Energies and E1, M1, E2 transition rates for states of the $2s^2 2p^5$ and $2s2p^6$ configurations in fluorine-like ions between Si VI and W LXVI

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Abstract

Energies and E1, M1, E2 transition rates from relativistic configuration interaction calculations are reported for the states of the $(1s^2)2s^2 2p^5$ and $2s2p^6$ configurations in all fluorine-like ions between Si VI and W LXVI. Valence, core-valence, and core-core correlation effects were accounted for through single-double expansions to increasing sets of active orbitals.

Contents

1. Introduction

During the years there has been considerable interest in the $2s^2 2p^5 - 2s2p^6$ transitions of fluorine-like ions. The transitions are observed in high-temperature plasmas and can be used for plasma diagnostics. Specially the magnetic-dipole transition $2s^2 2p^5\ ^2P_{3/2} - {}^2P_{1/2}$ is often observed in tokamaks, and its relatively long wavelength makes it useful for determining ion temperatures through measurement of Doppler broadening [1]. To match this interest measurements on highly charged fluorine-like ions have been done with various techniques. Using laser irradiated solid targets Reader et al. [2, 3] measured transition energies for ions from Sr XXX to Sn XLII. More recently measurements have also been done for F-like tungsten [4]. The experimental work has been followed by calculations. Already in 1979 Cheng et al. [5] presented energy levels, oscillator strengths and transition probabilities for ions isoelectronic to the first-row atoms (Li through F) using the multiconfigurational Dirac-Fock technique. Based on the results by Cheng et al. Edlén used a semiempirical formula with three adjustable parameters to predict transition energies for ions from $Z = 11$ to $Z = 33$ [6]. This formula was later adapted also to higher Z [3]. Additional theoretical work has been done by Mohan and Hibbert [7] and Blackford and Hibbert [8] who presented oscillator strengths of transition from ground states of fluorine-like ions using the CIV3 code. Froese Fischer and Tachiev [9] calculated energy levels and transitions rates for low-lying states for ions up to Ti XIV using multiconfigurational Breit-Pauli wave functions. More recently Jonauskas et al. [10] calculated energy levels and transition probabilities among the levels of the ground configuration and first 23 excited configurations of fluorine-like Fe XVIII using the multiconfigurational Dirac-Fock GRASP code. The purpose of the present work is to apply large scale fully relativistic multiconfiguration Dirac-Fock and configuration interaction calculations to provide a consistent and accurate data set of transition energies and transition rates in all F-like ions from Si VI and W LXVI that can be used for plasma diagnostics. The work complement previous systematic work on transition energies and transition rates in the boron, carbon and neon sequences [11–13].

2. Computational procedure

Here we give a brief outline of the multiconfiguration Dirac-Hartree-Fock (MCDHF) method. A comprehensive treatment can be found in [14]. Starting from the Dirac-Coulomb Hamiltonian

$$H_{\rm DC} = \sum_{i=1}^{N} \left(c\,\boldsymbol{\alpha}_i \cdot \boldsymbol{p}_i + (\beta_i - 1)c^2 + V_i^N \right) + \sum_{i>j}^{N} \frac{1}{r_{ij}}, \tag{1}$$

where V^N is the monopole part of the electron-nucleus Coulomb interaction, the atomic state functions (ASFs) describing different fine-structure states are obtained as linear combinations of symmetry adapted configuration state functions (CSFs)

$$|\gamma J M_J\rangle = \sum_{j=1}^{NCSFs} c_j |\gamma_j J M_J\rangle. \tag{2}$$

In the expression above J and M_J are the angular quantum numbers. γ denotes other appropriate labeling of the configuration state function, for example parity, orbital occupancy, and coupling scheme. The configuration state functions are built from products of one-electron Dirac orbitals. In the relativistic self-consistent field procedure both the radial parts of the Dirac orbitals and the expansion coefficients are optimized to self-consistency. The Breit interaction

$$H_{\rm Breit} = -\sum_{i<j}^{N} \left[\boldsymbol{\alpha}_i \cdot \boldsymbol{\alpha}_j \frac{\cos(\omega_{ij} r_{ij}/c)}{r_{ij}} \; + (\boldsymbol{\alpha}_i \cdot \boldsymbol{\nabla}_i)(\boldsymbol{\alpha}_j \cdot \boldsymbol{\nabla}_j) \frac{\cos(\omega_{ij} r_{ij}/c) - 1}{\omega_{ij}^2 r_{ij}/c^2} \right] \tag{3}$$

as well as leading QED corrections can be included in subsequent relativistic configuration interaction (RCI) calculations. Calculations can be done for single levels, but also for portions of a spectrum in the extended optimal level (EOL) scheme, where optimization is on a weighted sum of energies [15]. Using the latter scheme a balanced description of a number of fine-structure states belonging to one or more configurations can be obtained in a single calculation. All calculations were performed with the GRASP2K relativistic atomic structure package [16], in which for calculations of spin-angular parts of matrix elements the second quantization method in coupled tensorial form and quasispin technique [17, 18] were adopted.

3. Transition parameters

The transition parameters, such as rates for spontaneous decay, for multipole transitions between two atomic states $\gamma J M_J$ and $\gamma' J' M'_J$ can be expressed in terms of reduced transition matrix elements

$$\left\langle \gamma J \| \mathbf{Q}_k^{(\lambda)} \| \gamma' J' \right\rangle, \tag{4}$$

where $\mathbf{Q}_k^{(\lambda)}$ is the electromagnetic multipole operator of order k in Coulomb or Babushkin gauge [19]. The superscript designates the type of multipole: $\lambda = 1$ for electric multipoles and $\lambda = 0$ for magnetic multipoles. Inserting the CSF expansions (2), the expression above reduces to a sum over matrix elements between CSFs. Using Racah algebra techniques these matrix elements, in turn, can be obtained as sums over radial integrals [17]. Standard Racah algebra assumes that the atomic state functions are built from the same orthogonal radial orbital set. However, this restriction can be relaxed. To compute transition matrix elements between two atomic state functions described by independently optimized orbital sets, transformations of the atomic state functions are performed in such a way that the orbital sets become biorthogonal, in which case the calculation can be handled using standard techniques [20].

