3	E1	193994	515.481	7.38(+8)	7.24(+8)	2.05(–1)
2 – 7	1	1	E1	197267	506.928	2.54(+8)	2.36(+8)	2.94(–2)
2 – 8	1	2	E1	197354	506.704	7.15(+8)	6.85(+8)	1.37(–1)
1 – 7	0	1	E1	200334	499.167	5.65(+8)	5.33(+8)	6.33(–2)
4 – 11	2	1	E1	202492	493.847	1.22(+7)	1.19(+7)	1.34(–3)
4 – 12	2	2	E1	202615	493.548	1.63(+6)	1.62(+6)	2.97(–4)
3 – 11	2	1	E1	224216	445.999	7.24(+8)	7.08(+8)	6.47(–2)
3 – 12	2	2	E1	224338	445.755	1.77(+9)	1.76(+9)	2.65(–1)
4 – 13	2	2	E1	226117	442.249	3.03(+9)	2.95(+9)	4.44(–1)
2 – 10	1	0	E1	228224	438.166	2.33(+9)	2.34(+9)	6.72(–2)
2 – 11	1	1	E1	228361	437.903	8.20(+8)	8.10(+8)	7.07(–2)
2 – 12	1	2	E1	228484	437.667	3.90(+8)	3.93(+8)	5.60(–2)
1 – 11	0	1	E1	231428	432.099	7.44(+8)	7.40(+8)	6.25(–2)
5 – 14	0	1	E1	243042	411.451	2.11(+8)	2.08(+8)	1.61(–2)
3 – 13	2	2	E1	247841	403.485	1.41(+7)	1.29(+7)	1.72(–3)
2 – 13	1	2	E1	251986	396.847	1.53(+7)	1.52(+7)	1.81(–3)
5 – 17	0	1	E1	253225	394.906	2.37(+9)	2.36(+9)	1.66(–1)
4 – 14	2	1	E1	276069	362.228	1.00(+9)	1.01(+9)	5.90(–2)
4 – 15	2	2	E1	280422	356.606	6.05(+7)	6.20(+7)	5.77(–3)
4 – 16	2	3	E1	282992	353.367	1.01(+7)	1.01(+7)	1.32(–3)
4 – 17	2	1	E1	286252	349.342	1.91(+10)	1.93(+10)	1.04
3 – 14	2	1	E1	297794	335.803	2.24(+10)	2.28(+10)	1.14
5 – 20	0	1	E1	297915	335.666	1.51(+7)	1.65(+7)	7.67(–4)
2 – 14	1	1	E1	301939	331.193	1.25(+10)	1.28(+10)	6.21(–1)
3 – 15	2	2	E1	302145	330.967	1.49(+7)	1.54(+7)	1.23(–3)
3 – 16	2	3	E1	304716	328.174	5.23(+7)	5.42(+7)	5.91(–3)
1 – 14	0	1	E1	305006	327.862	4.60(+9)	4.68(+9)	2.22(–1)
5 – 23	0	1	E1	306103	326.687	9.44(+6)	1.07(+7)	4.53(–4)
2 – 15	1	2	E1	306291	326.487	2.14(+7)	2.21(+7)	1.71(–3)
3 – 17	2	1	E1	307976	324.701	1.42(+9)	1.44(+9)	6.74(–2)
2 – 17	1	1	E1	312122	320.388	2.44(+9)	2.48(+9)	1.12(–1)
1 – 17	0	1	E1	315189	317.270	5.46(+8)	5.58(+8)	2.47(–2)
4 – 19	2	2	E1	327394	305.442	9.76(+9)	1.01(+10)	6.83(–1)
4 – 20	2	1	E1	330943	302.167	2.85(+8)	2.95(+8)	1.17(–2)
4 – 22	2	2	E1	332710	300.562	3.28(+10)	3.39(+10)	2.22
4 – 23	2	1	E1	339131	294.871	1.21(+8)	1.26(+8)	4.75(–3)
4 – 24	2	2	E1	340361	293.806	4.25(+8)	4.41(+8)	2.75(–2)
4 – 25	2	3	E1	340791	293.435	4.80(+8)	5.03(+8)	4.34(–2)
3 – 19	2	2	E1	349118	286.436	1.40(+10)	1.44(+10)	8.62(–1)
3 – 20	2	1	E1	352667	283.554	1.04(+10)	1.08(+10)	3.79(–1)

TABLE II. E1 Transition Energies, Probabilities, and Weighted Oscillator Strengths for $3s^23p^2$–$3s3p^3$ and $3s^23p^2$–$3s^23p3d$

