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Atomic structure for carbon-like ions from Na VI to Ar XIII

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ABSTRACT

We have calculated the energy levels, oscillator strengths, and transition probabilities for eight carbon-like ions (Na VI, Mg VII, Al VIII, Si IX, P X, S XI, Cl XII and Ar XIII) using the Hartree–Fock pseudo-relativistic (HFR) and Thomas–Fermi–Dirac–Amaldi (TFDA) approaches. We used configuration expansions containing eight configurations, namely $2s^2\ 2p^2$, $2s\ 2p^3$, $2s^2\ 2p\ 3s$, $2s^2\ 2p\ 3p$, $2s^2\ 2p\ 3d$, $2s^2\ 2p\ 4s$, $2s^2\ 2p\ 4p$, and $2s^2\ 2p\ 5s$. For each of the considered ions we obtained 59 energy levels, a number of which are not in the NIST data base. We compared our results with critically selected experimental data from NIST and with calculations made using the MCHF method. We calculated weighted oscillator strengths and transition probabilities using two methods (HFR and TFDA) for the $2s^2\ 2p^2$ and $2s\ 2p^3$ configurations for the eight C-like ions considered here. We analysed the atomic structure parameter trends, which allowed us to find missing data belonging to an isoelectronic sequence. The energy levels, oscillator strengths, and transition probabilities calculated here are in good agreement with the data from the NIST data base. Because emission and absorption features from C-like ions are often used for density and temperature diagnostics of various plasmas in astrophysics, and in studies of the solar corona, including solar flares, and of the coronae of other stars and of ionized outflows in active galactic nuclei etc., the obtained data will be useful for improving plasma diagnostics and modelling, in particular for the X-ray Universe.

Key words: atomic data – atomic processes – Sun: corona – Sun: flares – Sun: X-rays, gamma rays – Sun: UV radiation – stars: atmospheres – ISM: jets and outflows.

1 INTRODUCTION

Atomic data are important for the modelling, investigation and diagnostics of stellar and interstellar plasmas (Singh et al. 2019). Data for C-like ions are of particular interest, not only for various cosmic plasma diagnostics but also for abundance determinations, radiative transfer calculations, and stellar atmosphere modelling. They are also of interest for the investigation and diagnostics of laboratory plasmas, fusion research, and various applications in technology. For example, in plasma diagnostics by line intensity ratio calculations, atomic parameters are needed: Ben Nessib et al. (2014) calculated atomic structure parameters for O IV; and Mason & Bhatia (1978) calculated these parameters for the C-like ions Mg VII, Si IX, and S XI. These ions are observed in the extreme UV region of the solar coronal spectrum by the Solar Ultraviolet Measurement of Emitted Radiation (SUMER) instrument onboard the *Solar and Heliospheric Observatory* (*SOHO*) satellite (see Feldman et al. 1997).

Atomic structure parameters are also necessary to calculate the radius expectations (Abdul Rahim Yaqub et al. 2018) and Stark broadening of spectral lines (Ben Nessib, Dimitrijević & Sahal-Bréchot 2004; Ben Nessib 2009; Sahal-Brechot, Dimitrijević & Ben Nessib 2014; Hamdi et al. 2018, 2019). Spectroscopic parameters of the carbon isoelectronic sequence are important not only for theoretical research, but also for experimental studies (Ivkovic, Ben Nessib & Konjević 2005).

A series of calculations of energy levels and electron impact data for C-like ions such as O III, Ne V, Mg VII, Si XI, and Fe XXI have been undertaken at Queen's University of Belfast using the CIV3 code of Hibbert (1975). They included the 12 lowest terms for the three configurations $2s^2\ 2p^2$, $2s\ 2p^3$, and $2p^4$. Aggarwal, Keenan & Msezane (2001) calculated energy levels and oscillator strengths for the C-like ions F IV, Na VI, Al VIII, P X, Cl XII, and Ar XIII, and references therein detail the study of the other C-like ions, namely O III, Ne V, Mg VII, Si IX, S XI, Ca XV, and Fe XXI. They used the CIV3 code of Hibbert (1975) and included the first six configurations, $2s^2\ 2p^2$, $2s\ 2p^3$, $2p^4$, $2s^2\ 2p\ 3\ell$ (ℓ=s, p, d).

A comparative study was done by Burgess, Mason & Tully (1991) for the configurations $2s^2\ 2p^2$ and $2s\ 2p^3$. They compared the energy levels of these two configurations and oscillator strengths between them for the C-like ion Mg VII calculated by the SUPERSTRUCTURE (Eissner, Jones & Nussbaumer 1974) and CIV3 (Hibbert 1975) atomic structure codes. They also calculated collision strengths between these two configurations and compared with different methods.

The IRON Project (Hummer et al. 1993) aimed to compute radiative and collisional data in isoelectronic sequences for astrophysical plasma diagnostics. In this framework, Mendoza, Zeippen & Storey

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(1999) calculated radiative decay rates with the atomic structure code SUPERSTRUCTURE (Eissner et al. 1974) for the 2s $2p^3$ $^5S^o_2$ – $2s^2$ $2p^2$ $^3P_1$, $^3P_2$ and $^1D_2$ intercombination transitions of the carbon isoelectronic sequence ($6 \leq Z \leq 28$).

Viltas et al. (1996) calculated the electric quadrupole (E2) and magnetic dipole (Ml) transitions between the levels of the $1s^2$ $2s^2$ $2p^2$, $1s^2$ 2s $2p^3$ and $1s^2$ $2p^4$ configurations in the carbon isoelectronic sequence. They used the stationary second-order many-body perturbation theory (MBPT).

Using the multiconfiguration Hartree–Fock (MCHF) method, Froese Fischer & Tachiev (2004) calculated energy levels, lifetimes, and transition probabilities for transitions between levels for Be-like ($4 \leq Z \leq 12$) to Ne-like ($10 \leq Z \leq 24$) sequences. They included all levels up to 2s 3d for Be-like ions and up to $2s^2$ $2p^n$ 3d, $0 \leq n \leq 5$, for B-like to Ne-like ions.

Using the multiconfiguration Dirac–Hartree–Fock (MCDHF) method, Jönsson, Rynkun & Gaigalas (2011) calculated energy levels, transition probabilities and hyperfine structure for the three configurations $2s^2$ $2p^2$, 2s $2p^3$ and $2p^4$ in C-like ions between F IV and Ni XXIII. The 20 energy levels obtained are compared with NIST (2019) data base values.

There are also recent works on atomic structure calculations for isoelectronic sequences: Lawler et al. (2019) studied the transition probabilities and abundances of scandium in the Sun and in the stars Arcturus and HD 84937. Sun et al. (2018) calculated energy levels and transition probabilities for C I and O III using the Rayleigh–Ritz variation method. Wang et al. (2014) calculated the energy levels and transition rates of C-like ions with $13 \leq Z \leq 36$. They used the six configurations $2s^2$ $2p^2$, 2s $2p^3$, $2p^4$, $2s^2$ 2p 3ℓ ($\ell = 0$, 1 and 2). Mao, Badnell & Del Zanna (2020) calculated effective collision strengths for C-like ions from N II to Kr XXXI (having ionic charge z from 3 to 32). They used the AUTOSTRUCTURE code to calculate the target atomic structure and covered the temperature range $(z+1)^2(2 \times 10^1, 2 \times 10^6)$ K.

The atomic structure parameters for multicharged C-like ions calculated here are needed in stellar atmosphere models of white dwarf stars. For example, for model atmosphere calculations of hot metal-polluted white dwarf stars, Preval et al. (2019) used energy levels and oscillator strengths for C I-V, N I-VI, O I-VII, Si I-VIII, P I-VIII, and S I-VIII, Ni III-VII and Fe III-VII multicharged ions, and they also included single-level ions for C VI, N VII, O VIII, Si IX, P IX, S IX, Fe VIII, and Ni VIII.

In a previous work, Al-Modlej, Alraddadi & Ben Nessib (2018) calculated atomic structure parameters for the first five C-like elements, and in this work we will continue the study for the next eight ions (from Na VI to Ar XIII), corresponding to all third-period C-like ions. We will describe briefly the Hartree–Fock pseudo-relativistic (HFR) and the Thomas–Fermi–Dirac–Amaldi (TFDA) methods, and we present calculations of energy levels, oscillator strengths and transition probabilities for all eight ions corresponding to the third period of the C-like ions. The trends of these atomic parameters are also studied, which allows us to obtain approximate values by interpolating or extrapolating the used analytic formula.

In order to obtain results with better precision than the previous calculations, we included eight configurations for all considered ions. This enabled us to obtain data for energy levels not listed in the NIST (2019) data base and previous calculations. Because the emission and absorption features of C-like ions are often used for density and temperature diagnostics of various plasmas in astrophysics, for studies of the solar corona, including solar flares (e.g. Neupert 1971), and other stellar coronae (e.g. Kastner et al. 2002), and for investigations into and density diagnostics of ionized outflows in active galactic nuclei (e.g. Mao et al. 2017), we hope that the results obtained here will be useful for improved plasma diagnostics and modelling, particularly of the X-ray Universe.

2 METHODS FOR CALCULATION

The theoretical methods of atomic structure calculations are well known, and here we will just give a brief summary of the HFR and TFDA methods.

2.1 Hartree–Fock pseudo-relativistic method

To obtain atomic states using the HFR method (Cowan 1981), a combination of the single electron wavefunction of the hydrogen atom (Slater-determinant) is used with relativistic corrections introduced by a Breit–Pauli Hamiltonian and treated with perturbation theory. So the radial functions in this method are a combination of Slater-type orbitals.

The Cowan (CW) code is a suite of four atomic structure programs (RCN, RCN2, RCG and RCE) using the HFR method (see Kramida 2019). Hartree–Fock equations are solved for each electron configuration, and a set of orbitals is obtained. The relativistic corrections included in this set of equations are: Blume–Watson spin-orbit, mass-variation, and one-body Darwin terms. The Blume–Watson spin-orbit term includes the part of the Breit interaction that can be reduced to a one-body operator. For *ab initio* atomic structure calculations, only the first three programs (RCN, RCN2 and RCG) are used. The fourth one (RCE) is used to fit the results by iterative procedures, so it is not used here. We used the Kramida (2018) version of the original Cowan atomic structure code.

2.2 Thomas–Fermi–Dirac–Amaldi method

To obtain the non-relativistic Hamiltonian in this method, the TFDA potential is used, and relativistic corrections are introduced by the Breit–Pauli Hamiltonian perturbation theory. Having the potential function, in this method, the radial wavefunctions are obtained numerically.

The AUTOSTRUCTURE (AS) atomic structure code (Badnell 1986, 2011) is an extension of the SUPERSTRUCTURE (SS) code (Eissner et al. 1974) incorporating various improvements and new options such as the two-body non-fine-structure operators of the Breit–Pauli Hamiltonian and polarization model potentials (Badnell 1997). We used version 26.23.9 of AS, updated in 2019 November.

3 RESULTS AND DISCUSSION

The calculated energy levels, oscillator strengths, and transition probabilities are *ab initio*, without any fitting with experimental values. They are compared with experimental data and with MCHF calculations.

3.1 Energy levels

Al-Modlej et al. (2018) calculated energy levels with the configuration expansion having eight configurations: $2s^2$ $2p^2$, 2s $2p^3$, $2s^2$ 2p 3s, $2s^2$ 2p 3p, $2s^2$ 3d, $2s^2$ 2p 4s, $2s^2$ 2p 4p, and $2s^2$ 2p 5s for the first five elements of the carbon isoelectronic sequence. In this work, we used the same eight configurations, and the calculations are for the next eight ions (Na VI to Ar XIII) of the same isoelectronic sequence C-like, corresponding to the third period in the periodic table.

In Tables 1 to 8, the energy levels of configurations $2s^2\ 2p^2$, $2s\ 2p^3$, $2s^2\ 2p\ ns$ (n=3, 5), $2s^2\ 2p\ np$ (n=3, 4) and $2s^2\ 2p\ 3d$ are calculated using the atomic structure codes CW and AS. The 59 energy levels obtained per ion are compared with those of the NIST atomic data base (NIST 2019) and with the Froese Fischer and Tachiev (FFT) values calculated using the MCHF method: for the ions Na VI, Mg VII and Al VIII we compared with the FFT paper (Froese Fischer & Tachiev 2004), and for the other ions with data at the site MCHF ADS NASA (Froese Fischer & Tachiev 2019) calculated by FFT.