4. Generation of atomic state functions

In this paper we are using the ASFs as a linear combination of CSFs (2). The wave functions for all states belonging to a specific configuration were determined simultaneously in an EOL calculation. The configuration expansions were obtained using the active set method [21, 22]. Here CSFs of a specified parity and J symmetry are generated by excitations from a number of reference configurations to a set of relativistic orbitals. To monitor the convergence of the calculated energies and transition parameters, the active sets were increased in a systematic way by adding layers of correlation orbitals. Each layer is characterized by a principal quantum number and angular symmetries. In the present work valence, core-valence, and core-core correlation effects were included. The configuration expansions were obtained by single and double excitations to active sets with principal quantum numbers $n = 3 \ldots 8$ for ions with $Z = 14 \ldots 32$, $n = 3 \ldots 7$ for ions with $Z = 33 \ldots 62$, and $n = 3 \ldots 6$ for ions with $Z = 63 \ldots 74$ with orbital quantum numbers $l = 0 \ldots 6$ (i.e. angular symmetries s, p, d, f, g, h, i) from all shells of the $1s^2 2s^2 2p^5$ and $1s^2 2s 2p^6$ configurations.

The self-consistent field calculations for the final layer of orbitals were followed by RCI calculations, including the transverse Breit interaction and the leading QED effects – vacuum polarization and self-energy. The final expansion, with the principal quantum number $n = 8$, for the $2s^2 2p^5$ states contained 73 000 CSFs distributed over the $J = 1/2$, $3/2$ symmetry blocks. For the $2s 2p^6$ state there were, about 15 000 CSFs distributed over the $J = 1/2$ symmetry block.

5. Results and evaluation of data

The experimental energy levels and computed energies from the largest RCI calculations including QED corrections are displayed in Table 1. The computed energies agree very well with experimental values. Starting from Si VI the energy differences rapidly goes down to a few hundred cm^{-1}, which corresponds to an error of around 0.02 %. From Sr XXX to Sn XLII experimental energies are given with error bars between 1000 and 2000 cm^{-1}. The calculated values are within the stated experimental error bars except for Cd XL and Sn XLII. The reason for the difference in these two ions is not known. Experimental data for ions from Sb XLIII to Ta LXV are not available. For the W LXVI ion, the differences between theoretical and experimental transition energies are a few thousand cm^{-1}. As discussed by Kramida [23] the total uncertainties of the measured energies in W LXVI were dominated by the calibration uncertainties and varied in the range 1.0 - 2.3 eV, which translates to 8000 - 20000 cm^{-1}. Based on the comparison between theory and experiment for the lighter ions as well as for W LXVI we estimate that the errors in the calculated transition energies for ions in the range Sb XLIII - Ta LXV, for which no experimental data are available, are less than 0.08 %.

Table 2 gives rates for all E1 transitions in the $2s2p^6 - 2s^22p^5$ configurations and for M1 and E2 transitions between the fine-structure levels of the $2s^22p^5$ configuration. Transition rates obtained in the Babushkin (length) and Coulomb (velocity) forms agree very well. Table 2 displays also oscillator strengths. The strength of the M1 transitions increases along the sequence to reach rates up to 10^{10} s^{-1} for W LXVI. In Table 3 the present transition rates in Si VI and Fe XVIII are compared with rates from multiconfiguration Breit-Pauli calculations by Froese Fischer and Tachiev [9], CIV3 calculations by Blackford and Hibbert [8] and by MCDF calculations by Jonauskas et al. [10]. Starting with Si VI we see that the rates for the E1 transitions in the length gauge differ from those by Froese Fischer and Tachiev by 1.7%. The agreement is even better with the values by Blackford and Hibbert. For values for the M1 and E2 transitions between the fine-structure levels of the $2s^22p^5$ are almost identical to the ones by Froese Fischer and Tachiev. Turning to Fe XVIII and the E1 transitions we again see a good agreement with the values presented by Blackford and Hibbert. The agreement with the MCDF calculation is less good and the difference reaches 7.5% for the $1/2 - 1/2$ transition. For the M1 and E2 transitions there is very good agreement with the values by Jonauskas et al. Overall, the agreement between different theoretical approaches is very satisfactory.

Error estimates for the calculated transition rates must be based on internal consistency between values in different gauges and on consistency with other calculations. Although not entirely straight forward due to differences in computational complexity, we may also draw from what we know about the accuracy of calculated values in similar systems for which accurate experimental rates are available. In theoretical studies rates in the Babushkin gauge are the preferred ones and the difference between the rates in the Babushkin and Coulomb gauges are taken as a rough estimate of the uncertainty in the calculation. Looking at the $2s2p^6\ ^2S_{1/2} - 2s^22p^5\ ^2P_{3/2}$ and $2s2p^6\ ^2S_{1/2} - 2s^22p^5\ ^2P_{1/2}$ E1 transitions, the rates in Babushkin and Coulomb gauges agree to within 1 % for ions up to Ni XX. Whereas the rates for the $1/2 - 3/2$ transition in the two gauges continue to be in good agreement, there is a difference for the $1/2 - 1/2$ transition that continues to grow as we move to the higher end of the sequence. For W LXVI the difference in rate in the two gauges has increased to 10 %. The reason for this is not known to the authors, but it may be related to ignored contributions from the negative continuum. As shown by Chen et al. [24] these contributions affect mainly the values in the Coulomb gaugue. Based on the analysis above, and also on the good agreement with the multiconfiguration Breit-Pauli calculations by Froese Fischer and Tachiev [9] and the CIV3 calculations by Blackford and Hibbert [8], we

estimate that the rates for the $2s2p^6\ ^2S_{1/2} - 2s^22p^5\ ^2P_{3/2}$ transition are correct to within a few percent. Due to possible contributions from the negative continuum the values for the $2s2p^6\ ^2S_{1/2} - 2s^22p^5\ ^2P_{1/2}$ transition are less certain, especially for the higher end of the sequence. At the higher end we estimate that the calculated rates are accurate to within 5 %. As seen from Table 2 the $2s^22p^5\ ^2P_{1/2} - 2s^22p^5\ ^2P_{3/2}$ transition is dominated by the contributions from the M1 multipole. The M1 transition is comparatively insensitve of correlation effects and for this reason easy to compute. Looking at Table 3 we see that here is a very good consistency with values from both the multiconfiguration Breit-Pauli calculations by Froese Fischer and Tachiev [9] and from the MCDF calculations by Jonauskas et al. [10]. We estimate that the calculated values of the M1 transition are accurate to within 2 %.