See page 69 for Explanation of Tables

Ti IX Emission Lines				Wavenumber	Wavelength	A (1/s)		
Trans.	J_F	J_I	Type	1/cm	Å	Length	Velocity	gf
2 − 19	1	2	E1	353263	283.075	1.21(+10)	1.25(+10)	7.28(–1)
3 − 22	2	2	E1	354434	282.140	1.57(+9)	1.62(+9)	9.41(–2)
5 − 27	0	1	E1	354468	282.113	4.21(+10)	4.32(+10)	1.50
2 − 20	1	1	E1	356813	280.259	2.23(+9)	2.28(+9)	7.89(–2)
2 − 21	1	0	E1	358205	279.170	3.30(+10)	3.40(+10)	3.85(–1)
2 − 22	1	2	E1	358578	278.879	5.67(+9)	5.87(+9)	3.30(–1)
1 − 20	0	1	E1	359879	277.871	2.08(+10)	2.16(+10)	7.25(–1)
3 − 23	2	1	E1	360855	277.120	4.50(+9)	4.66(+9)	1.55(–1)
3 − 24	2	2	E1	362085	276.178	2.14(+10)	2.22(+10)	1.22
3 − 25	2	3	E1	362515	275.851	4.95(+10)	5.15(+10)	3.95
2 − 23	1	1	E1	365001	273.972	2.73(+10)	2.83(+10)	9.23(–1)
2 − 24	1	2	E1	366231	273.052	2.80(+10)	2.92(+10)	1.56
1 − 23	0	1	E1	368068	271.689	1.84(+10)	1.92(+10)	6.12(–1)
4 − 26	2	3	E1	376990	265.259	5.36(+10)	5.54(+10)	3.95
4 − 27	2	1	E1	387495	258.068	1.01(+8)	9.95(+7)	3.03(–3)
3 − 26	2	3	E1	398715	250.806	7.21(+8)	7.43(+8)	4.76(–2)
3 − 27	2	1	E1	409219	244.368	5.53(+4)	8.81(+4)	1.48(–6)
2 − 27	1	1	E1	413365	241.917	3.34(+7)	3.44(+7)	8.80(–4)
1 − 27	0	1	E1	416432	240.135	1.14(+8)	1.16(+8)	2.97(–3)

TABLE II. E1 Transition Energies, Probabilities, and Weighted Oscillator Strengths for $3s^23p^2$–$3s3p^3$ and $3s^23p^2$–$3s^23p3d$