Li et al. (2020) studied the atomic structure of the neutral rhenium atom (Re I) using the HFR method with the Cowan code. Their obtained measured and calculated LS energy levels have an accuracy of the order of 20 per cent or even less. Aggarwal, Keenan & Lawson (2016) calculated the energy levels, lifetimes and transition probability values for all E1, E2, M1 and M2 transitions of N IV. They said that their results are probably accurate to better than 20 per cent for a majority of the strong E1 transitions.

Concerning the configuration $2s^2\ 2p^2$, the CW code gives better results than the AS code: it gives values within 4 per cent on average of NIST values, while AS gives values 7 per cent higher than NIST.

For the configuration $2s\ 2p^3$, CW calculations are 2.7 per cent different from the NIST ones, and AS calculations are within 3.3 per cent of the NIST values, except for Ar XIII, for which the difference between the CW results and the NIST data is within 4.8 per cent, while for AS and NIST data it is 2.5 per cent.

For configurations $2s^2\ 2p\ ns$, most values in the NIST data base for comparison are for n=3: there are data for the term $2s^2\ 2p\ 3s\ ^3P^o_0$ only for ions Mg VII, Al VIII, and P X. Concerning configurations for n=4, there are data only for one term of the ions Na VI and Al VIII ($^3P^o_2$). No data exist in the NIST database for n=5. When comparing with NIST values, CW and AS calculations are respectively 0.6 per cent and 0.4 per cent different. So we can say that the CW and AS codes give good values, and we can use the large amounts of values that are not in the NIST data base.

For configurations $2s^2\ 2p\ mp$, only a few data are in the NIST data base: they correspond to n=3 and terms $^3P_{1,2}$ and $^1D_2$ for Na VI, $^3P_{1,2,3}$ for Mg VII, and $^3S_1$ for Al VIII. So there are no data for the ions Si IX, P X, S XI, Cl XII, and Ar XIII. When comparing our calculated values with NIST ones, we obtained CW and AS values respectively 1.1 per cent and 0.8 per cent different from NIST data. We obtained new energy levels for the five ions Si IX and heavier, and for all ions considered here for levels corresponding to n=4; these last energy levels are not calculated by FFT.

For the configuration $2s^2\ 2p\ 3d$, most data are in the NIST data base. We obtained a difference from NIST values of 0.4 per cent with both atomic structure codes, CW and AS, except for Ar XIII, where with CW it is 1.7 per cent.

For the term $^3D^o_1$ of the configuration $2s^2\ 2p\ 3d$, there are energy levels for all elements except P X and Cl XII. Following the Z-expansion theory (see for example Weiss & Kim 1995), and to obtain values for these two ions, we used the empirical quadratic fit formula:

$$E = E_0 + E_1 Z + E_2 Z^2, \tag{1}$$

where E_0, E_1 and E_2 are fitting parameters. For this level ($2s^2\ 2p\ 3d\ ^3D^o_1$) we found $E_0 = 78\ 337.24\ cm^{-1}$, $E_1 = -91\ 928.58\ cm^{-1}$ and $E_2 = 15\ 392.93\ cm^{-1}$, and we put the fitted energy level values in square brackets in Tables 5 and 7.

We also used this fitting energy level formula to obtain the value for the level $2s^2\ 2p\ 3d\ ^3D^o_1$ of the ion Ar XIII. For this level ($2s^2\ 2p\ 3d\ ^3D^o_2$), we found the coefficients $E_0 = 102\ 201.43\ cm^{-1}$, $E_1 = -95\ 754.29\ cm^{-1}$ and $E_2 = 15\ 547.86\ cm^{-1}$. The obtained fitted energy level E($2s^2\ 2p\ 3d\ ^3D^o_2$)=3416 131 cm^{-1} is given in square brackets in Table 8.

Although energy levels of $2s^2\ 2p\ 3d\ ^3D^o_3$ exist for all the ions considered here, we tried to use the fitting formula to extrapolate data for the next ion K XIV, without any code calculation, just by the fitting formula: we obtained $E_0 = 149\ 188.21\ cm^{-1}$, $E_1 = -103\ 500.12\ cm^{-1}$ and $E_2 = 15\ 871.55\ cm^{-1}$ and an extrapolated energy level of 3912 315 cm^{-1}, which is 0.016 per cent the NIST value (3911 700 cm^{-1}).

Akerib (1963) suggested an empirical relationship for the energy levels of atoms and ions in an isoelectronic sequence of the form

$$\frac{E}{Z^s} = a + bZ, \tag{2}$$

where s, a and b are fitting parameters. We used this formula to calculate the energy levels of the $2s^2\ 2p^2\ ^3P$ terms for the eight ions used in this work to deduce the energy levels of the next ion, K XIV: we obtained $E = 13\ 192\ cm^{-1}$ and $E = 28\ 229\ cm^{-1}$, corresponding respectively to the $^3P_1$ and $^3P_2$ terms, which are respectively 0.32 lower and 0.01 higher than the NIST data base values.

Considering the energy levels obtained from CW and AS for the ions studied here, we recommend the use of CW code data: they are closer to the NIST data than the AS values.

3.2 Oscillator strengths

We used the weighted oscillator strengths gf,

$$gf = g_i f_{ij} = g_j f_{ji}, \tag{3}$$

instead of the absorption oscillator strengths f_{ij} or the emission oscillator strengths f_{ji}.

We computed the weighted oscillator strength for eight allowed transitions, namely $2s^2\ 2p^2\ ^3P - 2s\ 2p^3\ ^3S^o$, $2s^2\ 2p^2\ ^3P - 2s\ 2p^3\ ^3P^o$, $2s^2\ 2p^2\ ^3P - 2s^2\ 2p\ 3s\ ^3P^o$, $2s^2\ 2p^2\ ^1D - 2s\ 2p^3\ ^1D^o$, $2s^2\ 2p^2\ ^1D - 2s\ 2p^3\ ^1P^o$, $2s^2\ 2p^2\ ^1S - 2s\ 2p^3\ ^1P^o$, $2s^2\ 2p^2\ ^3P - 2s^2\ 2p\ 3d\ ^3P^o$, $2s^2\ 2p^2\ ^3P - 2s^2\ 2p\ 3d\ ^3D^o$, using the atomic structure codes CW and AS.

Tables 9 to 16 give the weighted oscillator strength values of these transitions for the ions considered here, obtained *ab initio* by the two atomic structure codes and compared with the values tabulated in the NIST (2019) data base and those of FFT (Froese Fischer & Tachiev 2004 for the first three ions, and Froese Fischer & Tachiev 2019 for the five others). The wavelengths in these tables are in Ångström (Å) from the NIST data base.

For the transition $2s^2\ 2p^2\ ^3P - 2s\ 2p^3\ ^3S^o$, CW and AS give energy level results about 30 per cent different from NIST data base values. Better results are obtained for the two other transitions: for $2s^2\ 2p^2\ ^3P - 2s\ 2p^3\ ^3P^o$, CW and AS give results respectively 16 per cent and 18 per cent different from the NIST values. Even better is the case of transition $2s^2\ 2p^2\ ^3P - 2s^2\ 2p\ 3s\ ^3P^o$, for which CW and AS give energy level results only 5 per cent and 3 per cent different from NIST data base values.

The trends of oscillator strengths have been studied with atomic number Z from 11 to 18, corresponding to the ions considered in this work.

We used an empirical formula of the weighted oscillator strengths gf to obtain interpolated values (see our precedent paper, Al-Modlej et al. 2018):

$$gf = a + b\frac{1}{Z - Z_o}, \tag{4}$$

where a, b and Z_o are three fitting parameters.

Table 1. Energy levels for Na VI. *E*(NIST) are from the NIST (2019) data base, *E*(CW) and *E*(AS) are the energy levels calculated using respectively the Cowan (CW) and AUTOSTRUCTURE (AS) codes. *E*(FFT) are energy values from Froese Fischer & Tachiev (2004). All energies are in cm^{-1}.

Key	Configuration	Term	J	*E*(NIST)	*E*(CW)	*E*(AS)	*E*(FFT)
1	$2s^2\ 2p^2$	^3P	0	0	0	0	0
2	$2s^2\ 2p^2$	^3P	1	695	694	742	700
3	$2s^2\ 2p^2$	^3P	2	1856	1973	1998	1858
4	$2s^2\ 2p^2$	^1D	2	35498	34441	38442	35605
5	$2s^2\ 2p^2$	^1S	0	74414	83587	93231	74400
6	$2s\ 2p^3$	$^5S^o$	2	103010	96988	83649	105169
7	$2s\ 2p^3$	$^3D^o$	3	204132	199562	199578	206534
8	$2s\ 2p^3$	$^3D^o$	1	204261	199531	199725	206664
9	$2s\ 2p^3$	$^3D^o$	2	204223	199525	199677	206626
10	$2s\ 2p^3$	$^3P^o$	1	241341	232657	237027	243794
11	$2s\ 2p^3$	$^3P^o$	2	241341	232681	237010	243793
12	$2s\ 2p^3$	$^3P^o$	0	241341	232643	237080	243841
13	$2s\ 2p^3$	$^1D^o$	2	312315	308504	322165	314889
14	$2s\ 2p^3$	$^3S^o$	1	320589	315326	329260	323060
15	$2s\ 2p^3$	$^1P^o$	1	350319	341688	359588	352977
16	$2s^2\ 2p\ 3s$	$^3P^o$	0	–	812949	809751	808638
17	$2s^2\ 2p\ 3s$	$^3P^o$	1	807320	813555	810353	809235
18	$2s^2\ 2p\ 3s$	$^3P^o$	2	808800	815100	811840	810728
19	$2s^2\ 2p\ 3s$	$^1P^o$	1	817740	823009	821404	819820
20	$2s^2\ 2p\ 4s$	$^3P^o$	0	–	1093318	1087559	–
21	$2s^2\ 2p\ 4s$	$^3P^o$	1	–	1093757	1088009	–
22	$2s^2\ 2p\ 4s$	$^3P^o$	2	1090760	1095497	1089664	–
23	$2s^2\ 2p\ 4s$	$^1P^o$	1	–	1097710	1092225	–
24	$2s^2\ 2p\ 5s$	$^3P^o$	0	–	1209918	1203629	–
25	$2s^2\ 2p\ 5s$	$^3P^o$	1	–	1210205	1203932	–
26	$2s^2\ 2p\ 5s$	$^3P^o$	2	–	1212103	1205738	–
27	$2s^2\ 2p\ 5s$	$^1P^o$	1	–	1213050	1206810	–
28	$2s^2\ 2p\ 3p$	^3P	0	–	883693	880120	874561
29	$2s^2\ 2p\ 3p$	^3P	1	872580	884229	880642	875127
30	$2s^2\ 2p\ 3p$	^3P	2	873290	885013	881375	875836
31	$2s^2\ 2p\ 3p$	^1D	2	877550	895211	892776	890587
32	$2s^2\ 2p\ 3p$	^1P	1	–	861535	858267	856914
33	$2s^2\ 2p\ 3p$	^3D	1	–	864953	862115	862202
34	$2s^2\ 2p\ 3p$	^3D	2	–	865604	862773	862902
35	$2s^2\ 2p\ 3p$	^3D	3	–	866922	864062	864197
36	$2s^2\ 2p\ 3p$	^3S	1	–	872468	870295	870269
37	$2s^2\ 2p\ 3p$	^1S	0	–	910835	910112	908019
38	$2s^2\ 2p\ 4p$	^3P	0	–	1119859	1113682	–
39	$2s^2\ 2p\ 4p$	^3P	1	–	1120585	1114426	–
40	$2s^2\ 2p\ 4p$	^3P	2	–	1121125	1114905	–
41	$2s^2\ 2p\ 4p$	^1D	2	–	1125089	1119165	–
42	$2s^2\ 2p\ 4p$	^1P	1	–	1113082	1107437	–
43	$2s^2\ 2p\ 4p$	^3D	1	–	1114445	1108804	–
44	$2s^2\ 2p\ 4p$	^3D	2	–	1114653	1109055	–
45	$2s^2\ 2p\ 4p$	^3D	3	–	1115950	1110305	–
46	$2s^2\ 2p\ 4p$	^3S	1	–	1117330	1111847	–
47	$2s^2\ 2p\ 4p$	^1S	0	–	1132069	1126702	–
48	$2s^2\ 2p\ 3d$	$^3F^o$	2	919480	924880	921365	921765
49	$2s^2\ 2p\ 3d$	$^3F^o$	3	–	925952	922348	922999
50	$2s^2\ 2p\ 3d$	$^3F^o$	4	–	927025	923373	924028
51	$2s^2\ 2p\ 3d$	$^1D^o$	2	920850	926544	923196	923130
52	$2s^2\ 2p\ 3d$	$^3D^o$	1	929774	934660	932610	931975
53	$2s^2\ 2p\ 3d$	$^3D^o$	2	930000	934918	932847	932244
54	$2s^2\ 2p\ 3d$	$^3D^o$	3	930510	935493	933402	932776
55	$2s^2\ 2p\ 3d$	$^3P^o$	2	933920	938338	936208	936161
56	$2s^2\ 2p\ 3d$	$^3P^o$	1	934460	938854	936734	936693
57	$2s^2\ 2p\ 3d$	$^3P^o$	0	934740	939112	937009	936982
58	$2s^2\ 2p\ 3d$	$^1F^o$	3	945450	951221	951027	947774
59	$2s^2\ 2p\ 3d$	$^1P^o$	1	946530	951466	951092	948864

Table 2. As Table 1, for Mg VII.