6. Summary

We report energy levels, transition rates and oscillator strengths for relativistic configuration interaction calculations for transitions among the $2s^22p^5$ and $2s2p^6$ configurations of all fluorine-like ions from Si VI to W LXVI. The calculations account for valence, core-valence and core-core correlation through large configuration expansions based on orbital sets with principal quantum numbers $n = 3 \ldots 8$ for ions with $Z = 14 \ldots 32$, $n = 3 \ldots 7$ for ions with $Z = 33 \ldots 62$, $n = 3 \ldots 6$ for ions with $Z = 63 \ldots 74$ and orbital quantum numbers $l = 0 \ldots 6$ (i.e. angular symmetries s, p, d, f, g, h, i).

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Explanation of Tables

Table 1. Energy levels in cm^{-1}

Level	Calculated (Calc.) and observed (Obs.) energies are given in units of cm^{-1} relative to a ground state energy of zero. The observed (Obs.) energies for Si VI to Rb XXIX are those of [25]. Observed energies for Sr XXX and Y XXXI are from [2]. Observed energies for Zr XXXI to Sb XLIII are from [3].

Table 2. Transition data

Upper	Characteristics of upper levels.
Lower	Characteristics of lower levels.
Type	Type of transitions (E1, E2, M1).
E1	Electric dipole transitions.
E2	Electric quadrupole transitions.
M1	Magnetic dipole transitions.
gf_B	Oscillator strengths in Babushkin (length) gauge.
gf_C	Oscillator strengths in Coulomb (velocity) gauge.
A_B	Transition rates for spontaneous emission in Babushkin (length) gauge in units of s^{-1}. Rates are based on computed transition energies.
A_C	Transition rates for spontaneous emission in Coulomb (velocity) gauge in units of s^{-1}. Rates are based on computed transition energies.

Table 3. Comparison of transition rates in s^{-1}

Upper	Characteristics of upper levels.
Lower	Characteristics of lower levels.
Type	Type of transitions (E1, E2, M1).
E1	Electric dipole transitions.
E2	Electric quadrupole transitions.
M1	Magnetic dipole transitions.
A_B	Transition rates for spontaneous emission in Babushkin (length) gauge in units of s^{-1}. Rates are based on computed transition energies.
A_C	Transition rates for spontaneous emission in Coulomb (velocity) gauge in units of s^{-1}. Rates are based on computed transition energies.
CIV3	Transition rates for spontaneous emission in s^{-1} from [8].
MCHFBP	Transition rates for spontaneous emission in s^{-1} from [9].
MCDF	Transition rates for spontaneous emission in s^{-1} from [10].

Table 1
Energy levels in cm^{-1}. See page 8 for Explanation of Tables.

Level	J	Level (cm^{-1})		
		Calc.	Obs.	Diff.
		Si VI		
$2s^2 2p^5\ ^2P^o$	3/2	0		
	1/2	5093.02	5090.00	3.02
$2s2p^6\ ^2S$	1/2	407480.13	406497.00	983.13
		P VII		
$2s^2 2p^5\ ^2P^o$	3/2	0		
	1/2	7272.36	7273.00	−0.64
$2s2p^6\ ^2S$	1/2	455512.92	454725.00	787.92
		S VIII		
$2s^2 2p^5\ ^2P^o$	3/2	0		
	1/2	10084.50	10085.00	−0.50
$2s2p^6\ ^2S$	1/2	504298.45	503644.00	654.45
		Cl IX		
$2s^2 2p^5\ ^2P^o$	3/2	0		
	1/2	13641.64	13629.00	12.64
$2s2p^6\ ^2S$	1/2	553941.10	553376.00	565.10
		Ar X		
$2s^2 2p^5\ ^2P^o$	3/2	0		
	1/2	18065.74	18065.00	0.74
$2s2p^6\ ^2S$	1/2	604574.89	604087.00	487.89
		K XI		
$2s^2 2p^5\ ^2P^o$	3/2	0		
	1/2	23488.47	23495.00	−6.53
$2s2p^6\ ^2S$	1/2	656344.83	655901.00	443.83
		Ca XII		
$2s^2 2p^5\ ^2P^o$	3/2	0		
	1/2	30051.30	30041.00	10.30
$2s2p^6\ ^2S$	1/2	709405.57	709030.00	375.57
		Sc XIII		
$2s^2 2p^5\ ^2P^o$	3/2	0		
	1/2	37905.65	37908.00	−2.35
$2s2p^6\ ^2S$	1/2	763921.75	763621.00	300.75
		Ti XIV		
$2s^2 2p^5\ ^2P^o$	3/2	0		
	1/2	47213.14	47219.00	−5.86
$2s2p^6\ ^2S$	1/2	820070.34	819772.00	298.34
		V XV		
$2s^2 2p^5\ ^2P^o$	3/2	0		
	1/2	58145.62	58093.00	52.62
$2s2p^6\ ^2S$	1/2	878036.32	877732.00	304.32
		Cr XVI		
$2s^2 2p^5\ ^2P^o$	3/2	0		
	1/2	70885.50	70892.00	−6.50
$2s2p^6\ ^2S$	1/2	938016.66	937790.00	226.66
		Mn XVII		
$2s^2 2p^5\ ^2P^o$	3/2	0		
	1/2	85625.84	85500.00	125.84
$2s2p^6\ ^2S$	1/2	1000217.31	1000000.00	217.31
		Fe XVIII		
$2s^2 2p^5\ ^2P^o$	3/2	0		
	1/2	102570.58	102579.00	−8.42
$2s2p^6\ ^2S$	1/2	1064858.16	1064702.00	156.16
		Co XIX		
$2s^2 2p^5\ ^2P^o$	3/2	0		
	1/2	121934.88	121960.00	−25.12
$2s2p^6\ ^2S$	1/2	1132165.65	1131860.00	305.65
		Ni XX		
$2s^2 2p^5\ ^2P^o$	3/2	0		
	1/2	143945.10	143959.00	−13.90
$2s2p^6\ ^2S$	1/2	1202382.90	1202200.00	182.90
		Cu XXI		
$2s^2 2p^5\ ^2P^o$	3/2	0		
	1/2	168839.27	168830.00	9.27
$2s2p^6\ ^2S$	1/2	1275750.19	1275750.00	0.19

Continued...