See page 69 for Explanation of Tables

Fe XIII Emission Lines				Wavenumber	Wavelength	A (1/s)		
Trans.	J_F	J_I	Type	1/cm	Å	Length	Velocity	gf
4 – 6	2	2	E1	165457	604.386	2.17(+5)	2.37(+5)	5.96(–5)
3 – 6	2	2	E1	195387	511.805	8.30(+6)	8.88(+6)	1.63(–3)
5 – 7	0	1	E1	195400	511.772	2.57(+6)	2.04(+6)	3.03(–4)
2 – 6	1	2	E1	204655	488.627	5.05(+6)	5.31(+6)	9.05(–4)
5 – 11	0	1	E1	238534	419.227	2.21(+7)	2.32(+7)	1.74(–3)
4 – 7	2	1	E1	239427	417.663	2.74(+7)	2.98(+7)	2.15(–3)
4 – 8	2	2	E1	239586	417.387	1.03(+7)	9.97(+6)	1.34(–3)
4 – 9	2	3	E1	242483	412.400	9.49(+7)	9.72(+7)	1.69(–2)
3 – 7	2	1	E1	269357	371.255	1.26(+7)	1.22(+7)	7.83(–4)
3 – 8	2	2	E1	269516	371.036	5.28(+7)	4.63(+7)	5.45(–3)
3 – 9	2	3	E1	272413	367.090	1.30(+9)	1.30(+9)	1.85(–1)
2 – 7	1	1	E1	278625	358.905	3.54(+8)	3.26(+8)	2.05(–2)
2 – 8	1	2	E1	278784	358.701	1.53(+9)	1.47(+9)	1.47(–1)
4 – 11	2	1	E1	282563	353.904	5.57(+7)	5.33(+7)	3.13(–3)
4 – 12	2	2	E1	283199	353.109	5.90(+6)	6.20(+6)	5.52(–4)
1 – 7	0	1	E1	287810	347.451	1.33(+9)	1.27(+9)	7.24(–2)
3 – 11	2	1	E1	312492	320.008	9.74(+8)	9.44(+8)	4.48(–2)
3 – 12	2	2	E1	313129	319.357	3.42(+9)	3.37(+9)	2.61(–1)
4 – 13	2	2	E1	315585	316.872	5.41(+9)	5.29(+9)	4.07(–1)
2 – 10	1	0	E1	321051	311.477	4.30(+9)	4.33(+9)	6.26(–2)
2 – 11	1	1	E1	321760	310.791	1.94(+9)	1.92(+9)	8.45(–2)
2 – 12	1	2	E1	322397	310.177	4.44(+8)	4.52(+8)	3.20(–2)
5 – 14	0	1	E1	329271	303.701	5.16(+8)	5.15(+8)	2.14(–2)
1 – 11	0	1	E1	330945	302.165	1.29(+9)	1.29(+9)	5.30(–2)
3 – 13	2	2	E1	345515	289.423	9.96(+7)	9.34(+7)	6.25(–3)
5 – 17	0	1	E1	350875	285.002	4.17(+9)	4.19(+9)	1.52(–1)
2 – 13	1	2	E1	354784	281.862	7.68(+7)	7.66(+7)	4.57(–3)
4 – 14	2	1	E1	373299	267.882	1.06(+9)	1.07(+9)	3.42(–2)
4 – 15	2	2	E1	383023	261.081	3.12(+8)	3.22(+8)	1.59(–2)
4 – 16	2	3	E1	389695	256.611	2.15(+7)	2.15(+7)	1.49(–3)
4 – 17	2	1	E1	394903	253.227	3.04(+10)	3.10(+10)	8.78(–1)
3 – 14	2	1	E1	403229	247.999	3.46(+10)	3.55(+10)	9.59(–1)
5 – 20	0	1	E1	406537	245.980	6.01(+7)	6.84(+7)	1.63(–3)
2 – 14	1	1	E1	412597	242.426	1.73(+10)	1.77(+10)	4.57(–1)
3 – 15	2	2	E1	412952	242.159	1.34(+8)	1.39(+8)	5.89(–3)
5 – 23	0	1	E1	418272	239.079	1.28(+7)	1.47(+7)	3.30(–4)
3 – 16	2	3	E1	419625	238.308	3.08(+8)	3.22(+8)	1.83(–2)
1 – 14	0	1	E1	421681	237.146	7.05(+9)	7.23(+9)	1.78(–1)
2 – 15	1	2	E1	422221	236.843	1.08(+8)	1.13(+8)	4.56(–3)
3 – 17	2	1	E1	424832	235.387	1.72(+9)	1.77(+9)	4.30(–2)
2 – 17	1	1	E1	434101	230.361	6.35(+9)	6.52(+9)	1.51(–1)
4 – 19	2	2	E1	442529	225.974	1.37(+10)	1.44(+10)	5.27(–1)
1 – 17	0	1	E1	443286	225.588	1.25(+9)	1.29(+9)	2.88(–2)
4 – 20	2	1	E1	450566	221.943	8.64(+8)	8.96(+8)	1.91(–2)
4 – 21	2	2	E1	455353	219.610	4.18(+10)	4.36(+10)	1.51
4 – 23	2	1	E1	462299	216.310	1.38(+9)	1.44(+9)	2.91(–2)
4 – 24	2	3	E1	465127	214.995	2.54(+9)	2.69(+9)	1.23(–1)
4 – 25	2	2	E1	465196	214.963	6.24(+9)	6.52(+9)	2.16(–1)
3 – 19	2	2	E1	472458	211.659	1.87(+10)	1.95(+10)	6.30(–1)
3 – 20	2	1	E1	480494	208.119	7.74(+9)	8.04(+9)	1.50(–1)

TABLE II. E1 Transition Energies, Probabilities, and Weighted Oscillator Strengths for $3s^23p^2$–$3s3p^3$ and $3s^23p^2$–$3s^23p3d$

See page 69 for Explanation of Tables

Fe XIII Emission Lines				Wavenumber	Wavelength	A (1/s)		
Trans.	J_F	J_I	Type	1/cm	Å	Length	Velocity	gf
2 − 19	1	2	E1	481726	207.587	2.07(+10)	2.16(+10)	6.68(–1)
5 − 27	0	1	E1	483688	206.745	5.88(+10)	6.10(+10)	1.13
3 − 21	2	2	E1	485281	206.066	2.02(+8)	2.17(+8)	6.45(–3)
2 − 20	1	1	E1	489764	204.180	1.61(+8)	1.81(+8)	3.02(–3)
3 − 23	2	1	E1	492228	203.158	1.28(+10)	1.33(+10)	2.38(–1)
2 − 21	1	2	E1	494550	202.204	1.80(+10)	1.88(+10)	5.52(–1)
3 − 24	2	3	E1	495057	201.997	6.70(+10)	7.04(+10)	2.87
3 − 25	2	2	E1	495125	201.969	3.49(+10)	3.65(+10)	1.06
2 − 22	1	0	E1	495793	201.697	4.82(+10)	5.00(+10)	2.94(–1)
1 − 20	0	1	E1	498947	200.422	4.70(+10)	4.90(+10)	8.49(–1)
2 − 23	1	1	E1	501497	199.403	4.21(+10)	4.39(+10)	7.53(–1)
2 − 25	1	2	E1	504393	198.258	2.71(+10)	2.57(+10)	7.59(–1)
1 − 23	0	1	E1	510681	195.817	9.28(+9)	9.78(+9)	1.60(–1)
4 − 26	2	3	E1	513418	194.773	7.07(+10)	7.37(+10)	2.81
4 − 27	2	1	E1	527716	189.496	1.66(+8)	1.54(+8)	2.69(–3)
3 − 26	2	3	E1	543348	184.044	3.63(+9)	3.76(+9)	1.29(–1)
3 − 27	2	1	E1	557647	179.325	9.12(+4)	1.74(+4)	1.31(–6)
2 − 27	1	1	E1	566913	176.394	1.45(+8)	1.51(+8)	2.03(–3)
1 − 27	0	1	E1	576100	173.581	4.06(+8)	4.10(+8)	5.50(–3)