Key	Configuration	Term	J	*E*(NIST)	*E*(CW)	*E*(AS)	*E*(FFT)
1	$2s^2\ 2p^2$	^3P	0	0	0	0	0
2	$2s^2\ 2p^2$	^3P	1	1107	1111	1175	1123
3	$2s^2\ 2p^2$	^3P	2	2924	3098	3127	2937
4	$2s^2\ 2p^2$	^1D	2	40948	39502	44017	41066
5	$2s^2\ 2p^2$	^1S	0	85153	95034	105875	85132
6	$2s\ 2p^3$	$^5S^o$	2	118100	112780	97943	120686
7	$2s\ 2p^3$	$^3D^o$	3	232853	227700	227643	235677
8	$2s\ 2p^3$	$^3D^o$	1	233024	227633	227824	235843
9	$2s\ 2p^3$	$^3D^o$	2	232957	227619	227753	235784
10	$2s\ 2p^3$	$^3P^o$	1	274897	265065	269897	277786

Table 3. As Table 1, for Al VIII.

Key	Configuration	Term	J	*E*(NIST)	*E*(CW)	*E*(AS)	*E*(FFT)
1	$2s^2\ 2p^2$	^3P	0	0	0	0	0
2	$2s^2\ 2p^2$	^3P	1	1710	1705	1789	1731
3	$2s^2\ 2p^2$	^3P	2	4420	4648	4680	4434
4	$2s^2\ 2p^2$	^1D	2	46720	44894	49931	46853
5	$2s^2\ 2p^2$	^1S	0	96260	106808	118846	96224
6	$2s\ 2p^3$	$^5S^o$	2	133840	129252	112864	136862
7	$2s\ 2p^3$	$^3D^o$	3	262180	256499	256338	265441
8	$2s\ 2p^3$	$^3D^o$	1	262330	256365	256539	265629
9	$2s\ 2p^3$	$^3D^o$	2	262270	256337	256433	265540
10	$2s\ 2p^3$	$^3P^o$	1	309110	298132	303394	312398

Table 4. As Table 1, for Si IX.

Key	Configuration	Term	J	*E*(NIST)	*E*(CW)	*E*(AS)	*E*(FFT)
1	$2s^2\ 2p^2$	^3P	0	0	0	0	0
2	$2s^2\ 2p^2$	^3P	1	2545	2533	2637	2582
3	$2s^2\ 2p^2$	^3P	2	6414	6721	6753	6452
4	$2s^2\ 2p^2$	^1D	2	52926	50726	56291	53076
5	$2s^2\ 2p^2$	^1S	0	107799	119027	132263	107826
6	$2s\ 2p^3$	$^5S^o$	2	150770	146529	128561	154077
7	$2s\ 2p^3$	$^3D^o$	3	292232	286103	285832	296224
8	$2s\ 2p^3$	$^3D^o$	1	292441	285850	286020	296405
9	$2s\ 2p^3$	$^3D^o$	2	292296	285798	285866	296274
10	$2s\ 2p^3$	$^3P^o$	1	344009	332017	337703	348047

Table 5. As Table 1, for P X.

Key	Configuration	Term	J	*E*(NIST)	*E*(CW)	*E*(AS)	*E*(FFT)
1	$2s^2\ 2p^2$	^3P	0	0	0	0	0
2	$2s^2\ 2p^2$	^3P	1	3692	3661	3784	3748
3	$2s^2\ 2p^2$	^3P	2	9045	9423	9454	9104
4	$2s^2\ 2p^2$	^1D	2	59690	57129	63226	59865
5	$2s^2\ 2p^2$	^1S	0	119960	131833	146264	120055
6	$2s\ 2p^3$	$^5S^o$	2	167740	164781	145194	172315
7	$2s\ 2p^3$	$^3D^o$	3	323234	316704	316307	328026
8	$2s\ 2p^3$	$^3D^o$	1	323416	316252	316423	328141
9	$2s\ 2p^3$	$^3D^o$	2	323201	316161	316202	327954
10	$2s\ 2p^3$	$^3P^o$	1	379910	366926	373024	384745

The numerical values of these three fitting parameters for the transition $2s^2\ 2p^2\ ^3P - 2s\ 2p^3\ ^3S^o$ are calculated, and the formula was applied to obtain *gf* values for Cl XII and Ar XIII; they appear in the *gf*(NIST) column in square brackets in Tables 15 and 16.

In some works there are oscillator strengths for only a few ions of an isoelectronic sequence. The use of formula (4) is important, enabling us to have *gf* data for other elements of the same isoelectronic sequence.

Table 6. As Table 1, for S XI.

Key	Configuration	Term	J	*E*(NIST)	*E*(CW)	*E*(AS)	*E*(FFT)
1	$2s^2\ 2p^2$	^3P	0	0	0	0	0
2	$2s^2\ 2p^2$	^3P	1	5208	5173	5313	5329
3	$2s^2\ 2p^2$	^3P	2	12388	12873	12898	12535
4	$2s^2\ 2p^2$	^1D	2	67146	64265	70892	67658
5	$2s^2\ 2p^2$	^1S	0	132929	145399	161015	133176
6	$2s\ 2p^3$	$^5S^o$	2	186251	184194	162950	187542
7	$2s\ 2p^3$	$^3D^o$	3	355350	348510	347973	357290
8	$2s\ 2p^3$	$^3D^o$	1	355364	347737	347921	357230
9	$2s\ 2p^3$	$^3D^o$	2	355076	347588	347608	356969
10	$2s\ 2p^3$	$^3P^o$	1	416986	403086	409585	418750

Table 7. As Table 1, for Cl XII.

Key	Configuration	Term	J	*E*(NIST)	*E*(CW)	*E*(AS)	*E*(FFT)
1	$2s^2\ 2p^2$	^3P	0	0	0	0	0
2	$2s^2\ 2p^2$	^3P	1	7240	7170	7321	7421
3	$2s^2\ 2p^2$	^3P	2	16629	17195	17211	16852
4	$2s^2\ 2p^2$	^1D	2	75530	72333	79479	76176
5	$2s^2\ 2p^2$	^1S	0	146917	159929	176715	147225
6	$2s\ 2p^3$	$^5S^o$	2	206100	204930	182038	208131
7	$2s\ 2p^3$	$^3D^o$	3	388838	381711	381069	391635
8	$2s\ 2p^3$	$^3D^o$	1	388581	380439	380701	391259
9	$2s\ 2p^3$	$^3D^o$	2	388179	380206	380266	390899
10	$2s\ 2p^3$	$^3P^o$	1	455554	440708	447650	458062

Table 8. As Table 1, for Ar XIII.

Key	Configuration	Term	J	*E*(NIST)	*E*(CW)	*E*(AS)	*E*(FFT)
1	$2s^2\ 2p^2$	^3P	0	0	0	0	0
2	$2s^2\ 2p^2$	^3P	1	9853	9299	9923	10163
3	$2s^2\ 2p^2$	^3P	2	21841	21543	22526	22219
4	$2s^2\ 2p^2$	^1D	2	85011	79421	89218	85880
5	$2s^2\ 2p^2$	^1S	0	162136	172063	193601	162579
6	$2s\ 2p^3$	$^5S^o$	2	225918	262207	202690	230568
7	$2s\ 2p^3$	$^3D^o$	3	422699	447349	414367	426533
8	$2s\ 2p^3$	$^3D^o$	1	423248	447685	414958	427018
9	$2s\ 2p^3$	$^3D^o$	2	423969	449579	415858	427932
10	$2s\ 2p^3$	$^3P^o$	1	495799	511329	487510	499414

3.3 Transition probabilities

The transition probability is an important atomic structure parameter, related to the oscillator strengths by

$$g_i f_{ik} = \frac{mc}{8\pi e^2}\lambda^2 g_k A_{ki}, \tag{5}$$

where m and e are the mass and absolute value of the electron charge, c is the speed of light in a vacuum, and λ is the wavelength of the atomic transition.

For the transitions $2s^2\ 2p^2\ ^3P - 2s\ 2p^3\ ^3S^o$ and $2s^2\ 2p^2\ ^3P - 2s\ 2p^3\ ^3P^o$, with the CW code, the transition probability results are respectively 27 per cent and 24 per cent different from NIST values, while AS gives 38 per cent and 23 per cent difference from NIST data. For the third transition, $2s^2\ 2p^2\ ^3P - 2s^2\ 2p\ 3s\ ^3P^o$, CW gives 7 per cent difference, and AS gives even better results (only 3 per cent difference from NIST data base values).

For the eight transitions studied here, we see that we obtain slightly better results with CW than with AS codes. For Ne VI, we obtain a value for the line $2s^2\ 2p^2\ ^3P_1 - 2s^2\ 2p\ 3s\ ^3P^o_0$, which is not in the NIST data base but was calculated by FFT: our AS values are closer to the FFT values than our CW ones.

As atomic data-users need more and more energy levels, oscillator strengths and transition probabilities mainly corresponding to highly excited levels and between them, the present data will be extremely useful. For example, in astrophysics the need for these data is mainly for calculating stellar atmosphere models and to simulate the spectra of typical celestial objects such as white dwarfs, active galactic nuclei, etc.

4 SUMMARY AND CONCLUSIONS

In this work, we calculated the energy levels of 59 lines arising from eight configurations and 45 oscillator strengths, and 45 transition probabilities arising from eight transitions for each of the eight ions considered in this work.

For energy level calculations, generally CW and AS give less than 5 per cent difference from NIST data base values. CW gives better values for $2s^2\ 2p^2$ and $2s\ 2p^3$ configurations, while AS gives better values for $2s^2\ 2p$ ns, $2s^2\ 2p$ mp and $2s^2\ 2p$ 3d configurations. For

Table 9. Weighted oscillator strengths and transition probabilities for Na VI. *gf*(NIST) and *gA*(NIST) are the weighted oscillator strengths and the weighted transition probabilities from NIST (2019). *gA*(CW) and *gA*(AS) are calculated using respectively the Cowan and AUTOSTRUCTURE atomic structure codes. *gf*(FFT) and *gA*(FFT) are from Froese Fischer & Tachiev (2004).