Table 1 (continued)

Level	J	Level (cm^{-1})		
		Calc.	Obs.	Diff.
		Zn XXII		
$2s^2 2p^5\ ^2P^o$	3/2	0		
	1/2	196867.57	196868.00	−0.43
$2s2p^6\ ^2S$	1/2	1352557.59	1352430.00	127.59
		Ga XXIII		
$2s^2 2p^5\ ^2P^o$	3/2	0		
	1/2	228291.84	228400.00	−108.16
$2s2p^6\ ^2S$	1/2	1433053.45	1433030.00	23.45
		Ge XXIV		
$2s^2 2p^5\ ^2P^o$	3/2	0		
	1/2	263386.64	263500.00	−113.36
$2s2p^6\ ^2S$	1/2	1517538.72	1517440.00	98.72
		As XXV		
$2s^2 2p^5\ ^2P^o$	3/2	0		
	1/2	302435.85	302687.00	−251.15
$2s2p^6\ ^2S$	1/2	1606312.11	1606352.00	−39.89
		Se XXVI		
$2s^2 2p^5\ ^2P^o$	3/2	0		
	1/2	345746.28	346080.00	−333.72
$2s2p^6\ ^2S$	1/2	1699684.89	1699800.00	−115.11
		Br XXVII		
$2s^2 2p^5\ ^2P^o$	3/2	0		
	1/2	393628.81	394072.00	−443.19
$2s2p^6\ ^2S$	1/2	1797993.61	1798200.00	−206.39
		Kr XXVIII		
$2s^2 2p^5\ ^2P^o$	3/2	0		
	1/2	446411.04	446440.00	−28.96
$2s2p^6\ ^2S$	1/2	1901562.99	1901350.00	212.99
		Rb XXIX		
$2s^2 2p^5\ ^2P^o$	3/2	0		
	1/2	504434.89	504370.00	64.89
$2s2p^6\ ^2S$	1/2	2010777.44	2010940.00	−162.56
		Sr XXX		
$2s^2 2p^5\ ^2P^o$	3/2	0		
	1/2	568056.90	568360±400	−303.10
$2s2p^6\ ^2S$	1/2	2126008.62	2126300±700	−291.38
		Y XXXI		
$2s^2 2p^5\ ^2P^o$	3/2	0		
	1/2	637648.58	637270±500	378.58
$2s2p^6\ ^2S$	1/2	2247622.42	2247400±700	222.42
		Zr XXXII		
$2s^2 2p^5\ ^2P^o$	3/2	0		
	1/2	713597.03	713300±900	297.03
$2s2p^6\ ^2S$	1/2	2376033.39	2376700±800	−666.61
		Nb XXXIII		
$2s^2 2p^5\ ^2P^o$	3/2	0		
	1/2	796305.23	795600±1000	705.23
$2s2p^6\ ^2S$	1/2	2511654.50	2510400±900	1254.50
		Mo XXXIV		
$2s^2 2p^5\ ^2P^o$	3/2	0		
	1/2	886192.79	886200±1200	−7.21
$2s2p^6\ ^2S$	1/2	2654927.09	2655300±1100	−372.91
		Tc XXXV		
$2s^2 2p^5\ ^2P^o$	3/2	0		
	1/2	983696.44		
$2s2p^6\ ^2S$	1/2	2806313.12		
		Ru XXXVI		
$2s^2 2p^5\ ^2P^o$	3/2	0		
	1/2	1089270.11		
$2s2p^6\ ^2S$	1/2	2966260.87		
		Rh XXXVII		
$2s^2 2p^5\ ^2P^o$	3/2	0		
	1/2	1203386.50	1204400±1600	−1013.50
$2s2p^6\ ^2S$	1/2	3135285.27	3137100±1500	−1814.73

Continued. . .

Table 1 (continued)

Level	J	Level (cm^{-1})		
		Calc.	Obs.	Diff.
		Pd XXXVIII		
$2s^2 2p^5\ ^2P^o$	3/2	0		
	1/2	1326536.65		
$2s2p^6\ ^2S$	1/2	3313875.76		
		Ag XXXIX		
$2s^2 2p^5\ ^2P^o$	3/2	0		
	1/2	1459231.43		
$2s2p^6\ ^2S$	1/2	3502579.61	3503600±1800	−1020.39
		Cd XL		
$2s^2 2p^5\ ^2P^o$	3/2	0		
	1/2	1602001.43		
$2s2p^6\ ^2S$	1/2	3701921.58	3706200±2100	−4278.49
		In XLI		
$2s^2 2p^5\ ^2P^o$	3/2	0		
	1/2	1755398.80		
$2s2p^6\ ^2S$	1/2	3912498.34		
		Sn XLII		
$2s^2 2p^5\ ^2P^o$	3/2	0		
	1/2	1919996.93		
$2s2p^6\ ^2S$	1/2	4134892.80	4138600±2600	−3707.20
		Sb XLIII		
$2s^2 2p^5\ ^2P^o$	3/2	0		
	1/2	2096391.96		
$2s2p^6\ ^2S$	1/2	4369687.71		
		Te XLIV		
$2s^2 2p^5\ ^2P^o$	3/2	0		
	1/2	2285202.09		
$2s2p^6\ ^2S$	1/2	4617573.96		
		I XLV		
$2s^2 2p^5\ ^2P^o$	3/2	0		
	1/2	2487073.80		
$2s2p^6\ ^2S$	1/2	4879258.19		
		Xe XLVI		
$2s^2 2p^5\ ^2P^o$	3/2	0		
	1/2	2702673.20		
$2s2p^6\ ^2S$	1/2	5155313.10		
		Cs XLVII		
$2s^2 2p^5\ ^2P^o$	3/2	0		
	1/2	2932697.32		
$2s2p^6\ ^2S$	1/2	5446538.64		
		Ba XLVIII		
$2s^2 2p^5\ ^2P^o$	3/2	0		
	1/2	3177867.04		
$2s2p^6\ ^2S$	1/2	5753626.47		
		La XLIX		
$2s^2 2p^5\ ^2P^o$	3/2	0		
	1/2	3438935.09		
$2s2p^6\ ^2S$	1/2	6077403.51		
		Ce L		
$2s^2 2p^5\ ^2P^o$	3/2	0		
	1/2	3716681.99		
$2s2p^6\ ^2S$	1/2	6418676.30		
		Pr LI		
$2s^2 2p^5\ ^2P^o$	3/2	0		
	1/2	4011918.40		
$2s2p^6\ ^2S$	1/2	6778252.22		
		Nd LII		
$2s^2 2p^5\ ^2P^o$	3/2	0		
	1/2	4325488.12		
$2s2p^6\ ^2S$	1/2	7156947.99		
		Pm LIII		
$2s^2 2p^5\ ^2P^o$	3/2	0		
	1/2	4658303.51		
$2s2p^6\ ^2S$	1/2	7555832.03		

Continued. . .