TABLE II. E1 Transition Energies, Probabilities, and Weighted Oscillator Strengths for $3s^23p^2$–$3s3p^3$ and $3s^23p^2$–$3s^23p3d$

See page 69 for Explanation of Tables

Zn XVII Emission Lines				Wavenumber	Wavelength	A (1/s)		
Trans.	J_F	J_I	Type	1/cm	Å	Length	Velocity	gf
4 − 6	2	2	E1	216465	461.969	2.04(+6)	2.24(+6)	3.27(−4)
5 − 7	0	1	E1	251196	398.095	9.18(+6)	7.52(+6)	6.54(−4)
3 − 6	2	2	E1	260455	383.943	3.49(+7)	3.76(+7)	3.86(−3)
2 − 6	1	2	E1	276422	361.766	2.98(+7)	3.14(+7)	2.92(−3)
4 − 7	2	1	E1	306092	326.699	1.03(+8)	1.10(+8)	4.96(−3)
4 − 8	2	2	E1	306816	325.928	2.48(+7)	2.44(+7)	1.97(−3)
5 − 11	0	1	E1	311440	321.089	7.71(+7)	8.22(+7)	3.57(−3)
4 − 9	2	3	E1	315287	317.171	3.57(+8)	3.68(+8)	3.77(−2)
3 − 7	2	1	E1	350082	285.647	4.81(+7)	5.02(+7)	1.76(−3)
3 − 8	2	2	E1	350807	285.057	1.80(+6)	7.33(+5)	1.10(−4)
3 − 9	2	3	E1	359278	278.336	1.82(+9)	1.82(+9)	1.48(−1)
2 − 7	1	1	E1	366048	273.188	3.00(+8)	2.67(+8)	1.00(−2)
4 − 11	2	1	E1	366335	272.979	1.03(+8)	9.47(+7)	3.47(−3)
2 − 8	1	2	E1	366773	272.648	2.63(+9)	2.58(+9)	1.47(−1)
4 − 12	2	2	E1	367903	271.811	4.05(+7)	4.37(+7)	2.24(−3)
1 − 7	0	1	E1	388760	257.228	2.77(+9)	2.66(+9)	8.25(−2)
4 − 13	2	2	E1	408627	244.722	7.14(+9)	7.07(+9)	3.20(−1)
3 − 11	2	1	E1	410325	243.709	9.63(+8)	9.18(+8)	2.57(−2)
3 − 12	2	2	E1	411894	242.781	5.82(+9)	5.78(+9)	2.57(−1)
5 − 14	0	1	E1	414571	241.213	8.56(+8)	8.59(+8)	2.24(−2)
2 − 10	1	0	E1	423822	235.948	6.91(+9)	6.97(+9)	5.77(−2)
2 − 11	1	1	E1	426292	234.581	4.10(+9)	4.07(+9)	1.01(−1)
2 − 12	1	2	E1	427861	233.721	2.83(+8)	2.98(+8)	1.16(−2)
1 − 11	0	1	E1	449002	222.716	1.92(+9)	1.94(+9)	4.28(−2)
3 − 13	2	2	E1	452618	220.937	1.79(+8)	1.68(+8)	6.56(−3)
5 − 17	0	1	E1	455973	219.311	6.07(+9)	6.13(+9)	1.31(−1)
2 − 13	1	2	E1	468584	213.409	2.53(+8)	2.57(+8)	8.66(−3)
4 − 14	2	1	E1	469468	213.007	3.44(+8)	3.36(+8)	7.02(−3)
4 − 15	2	2	E1	477801	209.292	9.36(+8)	9.70(+8)	3.07(−2)
4 − 16	2	3	E1	491674	203.387	1.15(+7)	1.08(+7)	5.00(−4)
5 − 20	0	1	E1	506568	197.407	7.20(+7)	8.60(+7)	1.26(−3)
4 − 17	2	1	E1	510869	195.745	4.43(+10)	4.53(+10)	7.63(−1)
3 − 14	2	1	E1	513458	194.758	4.97(+10)	5.12(+10)	8.48(−1)
3 − 15	2	2	E1	521793	191.647	7.34(+8)	7.66(+8)	2.02(−2)
2 − 14	1	1	E1	529423	188.885	2.17(+10)	2.23(+10)	3.48(−1)
5 − 23	0	1	E1	531166	188.265	1.66(+7)	1.80(+7)	2.65(−4)
3 − 16	2	3	E1	535665	186.684	1.22(+9)	1.28(+9)	4.47(−2)
2 − 15	1	2	E1	537759	185.957	3.92(+8)	4.13(+8)	1.01(−2)
4 − 19	2	2	E1	550436	181.674	1.00(+10)	1.06(+10)	2.49(−1)
1 − 14	0	1	E1	552135	181.115	1.03(+10)	1.06(+10)	1.52(−1)
3 − 17	2	1	E1	554859	180.226	7.41(+8)	7.72(+8)	1.08(−2)
4 − 20	2	1	E1	561463	178.106	1.66(+9)	1.72(+9)	2.38(−2)
2 − 17	1	1	E1	570825	175.185	1.27(+10)	1.31(+10)	1.75(−1)
4 − 21	2	2	E1	577444	173.177	4.06(+10)	4.26(+10)	9.13(−1)
4 − 23	2	1	E1	586063	170.630	6.54(+9)	6.84(+9)	8.56(−2)
4 − 24	2	3	E1	587948	170.083	7.55(+9)	8.04(+9)	2.29(−1)
4 − 25	2	2	E1	591188	169.151	3.06(+10)	3.23(+10)	6.58(−1)
1 − 17	0	1	E1	593535	168.482	2.74(+9)	2.84(+9)	3.50(−2)
3 − 19	2	2	E1	594428	168.229	2.56(+10)	2.67(+10)	5.43(−1)
3 − 20	2	1	E1	605455	165.165	4.25(+9)	4.42(+9)	5.22(−2)