Transition	λ (Å)	*gf*(NIST)	*gf*(CW)	*gf*(AS)	*gf*(FFT)	*gA*(NIST)	*gA*(CW)	*gA*(AS)	*gA*(FFT)
3 − 14	313.74	6.19E − 01	8.60E − 01	8.57E − 01	6.26E − 01	4.20E + 10	5.63E + 10	6.12E + 10	4.31E + 10
2 − 14	312.60	3.69E − 01	5.10E − 01	5.08E − 01	3.70E − 01	2.51E + 10	3.37E + 10	3.66E + 10	2.57E + 10
1 − 14	311.93	1.22E − 01	1.69E − 01	1.69E − 01	1.23E − 01	8.37E + 09	1.12E + 10	1.22E + 09	8.55E + 09
3 − 11	417.56	3.78E − 01	3.55E − 01	3.46E − 01	3.83E − 01	1.45E + 10	1.26E + 10	1.27E + 10	1.50E + 10
3 − 10	417.56	1.19E − 01	1.11E − 01	1.08E − 01	1.21E − 01	4.56E + 09	3.93E + 09	3.98E + 09	4.73E + 09
2 − 11	415.55	1.14E − 01	1.02E − 01	1.00E − 01	1.15E − 01	4.40E + 09	3.67E + 09	3.73E + 09	4.53E + 09
2 − 10	415.55	7.98E − 02	7.62E − 02	7.40E − 02	8.12E − 02	3.09E + 09	2.74E + 09	2.76E + 09	3.20E + 09
2 − 12	415.55	9.86E − 02	9.19E − 02	8.96E − 02	1.00E − 01	1.14E + 10	3.30E + 09	3.34E + 09	3.95E + 09
1 − 10	414.35	9.64E − 02	8.83E − 02	8.62E − 02	9.74E − 02	3.75E + 09	3.19E + 09	3.23E + 09	3.86E + 09
3 − 18	123.92	2.74E − 01	2.98E − 01	2.68E − 01	2.78E − 01	1.19E + 11	1.31E + 11	1.17E + 11	1.21E + 11
3 − 17	124.15	9.10E − 02	9.89E − 02	8.98E − 02	9.23E − 02	3.96E + 10	4.34E + 10	3.92E + 10	4.01E + 10
2 − 18	123.75	9.12E − 02	1.00E − 01	8.90E − 02	9.27E − 02	3.97E + 10	4.43E + 10	3.91E + 10	4.06E + 10
2 − 17	123.97	5.40E − 02	5.87E − 02	5.30E − 02	5.49E − 02	2.35E + 10	2.59E + 10	2.32E + 10	2.39E + 10
2 − 16	–	–	7.92E − 02	7.15E − 02	7.37E − 02	–	3.48E + 10	3.12E + 10	3.21E + 10
1 − 17	123.87	7.24E − 02	7.90E − 02	7.08E − 02	7.34E − 02	3.15E + 10	3.49E + 10	3.10E + 10	3.21E + 10
4 − 13	361.25	1.12E + 00	1.61E + 00	1.59E + 00	1.14E + 00	5.75E + 10	8.09E + 10	8.53E + 10	5.91E + 10
4 − 15	317.64	7.14E − 01	6.53E − 01	6.57E − 01	7.14E − 01	4.71E + 10	4.11E + 10	4.52E + 10	4.80E + 10
5 − 15	362.44	2.18E − 01	3.88E − 01	3.77E − 01	2.22E − 01	1.11E + 10	1.72E + 10	1.78E + 10	1.15E + 10
1 − 52	107.55	8.57E − 01	9.18E − 01	8.81E − 01	8.44E − 01	4.95E + 11	5.35E + 11	5.11E + 11	4.89E + 11
2 − 52	107.63	4.65E − 01	4.82E − 01	4.65E − 01	4.62E − 01	2.67E + 11	2.80E + 11	2.70E + 11	2.67E + 11
2 − 53	107.61	1.91E + 00	2.04E + 00	1.97E + 00	1.88E + 00	1.11E + 12	1.19E + 12	1.14E + 12	1.09E + 12
3 − 52	107.77	1.29E − 02	1.19E − 02	1.18E − 02	1.34E − 02	7.41E + 09	6.93E + 09	6.80E + 09	7.75E + 09
3 − 53	107.74	2.77E − 01	2.66E − 01	2.58E − 01	2.86E − 01	1.59E + 11	1.54E + 11	1.49E + 11	1.65E + 11
3 − 54	107.68	3.13E + 00	3.32E + 00	3.20E + 00	3.09E + 00	1.80E + 12	1.93E + 12	1.85E + 12	1.79E + 12
1 − 56	107.01	1.43E − 01	1.28E − 01	1.25E − 01	1.42E − 01	8.34E + 10	7.53E + 10	7.30E + 10	8.30E + 10
2 − 57	107.06	2.54E − 01	2.54E − 01	2.43E − 01	2.48E − 01	1.48E + 11	1.49E + 11	1.42E + 11	1.45E + 11
2 − 56	107.09	2.88E − 01	3.04E − 01	2.90E − 01	2.80E − 01	1.67E + 11	1.79E + 11	1.69E + 11	1.63E + 11
2 − 55	107.16	7.45E − 02	4.91E − 02	4.91E − 02	7.81E − 02	4.32E + 10	2.88E + 10	2.87E + 10	4.56E + 10
3 − 56	107.23	3.41E − 01	3.44E − 01	3.31E − 01	3.34E − 01	1.98E + 11	2.01E + 11	1.93E + 11	1.94E + 11
3 − 55	107.29	1.23E + 00	1.27E + 00	1.23E + 00	1.19E + 00	7.15E + 11	7.45E + 11	7.13E + 11	6.95E + 11
12 − 36	–	–	5.90E − 03	2.94E − 03	2.94E − 03	–	4.51E + 08	7.85E + 08	7.70E + 08
10 − 36	–	–	1.33E − 02	9.05E − 03	9.78E − 03	–	1.01E + 09	2.42E + 09	2.56E + 09
11 − 36	–	–	2.41E − 02	1.52E − 02	1.84E − 02	–	1.86E + 09	4.05E + 09	4.82E + 09
10 − 30	–	–	1.24E − 02	3.87E − 05	1.60E − 03	–	8.75E + 08	1.07E + 07	4.26E + 08
12 − 29	–	–	1.07E − 02	5.65E − 05	1.73E − 03	–	7.55E + 08	1.56E + 07	4.59E + 08
10 − 29	–	–	6.90E − 03	9.01E − 05	1.76E − 03	–	4.89E + 08	2.49E + 07	4.67E + 08
10 − 28	–	–	1.07E − 02	1.34E − 06	9.02E − 04	–	7.60E + 08	3.70E + 05	2.40E + 08
11 − 30	–	–	4.83E − 02	5.95E − 05	3.96E − 03	–	3.44E + 09	1.65E + 07	1.06E + 09
11 − 29	–	–	1.80E − 02	6.58E − 05	1.77E − 04	–	1.29E + 09	1.82E + 07	4.69E + 07
10 − 34	–	–	6.64E − 02	5.55E − 03	7.27E − 03	–	5.26E + 09	1.45E + 09	1.86E + 09
12 − 33	–	–	3.34E − 02	2.42E − 03	3.20E − 03	–	2.65E + 09	6.31E + 08	8.17E + 08
11 − 35	–	–	1.41E − 01	1.04E − 02	1.40E − 02	–	1.12E + 10	2.73E + 09	3.59E + 09
10 − 33	–	–	1.30E − 02	1.54E − 03	2.24E − 03	–	1.03E + 09	4.02E + 08	5.72E + 08
11 − 34	–	–	2.34E − 02	1.72E − 03	2.50E − 03	–	1.87E + 09	4.49E + 08	6.40E + 08
11 − 33	–	–	1.70E − 03	1.62E − 04	2.22E − 04	–	1.33E + 08	4.21E + 07	5.66E + 07

Table 10. As Table 9, for Mg VII.

Transition	λ (Å)	*gf*(NIST)	*gf*(CW)	*gf*(AS)	*gf*(FFT)	*gA*(NIST)	*gA*(CW)	*gA*(AS)	*gA*(FFT)
3 − 14	278.40	5.25E − 01	7.70E − 01	7.70E − 01	5.67E − 01	4.50E + 10	6.37E + 10	6.93E + 10	4.96E + 10
2 − 14	277.00	3.31E − 01	4.54E − 01	4.54E − 01	3.33E − 01	2.85E + 10	3.80E + 10	4.13E + 10	2.94E + 10
1 − 14	276.15	1.20E − 01	1.50E − 01	1.51E − 01	1.10E − 01	1.05E + 10	1.27E + 10	1.38E + 10	9.80E + 09
3 − 11	367.67	4.17E − 01	3.25E − 01	3.17E − 01	3.55E − 01	2.05E + 10	1.49E + 10	1.50E + 10	1.79E + 10
3 − 10	367.68	1.41E − 01	9.85E − 02	9.64E − 02	1.10E − 01	6.90E + 09	4.51E + 09	4.58E + 09	5.52E + 09
2 − 11	365.23	1.41E − 01	8.82E − 02	8.67E − 02	1.02E − 01	7.00E + 09	4.10E + 09	4.18E + 09	5.19E + 09
2 − 10	365.24	8.32E − 02	7.17E − 02	6.97E − 02	7.67E − 02	4.20E + 09	3.33E + 09	3.36E + 09	3.92E + 09
2 − 12	365.18	1.07E − 01	8.32E − 02	8.13E − 02	9.18E − 02	5.40E + 09	3.86E + 09	3.92E + 09	4.69E + 09
1 − 10	363.77	1.07E − 01	7.87E − 02	7.71E − 02	8.84E − 02	5.40E + 09	3.69E + 09	3.74E + 09	4.55E + 09
3 − 18	95.42	2.65E − 01	2.83E − 01	2.57E − 01	2.68E − 01	1.95E + 11	2.10E + 11	1.90E + 11	1.97E + 11

Table 11. As Table 9, for Al VIII.

Transition	λ (Å)	*gf*(NIST)	*gf*(CW)	*gf*(AS)	*gf*(FFT)	*gA*(NIST)	*gA*(CW)	*gA*(AS)	*gA*(FFT)
3 − 14	250.14	5.20E − 01	6.97E − 01	6.99E − 01	5.20E − 01	5.55E + 10	7.11E + 10	7.75E + 10	5.63E + 10
2 − 14	248.45	3.09E − 01	4.08E − 01	4.10E − 01	3.03E − 01	3.33E + 10	4.22E + 10	4.61E + 10	3.32E + 10
1 − 14	247.42	1.05E − 01	1.35E − 01	1.36E − 01	9.99E − 02	1.14E + 10	1.41E + 10	1.54E + 10	1.11E + 10
3 − 11	328.20	3.30E − 01	3.02E − 01	2.94E − 01	3.31E − 01	2.04E + 10	1.73E + 10	1.75E + 10	2.09E + 10
3 − 10	328.20	9.91E − 02	8.81E − 02	8.66E − 02	9.94E − 02	6.15E + 09	5.06E + 09	5.15E + 09	6.29E + 09
2 − 11	325.31	8.99E − 02	7.58E − 02	7.51E − 02	8.98E − 02	5.70E + 09	4.45E + 09	4.56E + 09	5.79E + 09
2 − 10	325.31	7.33E − 02	6.88E − 02	6.68E − 02	7.36E − 02	4.62E + 09	4.03E + 09	4.06E + 09	4.74E + 09
2 − 12	325.31	8.45E − 02	7.60E − 02	7.45E − 02	8.48E − 02	5.33E + 09	4.45E + 09	4.52E + 09	5.46E + 09
1 − 10	323.51	8.05E − 02	7.05E − 02	6.94E − 02	8.05E − 02	5.13E + 09	4.18E + 09	4.26E + 09	5.24E + 09
3 − 18	75.78	2.56E − 01	2.70E − 01	2.48E − 01	2.59E − 01	2.98E + 11	3.17E + 11	2.90E + 11	3.02E + 11

Table 12. As Table 9, for Si IX.

Transition	λ (Å)	*gf*(NIST)	*gf*(CW)	*gf*(AS)	*gf*(FFT)	*gA*(NIST)	*gA*(CW)	*gA*(AS)	*gA*(FFT)
3 − 14	227.00	4.80E − 01	6.38E − 01	6.41E − 01	4.81E − 01	6.21E + 10	7.87E + 10	8.58E + 10	6.34E + 10
2 − 14	225.02	2.76E − 01	3.70E − 01	3.72E − 01	2.77E − 01	3.63E + 10	4.65E + 10	5.08E + 10	3.72E + 10
1 − 14	223.74	9.10E − 02	1.22E − 01	1.23E − 01	9.12E − 02	1.21E + 10	1.56E + 10	1.70E + 10	1.24E + 10
3 − 11	296.12	3.10E − 01	2.83E − 01	2.76E − 01	3.12E − 01	2.36E + 10	2.00E + 10	2.02E + 10	2.43E + 10
3 − 10	296.21	8.99E − 02	7.90E − 02	7.80E − 02	9.04E − 02	6.84E + 09	5.58E + 09	5.69E + 09	7.04E + 09
2 − 11	292.76	7.93E − 02	6.47E − 02	6.46E − 02	7.91E − 02	6.15E + 09	4.69E + 09	4.84E + 09	6.30E + 09
2 − 10	292.86	7.11E − 02	6.71E − 02	6.51E − 02	7.16E − 02	5.52E + 09	4.86E + 09	4.88E + 09	5.70E + 09
2 − 12	292.80	7.80E − 02	7.01E − 02	6.89E − 02	7.90E − 02	6.07E + 09	5.07E + 09	5.16E + 09	6.29E + 09
1 − 10	290.69	7.36E − 02	6.35E − 02	6.27E − 02	7.37E − 02	5.82E + 09	4.67E + 09	4.77E + 09	5.95E + 09
3 − 18	61.65	2.49E − 01	2.59E − 01	2.40E − 01	2.52E − 01	4.38E + 11	4.59E + 11	4.24E + 11	4.43E + 11

Table 13. As Table 9, for P X.