Table 1 (continued)

Level	J	Level (cm^{-1})		
		Calc.	Obs.	Diff.
		Sm LIV		
$2s^2 2p^5\ ^2P^o$	3/2	0		
	1/2	5011225.50		
$2s2p^6\ ^2S$	1/2	7974977.80		
		Eu LV		
$2s^2 2p^5\ ^2P^o$	3/2	0		
	1/2	5385078.92		
$2s2p^6\ ^2S$	1/2	8417337.72		
		Gd LVI		
$2s^2 2p^5\ ^2P^o$	3/2	0		
	1/2	5781116.19		
$2s2p^6\ ^2S$	1/2	8882057.51		
		Tb LVII		
$2s^2 2p^5\ ^2P^o$	3/2	0		
	1/2	6200248.46		
$2s2p^6\ ^2S$	1/2	9370939.00		
		Dy LVIII		
$2s^2 2p^5\ ^2P^o$	3/2	0		
	1/2	6643541.67		
$2s2p^6\ ^2S$	1/2	9884937.93		
		Ho LIX		
$2s^2 2p^5\ ^2P^o$	3/2	0		
	1/2	7112112.60		
$2s2p^6\ ^2S$	1/2	10425231.37		
		Er LX		
$2s^2 2p^5\ ^2P^o$	3/2	0		
	1/2	7607125.16		
$2s2p^6\ ^2S$	1/2	10993065.32		
		Tm LXI		
$2s^2 2p^5\ ^2P^o$	3/2	0		
	1/2	8129788.37		
$2s2p^6\ ^2S$	1/2	11589628.99		
		Yb LXII		
$2s^2 2p^5\ ^2P^o$	3/2	0		
	1/2	8681358.45		
$2s2p^6\ ^2S$	1/2	12216087.56		
		Lu LXIII		
$2s^2 2p^5\ ^2P^o$	3/2	0		
	1/2	9263161.81		
$2s2p^6\ ^2S$	1/2	12874031.49		
		Hf LXIV		
$2s^2 2p^5\ ^2P^o$	3/2	0		
	1/2	9876562.18		
$2s2p^6\ ^2S$	1/2	13564668.78		
		Ta LXV		
$2s^2 2p^5\ ^2P^o$	3/2	0		
	1/2	10522998.26		
$2s2p^6\ ^2S$	1/2	14289483.89		
		W LXVI		
$2s^2 2p^5\ ^2P^o$	3/2	0		
	1/2	11203964.89	11201971.55	1993.34
$2s2p^6\ ^2S$	1/2	15049974.97	15054000.00	−4025.03

Table 2
Transition data in s^{-1}. See page 8 for Explanations of Tables.

States		Type	Transition rates (s^{-1})		Oscillator strengths	
Upper	Lower		A_B	A_C	gf_B	gf_C
			Si VI			
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E1	1.808e+10	1.778e+10	3.265e−01	3.210e−01
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{1/2}$	E1	8.664e+09	8.554e+09	1.605e−01	1.584e−01
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	M1	2.374e+00		2.744e−07	
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E2	1.536e−05	1.416e−05	1.776e−12	1.637e−12
			P VII			
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E1	2.138e+10	2.120e+10	3.090e−01	3.063e−01
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{1/2}$	E1	1.013e+10	1.010e+10	1.512e−01	1.506e−01
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	M1	6.910e+00		3.917e−07	
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E2	6.094e−05	5.522e−05	3.455e−12	3.131e−12
			S VIII			
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E1	2.492e+10	2.472e+10	2.938e−01	2.915e−01
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{1/2}$	E1	1.166e+10	1.163e+10	1.431e−01	1.428e−01
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	M1	1.842e+01		5.431e−07	
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E2	2.169e−04	2.004e−04	6.395e−12	5.909e−12
			Cl IX			
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E1	2.867e+10	2.846e+10	2.802e−01	2.781e−01
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{1/2}$	E1	1.321e+10	1.320e+10	1.357e−01	1.355e−01
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	M1	4.559e+01		7.346e−07	
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E2	7.037e−04	6.527e−04	1.134e−11	1.052e−11
			Ar X			
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E1	3.266e+10	3.242e+10	2.679e−01	2.660e−01
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{1/2}$	E1	1.480e+10	1.479e+10	1.290e−01	1.289e−01
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	M1	1.059e+02		9.726e−07	
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E2	2.108e−03	1.952e−03	1.937e−11	1.793e−11
			K XI			
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E1	3.691e+10	3.665e+10	2.569e−01	2.551e−01
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{1/2}$	E1	1.640e+10	1.641e+10	1.228e−01	1.229e−01
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	M1	2.326e+02		1.264e−06	
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E2	5.888e−03	5.445e−03	3.200e−11	2.959e−11
			Ca XII			
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E1	4.146e+10	4.117e+10	2.470e−01	2.453e−01
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{1/2}$	E1	1.803e+10	1.806e+10	1.172e−01	1.174e−01
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	M1	4.871e+02		1.617e−06	
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E2	1.547e−02	1.432e−02	5.136e−11	4.754e−11
			Sc XIII			
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E1	4.635e+10	4.602e+10	2.382e−01	2.365e−01
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{1/2}$	E1	1.968e+10	1.974e+10	1.120e−01	1.123e−01
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	M1	9.773e+02		2.039e−06	
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E2	3.849e−02	3.566e−02	8.032e−11	7.441e−11
			Ti XIV			
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E1	5.163e+10	5.127e+10	2.302e−01	2.286e−01
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{1/2}$	E1	2.136e+10	2.143e+10	1.072e−01	1.076e−01
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	M1	1.888e+03		2.539e−06	
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E2	9.124e−02	8.470e−02	1.227e−10	1.139e−10
			V XV			
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E1	5.735e+10	5.695e+10	2.231e−01	2.215e−01
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{1/2}$	E1	2.305e+10	2.316e+10	1.028e−01	1.033e−01
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	M1	3.525e+03		3.127e−06	
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E2	2.071e−01	1.926e−01	1.836e−10	1.709e−10
			Cr XVI			
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E1	6.358e+10	6.313e+10	2.167e−01	2.152e−01
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{1/2}$	E1	2.476e+10	2.491e+10	9.873e−02	9.931e−02
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	M1	6.386e+03		3.811e−06	
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E2	4.518e−01	4.213e−01	2.696e−10	2.514e−10

Continued...