TABLE II. E1 Transition Energies, Probabilities, and Weighted Oscillator Strengths for $3s^2 3p^2$–$3s3p^3$ and $3s^2 3p^2$–$3s^2 3p3d$

See page 69 for Explanation of Tables

Zn XVII Emission Lines				Wavenumber	Wavelength	A (1/s)		
Trans.	J_F	J_I	Type	1/cm	Å	Length	Velocity	gf
2 − 19	1	2	E1	610393	163.829	3.47(+10)	3.66(+10)	6.99(–1)
5 − 27	0	1	E1	611834	163.443	7.62(+10)	7.988+10)	9.15(–1)
2 − 20	1	1	E1	621419	160.922	5.80(+9)	6.18(+9)	6.76(–2)
3 − 21	2	2	E1	621435	160.918	1.54(+10)	1.62(+10)	2.99(–1)
3 − 23	2	1	E1	630052	158.717	2.03(+10)	2.12(+10)	2.30(–1)
3 − 24	2	3	E1	631939	158.243	8.25(+10)	8.71(+10)	2.16
3 − 25	2	2	E1	635179	157.436	3.38(+10)	3.55(+10)	6.29(–1)
2 − 21	1	2	E1	637401	156.887	3.28(+10)	3.45(+10)	6.05(–1)
2 − 22	1	0	E1	640194	156.227	6.61(+10)	6.88(+10)	2.42(–1)
1 − 20	0	1	E1	644131	155.248	7.29(+10)	7.65(+10)	7.91(–1)
2 − 23	1	1	E1	646020	154.794	5.06(+10)	5.29(+10)	5.45(–1)
4 − 26	2	3	E1	647178	154.517	8.40(+10)	8.80(+10)	2.10
2 − 25	1	2	E1	651143	153.576	1.67(+10)	1.77(+10)	2.95(–1)
4 − 27	2	1	E1	666729	149.986	4.12(+8)	3.85(+8)	4.17(–3)
1 − 23	0	1	E1	668731	149.537	2.31(+9)	2.48(+9)	2.32(–2)
3 − 26	2	3	E1	691171	144.682	1.05(+10)	1.09(+10)	2.32(–1)
3 − 27	2	1	E1	710722	140.702	5.36(+6)	3.83(+6)	4.78(–5)
2 − 27	1	1	E1	726686	137.611	4.23(+8)	4.46(+8)	3.60(–3)
1 − 27	0	1	E1	749400	133.440	8.62(+8)	8.72(+8)	6.90(–3)