Transition	λ (Å)	*gf*(NIST)	*gf*(CW)	*gf*(AS)	*gf*(FFT)	*gA*(NIST)	*gA*(CW)	*gA*(AS)	*gA*(FFT)
3 − 14	207.66	4.66E − 01	5.89E − 01	5.93E − 01	4.49E − 01	7.20E + 10	8.66E + 10	9.44E + 10	7.09E + 10
2 − 14	205.38	2.84E − 01	3.37E − 01	3.41E − 01	2.55E − 01	4.50E + 10	5.08E + 10	5.56E + 10	4.11E + 10
1 − 14	203.84	9.33E − 02	1.12E − 01	1.13E − 01	8.38E − 02	1.50E + 10	1.71E + 10	1.86E + 10	1.37E + 10
3 − 11	269.47	3.16E − 01	2.68E − 01	2.62E − 01	2.96E − 01	2.90E + 10	2.29E + 10	2.31E + 10	2.79E + 10
3 − 10	269.64	–	7.09E − 02	7.03E − 02	8.23E − 02	–	6.05E + 09	6.20E + 09	7.74E + 09
2 − 11	265.64	1.05E − 01	5.47E − 02	5.51E − 02	6.91E − 02	1.00E + 10	4.83E + 09	5.02E + 09	6.70E + 09
2 − 10	265.80	–	6.65E − 02	6.44E − 02	7.06E − 02	–	5.86E + 09	5.86E + 09	6.84E + 09
2 − 12	269.63	–	6.52E − 02	6.41E − 02	7.40E − 02	–	5.73E + 09	5.83E + 09	7.16E + 09
1 − 10	263.22	–	5.73E − 02	5.68E − 02	6.76E − 02	–	5.15E + 09	5.27E + 09	6.67E + 09
3 − 18	–	–	2.50E − 01	2.33E − 01	2.45E − 01	–	6.43E + 11	5.98E + 11	6.26E + 11

Table 14. As Table 9, for S XI.

Transition	λ (Å)	*gf*(NIST)	*gf*(CW)	*gf*(AS)	*gf*(FFT)	*gA*(NIST)	*gA*(CW)	*gA*(AS)	*gA*(FFT)
3 − 14	191.27	4.17E − 01	5.48E − 01	5.52E − 01	4.18E − 01	7.59E + 10	9.47E + 10	1.03E + 11	7.68E + 10
2 − 14	188.67	2.32E − 01	3.09E − 01	3.13E − 01	2.33E − 01	4.35E + 10	5.51E + 10	6.03E + 10	4.40E + 10
1 − 14	186.84	7.62E − 02	1.02E − 01	1.03E − 01	7.65E − 02	1.46E + 10	1.86E + 10	2.03E + 10	1.47E + 10
3 − 11	246.89	2.79E − 01	2.56E − 01	2.50E − 01	2.80E − 01	3.05E + 10	2.61E + 10	2.63E + 10	3.09E + 10
3 − 10	247.16	7.35E − 02	6.35E − 02	6.33E − 02	7.40E − 02	8.04E + 09	6.45E + 09	6.64E + 09	8.15E + 09
2 − 11	242.59	5.87E − 02	4.56E − 02	4.64E − 02	5.92E − 02	6.70E + 09	4.83E + 09	5.08E + 09	6.76E + 09
2 − 10	242.85	6.97E − 02	6.69E − 02	6.46E − 02	6.99E − 02	7.86E + 09	7.07E + 09	7.04E + 09	7.97E + 09
2 − 12	242.87	6.87E − 02	6.10E − 02	6.01E − 02	6.90E − 02	7.77E + 09	6.43E + 09	6.55E + 09	7.87E + 09
1 − 10	239.82	6.11E − 02	5.17E − 02	5.16E − 02	6.14E − 02	7.08E + 09	5.61E + 09	5.77E + 09	7.18E + 09
3 − 18	43.12	2.38E − 01	2.41E − 01	2.26E − 01	2.38E − 01	8.55E + 11	8.73E + 11	8.18E + 11	8.56E + 11

energy level values missing in the NIST data base, the fitting formulas presented here can be used.

Concerning oscillator strengths, CW and AS give about 30 per cent difference from NIST data base values for the transition $2s^2\ 2p^2\ {}^3P - 2s\ 2p^3\ {}^3S^o$. They give less than 20 per cent difference from NIST data base values for the transition $2s^2\ 2p^2\ {}^3P - 2s\ 2p^3\ {}^3P^o$ and less than 5 per cent for the transition $2s^2\ 2p^2\ {}^3P - 2s^2\ 2p\ 3s\ {}^3P^o$.

Transition probabilities were calculated using CW and AS atomic structure codes, and we obtained better results with the CW code than with the AS code for the transition $2s^2\ 2p^2\ {}^3P - 2s\ 2p^3\ {}^3S^o$ (27

Table 15. As Table 9, for Cl XII.

Transition	λ (Å)	*gf*(NIST)	*gf*(CW)	*gf*(AS)	*gf*(FFT)	*gA*(NIST)	*gA*(CW)	*gA*(AS)	*gA*(FFT)
3 – 14	177.13	[4.47E-01]	5.12E – 01	5.17E – 01	3.96E – 01	[9.51E+10]	1.03E + 11	1.13E + 11	8.49E + 10
2 – 14	174.23	[2.50E-01]	2.85E – 01	2.89E – 01	2.16E – 01	[5.50E+10]	5.94E + 10	6.51E + 10	4.79E + 10
1 – 14	172.06	[7.25E-02]	9.41E – 02	9.54E – 02	7.08E – 02	[1.63E+10]	2.01E + 10	2.20E + 10	1.61E + 10
3 – 11	227.45	–	2.46E – 01	2.41E – 01	2.69E – 01	–	2.96E + 10	2.99E + 10	3.51E + 10
3 – 10	227.83	–	5.67E – 02	5.68E – 02	6.70E – 02	–	6.78E + 09	7.02E + 09	8.70E + 09
2 – 11	222.69	–	3.72E – 02	3.84E – 02	5.05E – 02	–	4.68E + 09	4.99E + 09	6.87E + 09
2 – 10	223.06	–	6.82E – 02	6.56E – 02	7.05E – 02	–	8.55E + 09	8.49E + 09	9.56E + 09
2 – 12	223.14	–	4.67E – 02	5.67E – 02	6.53E – 02	–	6.05E + 09	7.32E + 09	8.84E + 09
1 – 10	219.51	–	5.74E – 02	4.67E – 02	5.63E – 02	–	7.18E + 09	6.25E + 09	7.87E + 09
3 – 18	36.87	–	2.33E – 01	2.20E – 01	1.67E + 00	–	1.16E + 12	1.09E + 12	9.84E + 12

Table 16. As Table 9, for Ar XIII.

Transition	λ (Å)	*gf*(NIST)	*gf*(CW)	*gf*(AS)	*gf*(FFT)	*gA*(NIST)	*gA*(CW)	*gA*(AS)	*gA*(FFT)
3 – 14	164.80	[4.43E-01]	5.28E – 01	4.87E – 01	3.78E – 01	[1.09E+11]	1.36E + 11	1.22E + 11	9.37E + 10
2 – 14	161.61	[2.45E-01]	2.88E – 01	2.67E – 01	2.01E – 01	[6.25E+10]	7.69E + 10	6.99E + 10	5.19E + 10
1 – 14	159.08	[6.59E-02]	9.53E – 02	8.84E – 02	6.57E – 02	[1.74E+10]	2.62E + 10	2.38E + 10	1.75E + 10
3 – 11	210.43	–	2.72E – 01	2.34E – 01	2.60E – 01	–	4.38E + 10	3.39E + 10	3.97E + 10
3 – 10	210.99	–	5.81E – 02	5.08E – 02	6.04E – 02	–	9.29E + 09	7.32E + 09	9.17E + 09
2 – 11	205.25	–	3.37E – 02	3.12E – 02	4.25E – 02	–	5.70E + 09	4.76E + 09	6.82E + 09
2 – 10	205.78	–	7.93E – 02	6.74E – 02	7.20E – 02	–	1.33E + 10	1.03E + 10	1.15E + 10
2 – 12	205.94	–	6.18E – 02	5.37E – 02	6.21E – 02	–	1.04E + 10	8.16E + 09	9.90E + 09
1 – 10	201.70	–	4.74E – 02	4.23E – 02	5.15E – 02	–	8.26E + 09	6.70E + 09	8.57E + 09
3 – 18	31.86	–	2.38E – 01	2.15E – 01	2.26E – 01	–	1.71E + 12	1.42E + 12	1.49E + 12

per cent difference from the NIST data base values using CW, and 38 per cent using AS). For the transition $2s^2\ 2p^2\ {}^3P - 2s\ 2p^3\ {}^3P^o$, the two codes give nearly the same values. For the transition $2s^2\ 2p^2\ {}^3P - 2s^2\ 2p\ 3s\ {}^3P^o$, the aS code reaches 3 per cent difference from NIST data base values.

For all missing atomic structure values in the NIST data base, where there are no experimental data, we obtained new values with the codes CW and AS, and we recommend the use of CW values, which are in better agreement with NIST data.

We used a fitting form function of the *gf* versus atomic number *Z*, which allowed us to obtain values for missing data in the isoelectronic sequence.

We recommend our new atomic structure results: they are expected to be very useful for studying laboratory and astrophysical plasmas; they cover the missing values in the literature; and we plan in the future to perform similar calculations for other isoelectronic sequence ions.

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DATA AVAILABILITY

The authors confirm that the data supporting the findings of this study are available within the article and its supplementary materials.

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SUPPORTING INFORMATION

Supplementary data are available at *MNRAS* online.

Table 2. As Table 1, for Mg VII.
Table 3. As Table 1, for Al VIII.
Table 4. As Table 1, for Si IX.
Table 5. As Table 1, for P X.
Table 6. As Table 1, for S XI.
Table 7. As Table 1, for Cl XII.
Table 8. As Table 1, for Ar XIII.
Table 10. As Table 9, for Mg VII.
Table 11. As Table 9, for Al VIII.
Table 12. As Table 9, for Si IX.
Table 13. As Table 9, for P X.
Table 14. As Table 9, for S XI.
Table 15. As Table 9, for Cl XII.
Table 16. As Table 9, for Ar XIII.

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The same as Table 1 for Mg VII.

Key	Configuration	Term	J	E(NIST)	E(CW)	E(AS)	E(FFT)
1	2s^2 2p^2	^{3}P	0	0	0	0	0
2	2s^2 2p^2	^{3}P	1	1107	1111	1175	1123
3	2s^2 2p^2	^{3}P	2	2924	3098	3127	2937
4	2s^2 2p^2	^{1}D	2	40948	39502	44017	41066
5	2s^2 2p^2	^{1}S	0	85153	95034	105875	85132
6	2s 2p^3	^{5}S^o	2	118100	112780	97943	120686
7	2s 2p^3	^{3}D^o	3	232853	227700	227643	235677
8	2s 2p^3	^{3}D^o	1	233024	227633	227824	235843
9	2s 2p^3	^{3}D^o	2	232957	227619	227753	235784
10	2s 2p^3	^{3}P^o	1	274897	265065	269897	277786
11	2s 2p^3	^{3}P^o	2	274904	265117	269893	277798
12	2s 2p^3	^{3}P^o	0	274947	265035	269960	277842
13	2s 2p^3	^{1}D^o	2	354401	348776	363813	357407
14	2s 2p^3	^{3}S^o	1	362117	355269	370519	365033
15	2s 2p^3	^{1}P^o	1	397153	386255	406038	400235
16	2s^2 2p 3s	^{3}P^o	0	1047610	1055026	1052231	1049834
17	2s^2 2p 3s	^{3}P^o	1	1048400	1055916	1053122	1050716
18	2s^2 2p 3s	^{3}P^o	2	1050890	1058359	1055476	1053074
19	2s^2 2p 3s	^{1}P^o	1	1061030	1067328	1066259	1063379
20	2s^2 2p 4s	^{3}P^o	0	-	1420314	1414872	-
21	2s^2 2p 4s	^{3}P^o	1	-	1420906	1415488	-
22	2s^2 2p 4s	^{3}P^o	2	-	1423687	1418141	-
23	2s^2 2p 4s	^{1}P^o	1	-	1426191	1421024	-
24	2s^2 2p 5s	^{3}P^o	0	-	1574227	1568199	-
25	2s^2 2p 5s	^{3}P^o	1	-	1574592	1568587	-
26	2s^2 2p 5s	^{3}P^o	2	-	1577609	1571473	-
27	2s^2 2p 5s	^{1}P^o	1	-	1578687	1572689	-
28	2s^2 2p 3p	^{3}P	0	1123740	1137320	1134372	1126685
29	2s^2 2p 3p	^{3}P	1	1124940	1138211	1135238	1127640