Table 2 (continued)

States		Type	Transition rates (s^{-1})		Oscillator strengths	
Upper	Lower		A_B	A_C	gf_B	gf_C
			Mn XVII			
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E1	7.038e+10	6.989e+10	2.109e−01	2.095e−02
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{1/2}$	E1	2.649e+10	2.668e+10	9.496e−02	9.563e−02
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	M1	1.125e+04		4.601e−06	
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E2	9.512e−01	8.891e−01	3.890e−10	3.636e−10
			Fe XVIII			
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E1	7.784e+10	7.730e+10	2.058e−01	2.044e−01
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{1/2}$	E1	2.824e+10	2.847e+10	9.146e−02	9.220e−02
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	M1	1.933e+04		5.510e−06	
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E2	1.939e+00	1.815e+00	5.526e−10	5.174e−10
			Co XIX			
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E1	8.605e+10	8.546e+10	2.013e−01	1.999e−01
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{1/2}$	E1	3.002e+10	3.030e+10	8.819e−02	8.901e−02
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	M1	3.247e+04		6.548e−06	
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E2	3.836e+00	3.601e+00	7.736e−10	7.262e−10
			Ni XX			
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E1	9.512e+10	9.445e+10	1.973e−01	1.959e−01
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{1/2}$	E1	3.181e+10	3.214e+10	8.515e−02	8.603e−02
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	M1	5.340e+04		7.727e−06	
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E2	7.386e+00	6.944e+00	1.069e−09	1.005e−09
			Cu XXI			
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E1	1.052e+11	1.044e+11	1.937e−01	1.923e−01
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{1/2}$	E1	3.363e+10	3.401e+10	8.230e−02	8.323e−02
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	M1	8.614e+04		9.060e−06	
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E2	1.387e+01	1.309e+01	1.459e−09	1.376e−09
			Zn XXII			
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E1	1.163e+11	1.155e+11	1.906e−01	1.893e−01
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{1/2}$	E1	3.547e+10	3.592e+10	7.962e−02	8.065e−02
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	M1	1.365e+05		1.056e−05	
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E2	2.544e+01	2.401e+01	1.968e−09	1.857e−09
			Ga XXIII			
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E1	1.287e+11	1.278e+11	1.880e−01	1.866e−01
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{1/2}$	E1	3.733e+10	3.786e+10	7.712e−02	7.821e−02
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	M1	2.128e+05		1.224e−05	
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E2	4.568e+01	4.320e+01	2.628e−09	2.485e−09
			Ge XXIV			
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E1	1.426e+11	1.416e+11	1.857e−01	1.843e−01
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{1/2}$	E1	3.922e+10	3.982e+10	7.476e−02	7.591e−02
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	M1	3.266e+05		1.412e−05	
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E2	8.040e+01	7.614e+01	3.475e−09	3.291e−09
			As XXV			
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E1	1.584e+11	1.570e+11	1.841e−01	1.825e−01
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{1/2}$	E1	4.122e+10	4.183e+10	7.270e−02	7.378e−02
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	M1	4.942e+05		1.620e−05	
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E2	1.389e+02	1.314e+02	4.553e−09	4.309e−09
			Se XXVI			
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E1	1.758e+11	1.743e+11	1.825e−01	1.809e−01
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{1/2}$	E1	4.316e+10	4.386e+10	7.059e−02	7.174e−02
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	M1	7.381e+05		1.851e−05	
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E2	2.358e+02	2.235e+02	5.914e−09	5.606e−09
			Br XXVII			
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E1	1.953e+11	1.936e+11	1.812e−01	1.796e−01
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{1/2}$	E1	4.512e+10	4.592e+10	6.859e−02	6.982e−02
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	M1	1.089e+06		2.107e−05	
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E2	3.939e+02	3.740e+02	7.622e−09	7.238e−09

Continued. . .

Table 2 (continued)

States		Type	Transition rates (s^{-1})		Oscillator strengths	
Upper	Lower		A_B	A_C	gf_B	gf_C
			Kr XXVIII			
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E1	2.173e+11	2.154e+11	1.802e−01	1.786e−01
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{1/2}$	E1	4.710e+10	4.802e+10	6.670e−02	6.800e−02
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	M1	1.587e+06		2.388e−05	
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E2	6.480e+02	6.163e+02	9.749e−09	9.272e−09
			Rb XXIX			
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E1	2.419e+11	2.400e+11	1.794e−01	1.779e−01
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{1/2}$	E1	4.911e+10	5.016e+10	6.490e−02	6.628e−02
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	M1	2.289e+06		2.697e−05	
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E2	1.051e+03	1.001e+03	1.238e−08	1.179e−08
			Sr XXX			
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E1	2.698e+11	2.676e+11	1.790e−01	1.775e−01
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{1/2}$	E1	5.116e+10	5.234e+10	6.320e−02	6.465e−02
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	M1	3.266e+06		3.035e−05	
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E2	1.681e+03	1.603e+03	1.562e−08	1.490e−08
			Y XXXI			
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E1	3.012e+11	2.988e+11	1.788e−01	1.774e−01
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{1/2}$	E1	5.323e+10	5.455e+10	6.158e−02	6.310e−02
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	M1	4.617e+06		3.405e−05	
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E2	2.656e+03	2.537e+03	1.959e−08	1.871e−08
			Zr XXXII			
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E1	3.367e+11	3.341e+11	1.788e−01	1.775e−01
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{1/2}$	E1	5.534e+10	5.681e+10	6.004e−02	6.163e−02
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	M1	6.468e+06		3.808e−05	
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E2	4.146e+03	3.964e+03	2.441e−08	2.334e−08
			Nb XXXIII			
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E1	3.768e+11	3.740e+11	1.791e−01	1.778e−01
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{1/2}$	E1	5.747e+10	5.911e+10	5.857e−02	6.023e−02
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	M1	8.981e+06		4.247e−05	
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E2	6.399e+03	6.126e+03	3.026e−08	2.897e−08
			Mo XXXIV			
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E1	4.222e+11	4.192e+11	1.796e−01	1.783e−01
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{1/2}$	E1	5.964e+10	6.146e+10	5.716e−02	5.890e−02
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	M1	1.237e+07		4.723e−05	
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E2	9.770e+03	9.365e+03	3.730e−08	3.576e−08
			Tc XXXV			
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E1	4.737e+11	4.704e+11	1.803e−01	1.791e−01
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{1/2}$	E1	6.185e+10	6.385e+10	5.582e−02	5.763e−02
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	M1	1.691e+07		5.239e−05	
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E2	1.477e+04	1.417e+04	4.575e−08	4.391e−08
			Ru XXXVI			
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E1	5.320e+11	5.284e+11	1.813e−01	1.801e−01
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{1/2}$	E1	6.409e+10	6.629e+10	5.454e−02	5.642e−02
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	M1	2.294e+07		5.797e−05	
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E2	2.210e+04	2.124e+04	5.585e−08	5.366e−08
			Rh XXXVII			
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E1	5.981e+11	5.942e+11	1.824e−01	1.813e−01
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{1/2}$	E1	6.637e+10	6.878e+10	5.332e−02	5.526e−02
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	M1	3.091e+07		6.400e−05	
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E2	3.278e+04	3.153e+04	6.787e−08	6.528e−08
			Pd XXXVIII			
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E1	6.731e+11	6.690e+11	1.838e−01	1.827e−01
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{1/2}$	E1	6.868e+10	7.133e+10	5.214e−02	5.415e−02
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	M1	4.137e+07		7.049e−05	
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E2	4.819e+04	4.641e+04	8.212e−08	7.907e−08