TABLE II. E1 Transition Energies, Probabilities, and Weighted Oscillator Strengths for $3s^23p^2$–$3s3p^3$ and $3s^23p^2$–$3s^23p3d$

See page 69 for Explanation of Tables

Kr XXIII Emission Lines				Wavenumber	Wavelength	A (1/s)		
Trans.	J_F	J_I	Type	1/cm	Å	Length	Velocity	gf
4 – 6	2	2	E1	284198	351.867	1.29(+7)	1.40(+7)	1.20(–3)
5 – 7	0	1	E1	321797	310.755	2.42(+7)	2.00(+7)	1.05(–3)
3 – 6	2	2	E1	375039	266.639	2.04(+8)	2.18(+8)	1.08(–2)
4 – 7	2	1	E1	391885	255.177	2.78(+8)	2.92(+8)	8.14(–3)
4 – 8	2	2	E1	400583	249.636	5.49(+7)	5.55(+7)	2.56(–3)
2 – 6	1	2	E1	401320	249.178	2.70(+8)	2.81(+8)	1.26(–2)
4 – 9	2	3	E1	427248	234.056	1.10(+9)	1.15(+9)	6.37(–2)
5 – 12	0	1	E1	428839	233.188	3.00(+8)	3.27(+8)	7.35(–3)
3 – 7	2	1	E1	482726	207.157	5.14(+8)	5.51(+8)	9.92(–3)
3 – 8	2	2	E1	491425	203.490	9.47(+7)	1.07(+8)	2.94(–3)
4 – 11	2	2	E1	496865	201.262	5.54(+8)	5.79(+8)	1.68(–2)
4 – 12	2	1	E1	498927	200.430	1.49(+7)	6.87(+6)	2.69(–4)
2 – 7	1	1	E1	509007	196.461	3.12(+7)	1.67(+7)	5.42(–4)
2 – 8	1	2	E1	517706	193.160	4.44(+9)	4.35(+9)	1.24(–1)
3 – 9	2	3	E1	518189	193.017	2.44(+9)	2.44(+9)	9.56(–2)
5 – 15	0	1	E1	539139	185.481	1.30(+9)	1.30(+9)	2.01(–2)
4 – 13	2	2	E1	559763	178.647	5.36(+9)	5.21(+9)	1.28(–1)
1 – 7	0	1	E1	576821	173.364	7.40(+9)	7.20(+9)	1.00(–1)
3 – 11	2	2	E1	587706	170.153	1.01(+10)	9.96(+9)	2.19(–1)
3 – 12	2	1	E1	589769	169.558	7.41(+8)	6.79(+8)	9.59(–3)
4 – 14	2	2	E1	603100	165.810	4.24(+9)	4.31(+9)	8.75(–2)
2 – 10	1	0	E1	607076	164.724	1.28(+10)	1.29(+10)	5.22(–2)
4 – 15	2	1	E1	609229	164.142	2.06(+8)	2.37(+8)	2.50(–3)
2 – 11	1	2	E1	613987	162.870	1.10(+5)	9.51(+5)	2.20(–6)
2 – 12	1	1	E1	616048	162.325	1.08(+10)	1.08(+10)	1.29(–1)
5 – 19	0	1	E1	625782	159.800	5.03(+9)	5.16(+9)	5.78(–2)
4 – 16	2	3	E1	629822	158.775	2.70(+7)	3.28(+7)	7.16(–4)
5 – 20	0	1	E1	640927	156.024	3.19(+9)	3.14(+9)	3.50(–2)
3 – 13	2	2	E1	650605	153.703	7.06(+8)	7.63(+8)	1.25(–2)
2 – 13	1	2	E1	676883	147.736	4.27(+8)	4.41(+8)	6.99(–3)
1 – 12	0	1	E1	683864	146.228	3.53(+9)	3.63(+9)	3.40(–2)
4 – 18	2	2	E1	693222	144.254	6.05(+9)	6.47(+9)	9.44(–2)
3 – 14	2	2	E1	693938	144.105	3.51(+9)	3.63(+9)	5.46(–2)
4 – 19	2	1	E1	695870	143.705	2.19(+10)	2.24(+10)	2.04(–1)
3 – 15	2	1	E1	700069	142.843	7.75(+10)	7.99(+10)	7.11(–1)
5 – 24	0	1	E1	706175	141.628	1.89(+8)	1.91(+8)	1.71(–3)
4 – 20	2	1	E1	711015	140.644	4.34(+10)	4.46(+10)	3.86(–1)
2 – 14	1	2	E1	720222	138.846	2.55(+9)	2.68(+9)	3.69(–2)
3 – 16	2	3	E1	720664	138.761	5.74(+9)	6.07(+9)	1.16(–1)
2 – 15	1	1	E1	726348	137.675	2.87(+10)	2.96(+10)	2.44(–1)
4 – 21	2	2	E1	759573	131.653	1.90(+10)	2.01(+10)	2.47(–1)
4 – 23	2	3	E1	770398	129.803	1.51(+10)	1.62(+10)	2.67(–1)
4 – 24	2	1	E1	776169	128.838	2.94(+10)	3.07(+10)	2.20(–1)
3 – 18	2	2	E1	784068	127.540	3.63(+10)	3.81(+10)	4.43(–1)
3 – 19	2	1	E1	786714	127.111	2.76(+9)	2.86(+9)	2.00(–2)
4 – 25	2	2	E1	789098	126.727	9.08(+10)	9.59(+10)	1.09
1 – 15	0	1	E1	794161	125.919	1.94(+10)	2.02(+10)	1.38(–1)
3 – 20	2	1	E1	801860	124.710	7.22(+8)	7.62(+8)	5.05(–3)
5 – 27	0	1	E1	808813	123.638	1.07(+11)	1.13(+11)	7.41(–1)
2 – 18	1	2	E1	810347	123.404	5.80(+10)	6.16(+10)	6.63(–1)