30	2s^2 2p 3p	^{3}P	2	1125840	1139400	1136356	1128701
31	2s^2 2p 3p	^{1}D	2	-	1151251	1149639	1146246
32	2s^2 2p 3p	^{1}P	1	-	1112240	1109197	1106478
33	2s^2 2p 3p	^{3}D	1	-	1116150	1113555	1112388
34	2s^2 2p 3p	^{3}D	2	-	1117032	1114473	1113400
35	2s^2 2p 3p	^{3}D	3	-	1119108	1116505	1115441
36	2s^2 2p 3p	^{3}S	1	-	1125247	1123448	1122154
37	2s^2 2p 3p	^{1}S	0	-	1169603	1170013	1167043
38	2s^2 2p 4p	^{3}P	0	-	1451548	1445719	-
39	2s^2 2p 4p	^{3}P	1	-	1452850	1447046	-
40	2s^2 2p 4p	^{3}P	2	-	1453570	1447675	-
41	2s^2 2p 4p	^{1}D	2	-	1458118	1452594	-
42	2s^2 2p 4p	^{1}P	1	-	1443723	1438356	-
43	2s^2 2p 4p	^{3}D	1	-	1445669	1440264	-
44	2s^2 2p 4p	^{3}D	2	-	1445822	1440485	-
45	2s^2 2p 4p	^{3}D	3	-	1447902	1442494	-
46	2s^2 2p 4p	^{3}S	1	-	1449260	1444025	-
47	2s^2 2p 4p	^{1}S	0	-	1466067	1461220	-
48	2s^2 2p 3d	^{3}F^o	2	1178750	1185166	1181954	1181242
49	2s^2 2p 3d	^{3}F^o	3	-	1186813	1183499	1183051
50	2s^2 2p 3d	^{3}F^o	4	-	1188511	1185123	1184680
51	2s^2 2p 3d	^{1}D^o	2	1180910	1187726	1184679	1183406
52	2s^2 2p 3d	^{3}D^o	1	1191750	1197576	1196109	1194227
53	2s^2 2p 3d	^{3}D^o	2	1192170	1197966	1196462	1194636
54	2s^2 2p 3d	^{3}D^o	3	1193050	1198956	1197422	1195549
55	2s^2 2p 3d	^{3}P^o	2	1196750	1202049	1200485	1199193
56	2s^2 2p 3d	^{3}P^o	1	1197450	1202757	1201214	1199938
57	2s^2 2p 3d	^{3}P^o	0	1197850	1203112	1201599	1200346
58	2s^2 2p 3d	^{1}F^o	3	1211810	1218264	1219103	1214350
59	2s^2 2p 3d	^{1}P^o	1	1212800	1218325	1218800	1215340

The same as Table 1 for Al VIII.

Key	Configuration	Term	J	E(NIST)	E(CW)	E(AS)	E(FFT)
1	2s^2 2p^2	^{3}P	0	0	0	0	0
2	2s^2 2p^2	^{3}P	1	1710	1705	1789	1731
3	2s^2 2p^2	^{3}P	2	4420	4648	4680	4434
4	2s^2 2p^2	^{1}D	2	46720	44894	49931	46853
5	2s^2 2p^2	^{1}S	0	96260	106808	118846	96224
6	2s 2p^3	^{5}S^o	2	133840	129252	112864	136862
7	2s 2p^3	^{3}D^o	3	262180	256499	256338	265441
8	2s 2p^3	^{3}D^o	1	262330	256365	256539	265629
9	2s 2p^3	^{3}D^o	2	262270	256337	256433	265540
10	2s 2p^3	^{3}P^o	1	309110	298132	303394	312398
11	2s 2p^3	^{3}P^o	2	309110	298238	303422	312443
12	2s 2p^3	^{3}P^o	0	309110	298073	303459	312460
13	2s 2p^3	^{1}D^o	2	397020	389646	406055	400494
14	2s 2p^3	^{3}S^o	1	404200	395741	412301	407556
15	2s 2p^3	^{1}P^o	1	444570	431439	453085	448092
16	2s^2 2p 3s	^{3}P^o	0	1319340	1327711	1325299	1321523
17	2s^2 2p 3s	^{3}P^o	1	1320440	1328947	1326549	1322760
18	2s^2 2p 3s	^{3}P^o	2	1324060	1332653	1330120	1326334
19	2s^2 2p 3s	^{1}P^o	1	1335300	1342607	1342039	1337797
20	2s^2 2p 4s	^{3}P^o	0	-	1788702	1783566	-
21	2s^2 2p 4s	^{3}P^o	1	-	1789461	1784363	-
22	2s^2 2p 4s	^{3}P^o	2	1785360	1793701	1788422	-
23	2s^2 2p 4s	^{1}P^o	1	-	1796485	1791614	-
24	2s^2 2p 5s	^{3}P^o	0	-	1984919	1979149	-
25	2s^2 2p 5s	^{3}P^o	1	-	1985362	1979624	-
26	2s^2 2p 5s	^{3}P^o	2	-	1989929	1984010	-
27	2s^2 2p 5s	^{1}P^o	1	-	1991137	1985370	-
28	2s^2 2p 3p	^{3}P	0	-	1421656	1419296	1409452
29	2s^2 2p 3p	^{3}P	1	-	1423084	1420680	1411001

30	2s^2 2p 3p	^{3}P	2	-	1424791	1422295	1412501	
31	2s^2 2p 3p	^{1}D	2	-	1438262	1437423	1432779	
32	2s^2 2p 3p	^{1}P	1	-	1393650	1390833	1386764	
33	2s^2 2p 3p	^{3}D	1	-	1398235	1395833	1393311	
34	2s^2 2p 3p	^{3}D	2	-	1399307	1396992	1394667	
35	2s^2 2p 3p	^{3}D	3	-	1402434	1400057	1397743	
36	2s^2 2p 3p	^{3}S	1	1402160	1408998	1407536	1404891	
37	2s^2 2p 3p	^{1}S	0	-	1459333	1460825	1456929	
38	2s^2 2p 4p	^{3}P	0	-	1824696	1819216	-	
39	2s^2 2p 4p	^{3}P	1	-	1826914	1821459	-	
40	2s^2 2p 4p	^{3}P	2	-	1827795	1822219	-	
41	2s^2 2p 4p	^{1}D	2	-	1832935	1827787	-	
42	2s^2 2p 4p	^{1}P	1	-	1818466	1813315	-	
43	2s^2 2p 4p	^{3}D	1	-	1815757	1810679	-	
44	2s^2 2p 4p	^{3}D	2	-	1818524	1813455	-	
45	2s^2 2p 4p	^{3}D	3	-	1821726	1816552	-	
46	2s^2 2p 4p	^{3}S	1	-	1822942	1817933	-	
47	2s^2 2p 4p	^{1}S	0	-	1841830	1837466	-	
48	2s^2 2p 3d	^{3}F^o	2	1468730	1476112	1473151	1471299	
49	2s^2 2p 3d	^{3}F^o	3	-	1478522	1475451	1473870	
50	2s^2 2p 3d	^{3}F^o	4	-	1481097	1477916	1476341	
51	2s^2 2p 3d	^{1}D^o	2	1472010	1479880	1477085	1474577	
52	2s^2 2p 3d	^{3}D^o	1	1484570	1491265	1490322	1487173	
53	2s^2 2p 3d	^{3}D^o	2	1485240	1491840	1490833	1487773	
54	2s^2 2p 3d	^{3}D^o	3	1486690	1493454	1492407	1489267	
55	2s^2 2p 3d	^{3}P^o	2	1490570	1496812	1495746	1493172	
56	2s^2 2p 3d	^{3}P^o	1	1491550	1497719	1496689	1494146	
57	2s^2 2p 3d	^{3}P^o	0	1492110	1498180	1497199	1494688	
58	2s^2 2p 3d	^{1}F^o	3	1509240	1516438	1518121	1511913	
59	2s^2 2p 3d	^{1}P^o	1	1510150	1516083	1517461	1512769	

The same as Table 1 for Si IX.

Key	Configuration	Term	J	E(NIST)	E(CW)	E(AS)	E(FFT)
1	2s^2 2p^2	^{3}P	0	0	0	0	0
2	2s^2 2p^2	^{3}P	1	2545	2533	2637	2582
3	2s^2 2p^2	^{3}P	2	6414	6721	6753	6452
4	2s^2 2p^2	^{1}D	2	52926	50726	56291	53076
5	2s^2 2p^2	^{1}S	0	107799	119027	132263	107826
6	2s 2p^3	^{5}S^o	2	150770	146529	128561	154077
7	2s 2p^3	^{3}D^o	3	292232	286103	285832	296224
8	2s 2p^3	^{3}D^o	1	292441	285850	286020	296405
9	2s 2p^3	^{3}D^o	2	292296	285798	285866	296274
10	2s 2p^3	^{3}P^o	1	344009	332017	337703	348047
11	2s 2p^3	^{3}P^o	2	344118	332217	337800	348157
12	2s 2p^3	^{3}P^o	0	344075	331907	337756	348103
13	2s 2p^3	^{1}D^o	2	440403	431290	449098	444583
14	2s 2p^3	^{3}S^o	1	446942	436901	454797	451039
15	2s 2p^3	^{1}P^o	1	492755	477444	500967	497004
16	2s^2 2p 3s	^{3}P^o	0	-	1631016	1628969	1623869
17	2s^2 2p 3s	^{3}P^o	1	1623380	1632657	1630646	1625527
18	2s^2 2p 3s	^{3}P^o	2	1628500	1638088	1635879	1630766
19	2s^2 2p 3s	^{1}P^o	1	1640850	1648965	1648854	1643254
20	2s^2 2p 4s	^{3}P^o	0	-	2198517	2193668	-
21	2s^2 2p 4s	^{3}P^o	1	-	2199448	2194654	-
22	2s^2 2p 4s	^{3}P^o	2	-	2205667	2200626	-
23	2s^2 2p 4s	^{1}P^o	1	-	2208719	2204119	-
24	2s^2 2p 5s	^{3}P^o	0	-	2442035	2436506	-
25	2s^2 2p 5s	^{3}P^o	1	-	2442557	2437068	-
26	2s^2 2p 5s	^{3}P^o	2	-	2449201	2443472	-
27	2s^2 2p 5s	^{1}P^o	1	-	2450536	2444974	-
28	2s^2 2p 3p	^{3}P	0	-	1736754	1734946	1723186
29	2s^2 2p 3p	^{3}P	1	-	1738971	1737088	1725617

30	2s^2 2p 3p	^{3}P	2	-	1741311	1739317	1727634	
31	2s^2 2p 3p	^{1}D	2	-	1756383	1756266	1750579	
32	2s^2 2p 3p	^{1}P	1	-	1705750	1703146	1697991	
33	2s^2 2p 3p	^{3}D	1	-	1711369	1709091	1705325	
34	2s^2 2p 3p	^{3}D	2	-	1712515	1710400	1707004	
35	2s^2 2p 3p	^{3}D	3	-	1717062	1714859	1711479	
36	2s^2 2p 3p	^{3}S	1	-	1723857	1722672	1718810	
37	2s^2 2p 3p	^{1}S	0	-	1780160	1782682	1778071	
38	2s^2 2p 4p	^{3}P	0	-	2239352	2234207	-	
39	2s^2 2p 4p	^{3}P	1	-	2242944	2237807	-	
40	2s^2 2p 4p	^{3}P	2	-	2243948	2238663	-	
41	2s^2 2p 4p	^{1}D	2	-	2249705	2244907	-	
42	2s^2 2p 4p	^{1}P	1	-	2232838	2227926	-	
43	2s^2 2p 4p	^{3}D	1	-	2229223	2224401	-	
44	2s^2 2p 4p	^{3}D	2	-	2232801	2227972	-	
45	2s^2 2p 4p	^{3}D	3	-	2237566	2232583	-	
46	2s^2 2p 4p	^{3}S	1	-	2238551	2233714	-	
47	2s^2 2p 4p	^{1}S	0	-	2259526	2255633	-	
48	2s^2 2p 3d	^{3}F^o	2	-	1797795	1795040	1792022	
49	2s^2 2p 3d	^{3}F^o	3	-	1801187	1798319	1795571	
50	2s^2 2p 3d	^{3}F^o	4	-	1804962	1801934	1799198	
51	2s^2 2p 3d	^{1}D^o	2	1794050	1803122	1800544	1796778	
52	2s^2 2p 3d	^{3}D^o	1	1808160	1815801	1815333	1810903	
53	2s^2 2p 3d	^{3}D^o	2	1809040	1816653	1816074	1811773	
54	2s^2 2p 3d	^{3}D^o	3	1811430	1819144	1818520	1814103	
55	2s^2 2p 3d	^{3}P^o	2	1815650	1822819	1822187	1818302	
56	2s^2 2p 3d	^{3}P^o	1	1816900	1823917	1823341	1819504	
57	2s^2 2p 3d	^{3}P^o	0	1817630	1824486	1823983	1820192	
58	2s^2 2p 3d	^{1}F^o	3	1837780	1845703	1848230	1840609	
59	2s^2 2p 3d	^{1}P^o	1	1838560	1845076	1847232	1841316	

The same as Table 1 for P X.