Continued. . .

Table 2 (continued)

States		Type	Transition rates (s^{-1})		Oscillator strengths	
Upper	Lower		A_B	A_C	gf_B	gf_C
			Ag XXXIX			
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E1	7.582e+11	7.538e+11	1.853e−01	1.842e−01
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{1/2}$	E1	7.104e+10	7.393e+10	5.102e−02	5.309e−02
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	M1	5.503e+07		7.748e−05	
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E2	7.027e+04	6.773e+04	9.895e−08	9.537e−08
			Cd XL			
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E1	8.548e+11	8.501e+11	1.870e−01	1.860e−01
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{1/2}$	E1	7.343e+10	7.658e+10	4.993e−02	5.207e−02
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	M1	7.275e+07		8.499e−05	
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E2	1.016e+05	9.807e+04	1.188e−07	1.146e−07
			In XLI			
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E1	9.645e+11	9.594e+11	1.889e−01	1.879e−01
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{1/2}$	E1	7.587e+10	7.929e+10	4.889e−02	5.110e−02
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	M1	9.563e+07		9.305e−05	
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E2	1.459e+05	1.409e+05	1.420e−07	1.371e−07
			Sn XLII			
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E1	1.089e+12	1.084e+12	1.910e−01	1.901e−01
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{1/2}$	E1	7.836e+10	8.206e+10	4.789e−02	5.016e−02
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	M1	1.250e+08		1.017e−04	
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E2	2.080e+05	2.010e+05	1.692e−07	1.635e−07
			Sb XLIII			
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E1	1.231e+12	1.225e+12	1.932e−01	1.924e−01
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{1/2}$	E1	8.088e+10	8.492e+10	4.693e−02	4.927e−02
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	M1	1.626e+08		1.109e−04	
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E2	2.944e+05	2.851e+05	2.008e−07	1.945e−07
			Te XLIV			
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E1	1.391e+12	1.385e+12	1.957e−01	1.948e−01
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{1/2}$	E1	8.346e+10	8.780e+10	4.600e−02	4.839e−02
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	M1	2.104e+08		1.208e−04	
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E2	4.139e+05	4.008e+05	2.376e−07	2.301e−07
			I XLV			
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E1	1.574e+12	1.568e+12	1.983e−01	1.975e−01
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{1/2}$	E1	8.609e+10	9.077e+10	4.511e−02	4.756e−02
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	M1	2.709e+08		1.313e−04	
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E2	5.783e+05	5.605e+05	2.803e−07	2.717e−07
			Xe XLVI			
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E1	1.782e+12	1.775e+12	2.010e−01	2.003e−01
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{1/2}$	E1	8.876e+10	9.381e+10	4.424e−02	4.676e−02
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	M1	3.473e+08		1.426e−04	
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E2	8.031e+05	7.789e+05	3.297e−07	3.198e−07
			Cs XLVII			
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E1	2.017e+12	2.011e+12	2.039e−01	2.033e−01
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{1/2}$	E1	9.149e+10	9.692e+10	4.341e−02	4.599e−02
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	M1	4.433e+08		1.546e−04	
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E2	1.109e+06	1.076e+06	3.865e−07	3.752e−07
			Ba XLVIII			
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E1	2.285e+12	2.279e+12	2.070e−01	2.064e−01
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{1/2}$	E1	9.427e+10	1.001e+11	4.261e−02	4.525e−02
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	M1	5.634e+08		1.673e−04	
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E2	1.522e+06	1.479e+06	4.520e−07	4.391e−07
			La XLIX			
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E1	2.589e+12	2.583e+12	2.102e−01	2.097e−01
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{1/2}$	E1	9.711e+10	1.034e+11	4.183e−02	4.453e−02
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	M1	7.132e+08		1.808e−04	
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E2	2.079e+06	2.021e+06	5.271e−07	5.125e−07

Continued. . .