TABLE II. E1 Transition Energies, Probabilities, and Weighted Oscillator Strengths for $3s^23p^2$–$3s3p^3$ and $3s^23p^2$–$3s^23p3d$

See page 69 for Explanation of Tables

Kr XXIII Emission Lines				Wavenumber	Wavelength	A (1/s)		
Trans.	J_F	J_I	Type	1/cm	Å	Length	Velocity	gf
2 – 19	1	1	E1	812995	123.002	1.53(+9)	1.52(+9)	1.04(–2)
2 – 20	1	1	E1	828137	120.753	5.25(+10)	5.51(+10)	3.44(–1)
4 – 26	2	3	E1	847041	118.058	1.05(+11)	1.10(+11)	1.53
3 – 21	2	2	E1	850412	117.590	7.21(+10)	7.61(+10)	7.47(–1)
3 – 23	2	3	E1	861245	116.111	1.11(+11)	1.17(+11)	1.57
3 – 24	2	1	E1	867079	115.339	2.55(+10)	2.67(+10)	1.52(–1)
2 – 21	1	2	E1	876693	114.065	5.43(+10)	5.75(+10)	5.30(–1)
4 – 27	2	1	E1	878905	113.778	1.99(+9)	1.94(+9)	1.15(–2)
3 – 25	2	2	E1	879941	113.644	1.24(+10)	1.30(+10)	1.20(–1)
1 – 19	0	1	E1	880801	113.533	7.84(+10)	8.22(+10)	4.54(–1)
2 – 22	1	0	E1	882091	113.367	1.02(+11)	1.07(+11)	1.98(–1)
2 – 24	1	1	E1	893288	111.946	5.80(+10)	6.08(+10)	3.27(–1)
1 – 20	0	1	E1	895953	111.613	3.93(+10)	4.14(+10)	2.20(–1)
2 – 25	1	2	E1	906216	110.349	6.79(+9)	7.32(+9)	6.19(–2)
3 – 26	2	3	E1	937884	106.623	2.19(+10)	2.28(+10)	2.62(–1)
1 – 24	0	1	E1	961104	104.047	2.99(+8)	3.41(+8)	1.45(–3)
3 – 27	2	1	E1	969744	103.120	5.35(+7)	4.49(+7)	2.56(–4)
2 – 27	1	1	E1	996026	100.399	1.20(+9)	1.28(+9)	5.47(–3)
1 – 27	0	1	E1	1063840	93.999	1.42(+9)	1.43(+9)	5.64(–3)

TABLE III. M1, E2, and M2 Transition Energies, Probabilities, and Weighted Oscillator Strengths for the $3s^23p3d$ J = 4 Level