Key	Configuration	Term	J	E(NIST)	E(CW)	E(AS)	E(FFT)
1	2s^2 2p^2	^{3}P	0	0	0	0	0
2	2s^2 2p^2	^{3}P	1	3692	3661	3784	3748
3	2s^2 2p^2	^{3}P	2	9045	9423	9454	9104
4	2s^2 2p^2	^{1}D	2	59690	57129	63226	59865
5	2s^2 2p^2	^{1}S	0	119960	131833	146264	120055
6	2s 2p^3	^{5}S^o	2	167740	164781	145194	172315
7	2s 2p^3	^{3}D^o	3	323234	316704	316307	328026
8	2s 2p^3	^{3}D^o	1	323416	316252	316423	328141
9	2s 2p^3	^{3}D^o	2	323201	316161	316202	327954
10	2s 2p^3	^{3}P^o	1	379910	366926	373024	384745
11	2s 2p^3	^{3}P^o	2	380149	367283	373246	384974
12	2s 2p^3	^{3}P^o	0	379929	366732	373040	384774
13	2s 2p^3	^{1}D^o	2	484750	473932	493157	489697
14	2s 2p^3	^{3}S^o	1	490592	478947	498193	495473
15	2s 2p^3	^{1}P^o	1	541990	524527	549933	547020
16	2s^2 2p 3s	^{3}P^o	0	1954000	1964974	1963271	1956880
17	2s^2 2p 3s	^{3}P^o	1	1956300	1967069	1965434	1959023
18	2s^2 2p 3s	^{3}P^o	2	1963700	1974800	1972883	1966475
19	2s^2 2p 3s	^{1}P^o	1	1976900	1986529	1986847	1980052
20	2s^2 2p 4s	^{3}P^o	0	-	2649778	2645224	-
21	2s^2 2p 4s	^{3}P^o	1	-	2650883	2646404	-
22	2s^2 2p 4s	^{3}P^o	2	-	2659707	2654903	-
23	2s^2 2p 4s	^{1}P^o	1	-	2663021	2658693	-
24	2s^2 2p 5s	^{3}P^o	0	-	2945608	2940322	-
25	2s^2 2p 5s	^{3}P^o	1	-	2946208	2940971	-
26	2s^2 2p 5s	^{3}P^o	2	-	2955557	2950010	-
27	2s^2 2p 5s	^{1}P^o	1	-	2957020	2951657	-
28	2s^2 2p 3p	^{3}P	0	-	2082650	2081379	2067759
29	2s^2 2p 3p	^{3}P	1	-	2086001	2084607	2071465

30	2s^2 2p 3p	^{3}P	2	-	2089082	2087562	2074059	
31	2s^2 2p 3p	^{1}D	2	-	2105768	2106335	2099601	
32	2s^2 2p 3p	^{1}P	1	-	2048498	2046111	2039952	
33	2s^2 2p 3p	^{3}D	1	-	2055658	2053480	2048400	
34	2s^2 2p 3p	^{3}D	2	-	2056711	2054783	2050313	
35	2s^2 2p 3p	^{3}D	3	-	2063131	2061078	2056636	
36	2s^2 2p 3p	^{3}S	1	-	2069947	2069003	2063855	
37	2s^2 2p 3p	^{1}S	0	-	2132242	2135756	2130418	
38	2s^2 2p 4p	^{3}P	0	-	2695536	2690734	-	
39	2s^2 2p 4p	^{3}P	1	-	2701088	2696252	-	
40	2s^2 2p 4p	^{3}P	2	-	2702162	2697162	-	
41	2s^2 2p 4p	^{1}D	2	-	2708583	2704119	-	
42	2s^2 2p 4p	^{1}P	1	-	2688764	2684112	-	
43	2s^2 2p 4p	^{3}D	1	-	2684148	2679583	-	
44	2s^2 2p 4p	^{3}D	2	-	2688676	2684096	-	
45	2s^2 2p 4p	^{3}D	3	-	2695564	2690762	-	
46	2s^2 2p 4p	^{3}S	1	-	2696269	2691583	-	
47	2s^2 2p 4p	^{1}S	0	-	2719304	2715867	-	
48	2s^2 2p 3d	^{3}F^o	2	2140900	2150272	2147707	2143648	
49	2s^2 2p 3d	^{3}F^o	3	-	2154892	2152221	2148424	
50	2s^2 2p 3d	^{3}F^o	4	-	2160276	2157375	2153600	
51	2s^2 2p 3d	^{1}D^o	2	2147600	2157538	2155179	2150280	
52	2s^2 2p 3d	^{3}D^o	1	[2162818]	2171238	2171233	2165639	
53	2s^2 2p 3d	^{3}D^o	2	2164200	2172536	2172337	2166916	
54	2s^2 2p 3d	^{3}D^o	3	2167500	2176182	2175946	2170372	
55	2s^2 2p 3d	^{3}P^o	2	2172100	2180245	2180013	2174942	
56	2s^2 2p 3d	^{3}P^o	1	2173800	2181514	2181363	2176355	
57	2s^2 2p 3d	^{3}P^o	0	-	2182188	2182141	2177194	
58	2s^2 2p 3d	^{1}F^o	3	2197900	2206263	2209601	2200735	
59	2s^2 2p 3d	^{1}P^o	1	2198400	2205399	2208297	2201294	

The same as Table 1 for S XI.

Key	Configuration	Term	J	E(NIST)	E(CW)	E(AS)	E(FFT)
1	2s^2 2p^2	^{3}P	0	0	0	0	0
2	2s^2 2p^2	^{3}P	1	5208	5173	5313	5329
3	2s^2 2p^2	^{3}P	2	12388	12873	12898	12535
4	2s^2 2p^2	^{1}D	2	67146	64265	70892	67658
5	2s^2 2p^2	^{1}S	0	132929	145399	161015	133176
6	2s 2p^3	^{5}S^o	2	186251	184194	162950	187542
7	2s 2p^3	^{3}D^o	3	355350	348510	347973	357290
8	2s 2p^3	^{3}D^o	1	355364	347737	347921	357230
9	2s 2p^3	^{3}D^o	2	355076	347588	347608	356969
10	2s 2p^3	^{3}P^o	1	416986	403086	409585	418750
11	2s 2p^3	^{3}P^o	2	417419	403693	410016	419184
12	2s 2p^3	^{3}P^o	0	416947	402758	409521	418715
13	2s 2p^3	^{1}D^o	2	530177	517810	538477	532410
14	2s 2p^3	^{3}S^o	1	535220	522072	542697	537034
15	2s 2p^3	^{1}P^o	1	592480	572968	600267	594553
16	2s^2 2p 3s	^{3}P^o	0	-	2329574	2328255	2321134
17	2s^2 2p 3s	^{3}P^o	1	2320260	2332163	2330954	2323804
18	2s^2 2p 3s	^{3}P^o	2	2331340	2342891	2341295	2334167
19	2s^2 2p 3s	^{1}P^o	1	2345060	2355420	2356187	2348618
20	2s^2 2p 4s	^{3}P^o	0	-	3142548	3138310	-
21	2s^2 2p 4s	^{3}P^o	1	-	3143827	3139684	-
22	2s^2 2p 4s	^{3}P^o	2	-	3155996	3151437	-
23	2s^2 2p 4s	^{1}P^o	1	-	3159576	3155522	-
24	2s^2 2p 5s	^{3}P^o	0	-	3495688	3490678	-
25	2s^2 2p 5s	^{3}P^o	1	-	3496365	3491413	-
26	2s^2 2p 5s	^{3}P^o	2	-	3509162	3503818	-
27	2s^2 2p 5s	^{1}P^o	1	-	3510755	3505610	-
28	2s^2 2p 3p	^{3}P	0	-	2459388	2458668	2443277
29	2s^2 2p 3p	^{3}P	1	-	2464335	2463420	2448803

30	2s^2 2p 3p	^{3}P	2	-	2468244	2467195	2451993	
31	2s^2 2p 3p	^{1}D	2	-	2486604	2487834	2480221	
32	2s^2 2p 3p	^{1}P	1	-	2421891	2419746	2412769	
33	2s^2 2p 3p	^{3}D	1	-	2431178	2429137	2422844	
34	2s^2 2p 3p	^{3}D	2	-	2431961	2430242	2424848	
35	2s^2 2p 3p	^{3}D	3	-	2440808	2438913	2433583	
36	2s^2 2p 3p	^{3}S	1	-	2447427	2446712	2440287	
37	2s^2 2p 3p	^{1}S	0	-	2515769	2520253	2514245	
38	2s^2 2p 4p	^{3}P	0	-	3193287	3188865	-	
39	2s^2 2p 4p	^{3}P	1	-	3201516	3196990	-	
40	2s^2 2p 4p	^{3}P	2	-	3202608	3197907	-	
41	2s^2 2p 4p	^{1}D	2	-	3209756	3205634	-	
42	2s^2 2p 4p	^{1}P	1	-	3186267	3181915	-	
43	2s^2 2p 4p	^{3}D	1	-	3180583	3176301	-	
44	2s^2 2p 4p	^{3}D	2	-	3186195	3181898	-	
45	2s^2 2p 4p	^{3}D	3	-	3195895	3191285	-	
46	2s^2 2p 4p	^{3}S	1	-	3196307	3191778	-	
47	2s^2 2p 4p	^{1}S	0	-	3221353	3218382	-	
48	2s^2 2p 3d	^{3}F^o	2	-	2533614	2531256	2527900	
49	2s^2 2p 3d	^{3}F^o	3	-	2539730	2537283	2534177	
50	2s^2 2p 3d	^{3}F^o	4	-	2547232	2544461	2541405	
51	2s^2 2p 3d	^{1}D^o	2	2532260	2543201	2541111	2536851	
52	2s^2 2p 3d	^{3}D^o	1	2548420	2557644	2558123	2553142	
53	2s^2 2p 3d	^{3}D^o	2	2549740	2559679	2559825	2555066	
54	2s^2 2p 3d	^{3}D^o	3	2555430	2564751	2564899	2559961	
55	2s^2 2p 3d	^{3}P^o	2	2560810	2569285	2569451	2564991	
56	2s^2 2p 3d	^{3}P^o	1	2562100	2570700	2570976	2566593	
57	2s^2 2p 3d	^{3}P^o	0	-	2571473	2571890	2567585	
58	2s^2 2p 3d	^{1}F^o	3	2589340	2598294	2602442	2594140	
59	2s^2 2p 3d	^{1}P^o	1	2589510	2597240	2600874	2594603	

The same as Table 1 for Cl XII.