Table 2 (continued)

States		Type	Transition rates (s^{-1})		Oscillator strengths	
Upper	Lower		A_B	A_C	gf_B	gf_C
			Ce L			
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E1	2.935e+12	2.929e+12	2.136e−01	2.131e−01
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{1/2}$	E1	1.000e+11	1.067e+11	4.107e−02	4.384e−02
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	M1	8.992e+08		1.952e−04	
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E2	2.824e+06	2.748e+06	6.131e−07	5.966e−07
			Pr LI			
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E1	3.327e+12	3.321e+12	2.171e−01	2.168e−01
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{1/2}$	E1	1.030e+11	1.102e+11	4.034e−02	4.318e−02
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	M1	1.130e+09		2.104e−04	
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E2	3.818e+06	3.719e+06	7.113e−07	6.923e−07
			Nd LII			
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E1	3.772e+12	3.767e+12	2.208e−01	2.205e−01
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{1/2}$	E1	1.060e+11	1.137e+11	3.964e−02	4.253e−02
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	M1	1.414e+09		2.266e−04	
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E2	5.137e+06	5.007e+06	8.233e−07	8.024e−07
			Pm LIII			
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E1	4.278e+12	4.273e+12	2.247e−01	2.244e−01
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{1/2}$	E1	1.091e+11	1.177e+11	3.896e−02	4.203e−02
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	M1	1.764e+09		2.437e−04	
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E2	6.884e+06	6.692e+06	9.512e−07	9.247e−07
			Sm LIV			
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E1	4.850e+12	4.846e+12	2.286e−01	2.285e−01
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{1/2}$	E1	1.122e+11	1.227e+11	3.830e−02	4.188e−02
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	M1	2.193e+09		2.618e−04	
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E2	9.180e+06	8.923e+06	1.096e−06	1.066e−06
			Eu LV			
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E1	5.503e+12	5.496e+12	2.329e−01	2.326e−01
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{1/2}$	E1	1.155e+11	1.245e+11	3.766e−02	4.061e−02
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	M1	2.717e+09		2.810e−04	
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E2	1.217e+07	1.187e+07	1.259e−06	1.228e−06
			Gd LVI			
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E1	6.240e+12	6.235e+12	2.372e−01	2.370e−01
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{1/2}$	E1	1.188e+11	1.284e+11	3.703e−02	4.005e−02
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	M1	3.357e+09		3.012e−04	
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E2	1.610e+07	1.571e+07	1.444e−06	1.409e−06
			Tb LVII			
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E1	7.075e+12	7.072e+12	2.416e−01	2.415e−01
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{1/2}$	E1	1.221e+11	1.324e+11	3.642e−02	3.950e−02
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	M1	4.135e+09		3.225e−04	
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E2	2.121e+07	2.070e+07	1.654e−06	1.615e−06
			Dy LVIII			
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E1	8.022e+12	8.022e+12	2.462e−01	2.462e−01
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{1/2}$	E1	1.255e+11	1.366e+11	3.582e−02	3.898e−02
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	M1	5.079e+09		3.450e−04	
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E2	2.783e+07	2.718e+07	1.890e−06	1.846e−06
			Ho LIX			
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E1	9.093e+12	9.098e+12	2.509e−01	2.510e−01
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{1/2}$	E1	1.290e+11	1.408e+11	3.524e−02	3.847e−02
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	M1	6.221e+09		3.688e−04	
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E2	3.638e+07	3.555e+07	2.156e−06	2.107e−06
			Er LX			
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E1	1.031e+13	1.032e+13	2.557e−01	2.560e−01
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{1/2}$	E1	1.326e+11	1.452e+11	3.468e−02	3.797e−02
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	M1	7.600e+09		3.938e−04	
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E2	4.739e+07	4.634e+07	2.456e−06	2.401e−06

Continued. . .

Table 2 (continued)

States		Type	Transition rates (s^{-1})		Oscillator strengths	
Upper	Lower		A_B	A_C	gf_B	gf_C
			Tm LXI			
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E1	1.168e+13	1.170e+13	2.607e−01	2.611e−01
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{1/2}$	E1	1.363e+11	1.497e+11	3.413e−02	3.749e−02
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	M1	9.260e+09		4.201e−04	
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E2	6.153e+07	6.019e+07	2.791e−06	2.731e−06
			Yb LXII			
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E1	1.323e+13	1.326e+13	2.659e−01	2.664e−01
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{1/2}$	E1	1.400e+11	1.543e+11	3.359e−02	3.702e−02
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	M1	1.126e+10		4.478e−04	
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E2	7.962e+07	7.793e+07	3.168e−06	3.100e−06
			Lu LXIII			
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E1	1.499e+13	1.502e+13	2.712e−01	2.712e−01
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{1/2}$	E1	1.438e+11	1.590e+11	3.307e−02	3.656e−02
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	M1	1.365e+10		4.769e−04	
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E2	1.027e+08	1.006e+08	3.589e−06	3.514e−06
			Hf LXIV			
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E1	1.698e+13	1.702e+13	2.766e−01	2.773e−01
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{1/2}$	E1	1.477e+11	1.639e+11	3.256e−02	3.612e−02
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	M1	1.651e+10		5.075e−04	
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E2	1.321e+08	1.294e+08	4.060e−06	3.977e−06
			Ta LXV			
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E1	1.923e+13	1.928e+13	2.822e−01	2.831e−01
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{1/2}$	E1	1.517e+11	1.689e+11	3.206e−02	3.569e−02
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	M1	1.993e+10		5.396e−04	
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E2	1.694e+08	1.660e+08	4.586e−06	4.494e−06
			W LXVI			
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E1	2.175e+13	2.182e+13	2.879e−01	2.889e−01
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{1/2}$	E1	1.557e+11	1.740e+11	3.157e−02	3.527e−02
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	M1	2.400e+10		5.734e−04	
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E2	2.165e+08	2.123e+08	5.172e−06	5.071e−06

Table 3
Comparison of transition rates in s^{-1}. See page 8 for Explanations of Tables.

States		Type	This work		CIV3	MCHFBP	MCDF
Upper	Lower		A_B	A_C			
			Si VI				
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E1	1.808e+10	1.778e+10	1.797e+10	1.777e+10	
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{1/2}$	E1	8.664e+09	8.554e+09	8.600e+09	8.517e+09	
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	M1	2.374e+00			2.376e+00	
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E2	1.536e−05	1.416e−05		1.541e−05	
			Fe XVIII				
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E1	7.784e+10	7.730e+10	7.740e+10		8.313e+10
$2s2p^6\ ^2S_{1/2}$	$2s^22p^5\ ^2P^o_{1/2}$	E1	2.824e+10	2.847e+10	2.744e+10		3.035e+10
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	M1	1.933e+04				1.905e+04
$2s^22p^5\ ^2P^o_{1/2}$	$2s^22p^5\ ^2P^o_{3/2}$	E2	1.939e+00	1.815e+00			1.941e+00