See page 69 for Explanation of Tables

				Wavenumber	Wavelength	A (1/s)		
Trans.	J_F	J_I	Type	1/cm	Å	Length	Velocity	gf
				S III Emission Lines				
12 −16	2	4	E2	24066	4155.2	7.91(−1)	1.05	1.84(−8)
9 −16	3	4	E2	39096	2557.8	6.16(−2)	1.07(−1)	5.44(−10)
3 −16	2	4	M2	121926	820.172	1.28(−1)		1.16(−10)
4 −16	2	4	M2	111145	899.726	4.67(−1)		5.10(−10)
				Ar V Emission Lines				
12 −16	2	4	E2	46393	2155.49	4.30	5.96	2.70(−8)
8 −16	2	4	E2	67018	1492.1	1.67(−1)	3.04(−1)	5.00(−10)
6 −16	2	4	E2	103729	964.015	1.01(−1)	2.62(−1)	1.27(−10)
4 −16	2	4	M2	171740	582.277	2.26		1.03(−9)
3 −16	2	4	M2	186376	536.551	5.02(−1)		1.95(−10)
				Ca VII Emission Lines				
16 −17	3	4	M1	1849	54084.	1.27(−1)		5.02(−7)
12 −17	2	4	E2	66024	1514.6	8.98	1.08(+1)	2.78(−8)
9 −17	3	4	E2	91458	1093.4	3.58(−1)	5.26	5.78(−10)
9 −17	3	4	M1	91458	1093.4	2.69(−1)		4.34(−10)
8 −17	2	4	E2	91836	1088.9	7.68(−1)	1.97	1.23(−9)
6 −17	2	4	E2	138529	721.87	2.80(−1)	3.13(−1)	1.97(−10)
4 −17	2	4	M2	229716	435.320	6.15		1.57(−9)
3 −17	2	4	M2	247930	403.339	1.04		2.29(−10)
				Ti IX Emission Lines				
16 −18	3	4	M1	3507	28516.	8.69(−1)		9.54(−7)
12 −18	2	4	E2	83886	1192.1	1.36(+1)	1.74(+1)	2.60(−8)
9 −18	3	4	E2	114230	875.43	1.79	1.21	1.85(−9)
9 −18	3	4	M1	114230	875.43	1.03		1.06(−9)
8 −18	2	4	E2	115014	869.46	2.62	3.64	2.68(−9)
6 −18	2	4	E2	171253	583.93	9.43(−1)	1.71	4.34(−10)
4 −18	2	4	M2	286499	349.041	1.30(+1)		2.14(−9)
3 −18	2	4	M2	308222	324.441	1.50		2.14(−10)

TABLE III. M1, E2, and M2 Transition Energies, Probabilities, and Weighted Oscillator Strengths for the $3s^2 3p3d$ $J = 4$ Level

See page 69 for Explanation of Tables

Trans.	J_F	J_I	Type	Wavenumber 1/cm	Wavelength Å	A (1/s) Length	A (1/s) Velocity	gf
				Fe XIII Emission Lines				
16 −18	3	4	M1	9773	10232.	1.87(+1)		2.64(−6)
13 −18	2	4	E2	83886	1192.1	2.02(−1)	2.83(−1)	3.87(−10)
12 −18	2	4	E2	116270	860.07	1.95(+1)	2.48(+1)	1.96(−8)
9 −18	3	4	E2	156986	637.00	4.97	3.97	2.72(−9)
9 −18	3	4	M1	156986	637.00	9.12		4.99(−9)
8 −18	2	4	E2	159882	625.46	1.10(+1)	1.47(+1)	5.81(−9)
6 −18	2	4	E2	234011	427.33	4.73	7.53	1.17(−9)
4 −18	2	4	M2	399468	250.333	3.97(+1)		3.35(−9)
3 −18	2	4	M2	429398	232.884	9.96(−1)		7.29(−11)
				Zn XVII Emission Lines				
16 −18	3	4	M1	22226	4499.3	2.17(+2)		5.93(−6)
13 −18	2	4	E2	105273	949.91	7.29(−1)	1.06	8.87(−10)
12 −18	2	4	E2	145996	684.95	2.08(+1)	2.61(+1)	1.32(−8)
9 −18	3	4	E2	198614	503.49	9.54	8.15	3.26(−9)
9 −18	3	4	M1	198614	503.49	5.70(+1)		1.95(−8)
8 −18	2	4	E2	207082	482.90	3.10(+1)	4.04(+1)	9.75(−9)
6 −18	2	4	E2	306551	326.21	1.83(+1)	2.64(+1)	2.79(−9)
4 −18	2	4	M2	513901	194.590	8.91(+1)		4.55(−9)
3 −18	2	4	M2	557889	179.247	2.47(−1)		1.07(−11)
				Kr XXIII Emission Lines				
16 −17	3	4	M1	1848	54084	1.27(−1)		5.024(−7)
13 −17	2	4	E2	131032	763.17	2.62	3.64	2.058(−9)
11 −17	2	4	E2	193930	515.65	1.61(+1)	1.92(+1)	5.762(−9)
9 −17	3	4	E2	263546	379.44	2.24(+1)	2.02(+1)	4.355(−9)
9 −17	3	4	M1	263546	379.44	6.48(+2)		1.259(−7)
8 −17	2	4	E2	290208	344.58	9.56(+1)	1.20(+2)	1.531(−8)
6 −17	2	4	E2	406603	245.94	1.13(+2)	1.50(+2)	9.253(−9)
4 −18	2	4	M2	690794	144.761	2.13(+2)		6.03(−9)
3 −18	2	4	M2	781635	127.937	2.63(+1)		5.78(−10)