Key	Configuration	Term	J	E(NIST)	E(CW)	E(AS)	E(FFT)
1	2s^2 2p^2	^{3}P	0	0	0	0	0
2	2s^2 2p^2	^{3}P	1	7240	7170	7321	7421
3	2s^2 2p^2	^{3}P	2	16629	17195	17211	16852
4	2s^2 2p^2	^{1}D	2	75530	72333	79479	76176
5	2s^2 2p^2	^{1}S	0	146917	159929	176715	147225
6	2s 2p^3	^{5}S^o	2	206100	204930	182038	208131
7	2s 2p^3	^{3}D^o	3	388838	381711	381069	391635
8	2s 2p^3	^{3}D^o	1	388581	380439	380701	391259
9	2s 2p^3	^{3}D^o	2	388179	380206	380266	390899
10	2s 2p^3	^{3}P^o	1	455554	440708	447650	458062
11	2s 2p^3	^{3}P^o	2	456294	441699	448414	458814
12	2s 2p^3	^{3}P^o	0	455399	440176	447447	457911
13	2s 2p^3	^{1}D^o	2	577110	563148	585331	580204
14	2s 2p^3	^{3}S^o	1	581190	566439	588523	583752
15	2s 2p^3	^{1}P^o	1	644595	623042	652296	647484
16	2s^2 2p 3s	^{3}P^o	0	-	2724977	2723974	2716619
17	2s^2 2p 3s	^{3}P^o	1	2715700	2728087	2727244	2719859
18	2s^2 2p 3s	^{3}P^o	2	2729200	2742641	2741285	2733936
19	2s^2 2p 3s	^{1}P^o	1	2744760	2755953	2757064	2749310
20	2s^2 2p 4s	^{3}P^o	0	-	3676968	3673002	-
21	2s^2 2p 4s	^{3}P^o	1	-	3678420	3674568	-
22	2s^2 2p 4s	^{3}P^o	2	-	3694798	3690425	-
23	2s^2 2p 4s	^{1}P^o	1	-	3698643	3694808	-
24	2s^2 2p 5s	^{3}P^o	0	-	4092442	4087660	-
25	2s^2 2p 5s	^{3}P^o	1	-	4093194	4088479	-
26	2s^2 2p 5s	^{3}P^o	2	-	4110304	4105099	-
27	2s^2 2p 5s	^{1}P^o	1	-	4112027	4107038	-
28	2s^2 2p 3p	^{3}P	0	-	2867086	2866877	2850903
29	2s^2 2p 3p	^{3}P	1	-	2874234	2873725	2858889

30	2s^2 2p 3p	^{3}P	2	-	2879022	2878386	2862691	
31	2s^2 2p 3p	^{1}D	2	-	2899174	2900984	2893457	
32	2s^2 2p 3p	^{1}P	1	-	2826054	2824097	2817331	
33	2s^2 2p 3p	^{3}D	1	-	2838069	2836153	2829629	
34	2s^2 2p 3p	^{3}D	2	-	2838437	2836883	2831564	
35	2s^2 2p 3p	^{3}D	3	-	2850378	2848580	2843359	
36	2s^2 2p 3p	^{3}S	1	-	2931016	2936389	2930733	
37	2s^2 2p 3p	^{1}S	0	-	2856591	2856015	2849269	
38	2s^2 2p 4p	^{3}P	0	-	3732743	3728666	-	
39	2s^2 2p 4p	^{3}P	1	-	3744509	3740224	-	
40	2s^2 2p 4p	^{3}P	2	-	3745567	3741105	-	
41	2s^2 2p 4p	^{1}D	2	-	3753525	3749678	-	
42	2s^2 2p 4p	^{1}P	1	-	3725491	3734531	-	
43	2s^2 2p 4p	^{3}D	1	-	3718680	3714637	-	
44	2s^2 2p 4p	^{3}D	2	-	3725504	3721455	-	
45	2s^2 2p 4p	^{3}D	3	-	3738847	3734368	-	
46	2s^2 2p 4p	^{3}S	1	-	3738963	3721404	-	
47	2s^2 2p 4p	^{1}S	0	-	3765973	3763404	-	
48	2s^2 2p 3d	^{3}F^o	2	-	2947992	2945790	2942932	
49	2s^2 2p 3d	^{3}F^o	3	-	2955889	2953631	2951006	
50	2s^2 2p 3d	^{3}F^o	4	-	2966133	2963427	2960884	
51	2s^2 2p 3d	^{1}D^o	2	2948600	2960251	2958432	2954590	
52	2s^2 2p 3d	^{3}D^o	1	[2964108]	2975184	2976104	2971502	
53	2s^2 2p 3d	^{3}D^o	2	2968100	2978419	2978789	2974465	
54	2s^2 2p 3d	^{3}D^o	3	2976200	2985147	2985605	2981080	
55	2s^2 2p 3d	^{3}P^o	2	2980750	2990241	2990733	2986660	
56	2s^2 2p 3d	^{3}P^o	1	-	2991772	2992406	2988416	
57	2s^2 2p 3d	^{3}P^o	0	-	2992635	2993456	2989557	
58	2s^2 2p 3d	^{1}F^o	3	3012100	3022087	3026973	3019041	
59	2s^2 2p 3d	^{1}P^o	1	3012700	3020904	3025197	3019418	

The same as Table 1 for Ar XIII.

Key	Configuration	Term	J	E(NIST)	E(CW)	E(AS)	E(FFT)
1	2s^2 2p^2	^{3}P	0	0	0	0	0
2	2s^2 2p^2	^{3}P	1	9853	9299	9923	10163
3	2s^2 2p^2	^{3}P	2	21841	21543	22526	22219
4	2s^2 2p^2	^{1}D	2	85011	79421	89218	85880
5	2s^2 2p^2	^{1}S	0	162136	172063	193601	162579
6	2s 2p^3	^{5}S^o	2	225918	262207	202690	230568
7	2s 2p^3	^{3}D^o	3	422699	447349	414367	426533
8	2s 2p^3	^{3}D^o	1	423248	447685	414958	427018
9	2s 2p^3	^{3}D^o	2	423969	449579	415858	427932
10	2s 2p^3	^{3}P^o	1	495799	511329	487510	499414
11	2s 2p^3	^{3}P^o	2	497055	512795	488774	500651
12	2s 2p^3	^{3}P^o	0	495432	510535	487080	499071
13	2s 2p^3	^{1}D^o	2	625844	640656	634021	630063
14	2s 2p^3	^{3}S^o	1	628627	642012	635898	632261
15	2s 2p^3	^{1}P^o	1	698669	703624	706383	702698
16	2s^2 2p 3s	^{3}P^o	0	-	3277093	3150521	3143381
17	2s^2 2p 3s	^{3}P^o	1	-	3280247	3154387	3147219
18	2s^2 2p 3s	^{3}P^o	2	3160180	3299386	3173076	3165967
19	2s^2 2p 3s	^{1}P^o	1	3177200	3310347	3189713	3182243
20	2s^2 2p 4s	^{3}P^o	0	-	3280168	4249425	-
21	2s^2 2p 4s	^{3}P^o	1	-	3280828	4251181	-
22	2s^2 2p 4s	^{3}P^o	2	-	3302350	4272123	-
23	2s^2 2p 4s	^{1}P^o	1	-	3303800	4276806	-
24	2s^2 2p 5s	^{3}P^o	0	-	3440220	4731405	-
25	2s^2 2p 5s	^{3}P^o	1	-	3440486	4732306	-
26	2s^2 2p 5s	^{3}P^o	2	-	3462413	4754122	-
27	2s^2 2p 5s	^{1}P^o	1	-	3462964	4756209	-
28	2s^2 2p 3p	^{3}P	0	-	3341044	3306094	3290176
29	2s^2 2p 3p	^{3}P	1	-	3351235	3315776	3301441

30	2s^2 2p 3p	^{3}P	2	-	3356480	3321339	3305828	
31	2s^2 2p 3p	^{1}D	2	-	3377233	3346031	3339129	
32	2s^2 2p 3p	^{1}P	1	-	3313885	3274661	3253242	
33	2s^2 2p 3p	^{3}D	1	-	3299283	3259317	3268395	
34	2s^2 2p 3p	^{3}D	2	-	3299283	3274889	3270140	
35	2s^2 2p 3p	^{3}D	3	-	3329182	3290380	3285788	
36	2s^2 2p 3p	^{3}S	1	-	3334118	3297227	3290596	
37	2s^2 2p 3p	^{1}S	0	-	3409712	3384371	3379610	
38	2s^2 2p 4p	^{3}P	0	-	3326672	4310251	-	
39	2s^2 2p 4p	^{3}P	1	-	3323883	4326218	-	
40	2s^2 2p 4p	^{3}P	2	-	3346018	4327019	-	
41	2s^2 2p 4p	^{1}D	2	-	3348936	4336533	-	
42	2s^2 2p 4p	^{1}P	1	-	3343726	4320116	-	
43	2s^2 2p 4p	^{3}D	1	-	3321024	4294719	-	
44	2s^2 2p 4p	^{3}D	2	-	3324179	4302893	-	
45	2s^2 2p 4p	^{3}D	3	-	3344032	4320283	-	
46	2s^2 2p 4p	^{3}S	1	-	3346051	4302715	-	
47	2s^2 2p 4p	^{1}S	0	-	3352647	4351216	-	
48	2s^2 2p 3d	^{3}F^o	2	3379900	3028296	3391453	3389662	
49	2s^2 2p 3d	^{3}F^o	3	3390500	3036432	3401424	3399840	
50	2s^2 2p 3d	^{3}F^o	4	-	3051305	3414559	3413109	
51	2s^2 2p 3d	^{1}D^o	2	3394740	3037947	3407239	3404384	
52	2s^2 2p 3d	^{3}D^o	1	3410800	3045038	3425311	3421652	
53	2s^2 2p 3d	^{3}D^o	2	[3416131]	3053908	3429572	3426257	
54	2s^2 2p 3d	^{3}D^o	3	3429230	3059589	3438345	3434815	
55	2s^2 2p 3d	^{3}P^o	2	3432510	3064694	3444141	3441043	
56	2s^2 2p 3d	^{3}P^o	1	3433730	3066396	3445932	3442918	
57	2s^2 2p 3d	^{3}P^o	0	-	3067541	3447115	3444206	
58	2s^2 2p 3d	^{1}F^o	3	3469220	3083523	3483471	3476512	
59	2s^2 2p 3d	^{1}P^o	1	3466830	3083554	3481559	3476858	

The same as Table 9 for Mg VII.

Transition	lambda (A)	gf(NIST)	gf(CW)	gf(AS)	gf(FFT)	gA(NIST)	gA(CW)	gA(AS)	gA(FFT)
3-14	278.40	5.25E-01	7.70E-01	7.70E-01	5.67E-01	4.50E+10	6.37E+10	6.93E+10	4.96E+10
2-14	277.00	3.31E-01	4.54E-01	4.54E-01	3.33E-01	2.85E+10	3.80E+10	4.13E+10	2.94E+10
1-14	276.15	1.20E-01	1.50E-01	1.51E-01	1.10E-01	1.05E+10	1.27E+10	1.38E+10	9.80E+09
3-11	367.67	4.17E-01	3.25E-01	3.17E-01	3.55E-01	2.05E+10	1.49E+10	1.50E+10	1.79E+10
3-10	367.68	1.41E-01	9.85E-02	9.64E-02	1.10E-01	6.90E+09	4.51E+09	4.58E+09	5.52E+09
2-11	365.23	1.41E-01	8.82E-02	8.67E-02	1.02E-01	7.00E+09	4.10E+09	4.18E+09	5.19E+09
2-10	365.24	8.32E-02	7.17E-02	6.97E-02	7.67E-02	4.20E+09	3.33E+09	3.36E+09	3.92E+09
2-12	365.18	1.07E-01	8.32E-02	8.13E-02	9.18E-02	5.40E+09	3.86E+09	3.92E+09	4.69E+09
1-10	363.77	1.07E-01	7.87E-02	7.71E-02	8.84E-02	5.40E+09	3.69E+09	3.74E+09	4.55E+09
3-18	95.42	2.65E-01	2.83E-01	2.57E-01	2.68E-01	1.95E+11	2.10E+11	1.90E+11	1.97E+11
3-17	95.65	8.85E-02	9.38E-02	8.63E-02	8.89E-02	6.45E+10	6.93E+10	6.35E+10	6.51E+10
2-18	95.26	8.85E-02	9.51E-02	8.54E-02	8.93E-02	6.50E+10	7.09E+10	6.33E+10	6.60E+10
2-17	95.48	5.22E-02	5.52E-02	5.05E-02	5.25E-02	3.81E+10	4.10E+10	3.73E+10	3.86E+10
2-16	95.56	7.05E-02	7.50E-02	6.86E-02	7.08E-02	5.15E+10	5.56E+10	5.06E+10	5.20E+10
1-17	95.38	7.00E-02	7.47E-02	6.76E-02	7.04E-02	5.13E+10	5.55E+10	5.00E+10	5.19E+10
4-13	319.03	6.76E-01	1.45E+00	1.44E+00	1.04E+00	4.45E+10	9.27E+10	9.79E+10	6.95E+10
4-15	280.74	7.08E-01	5.81E-01	5.85E-01	6.41E-01	6.00E+10	4.66E+10	5.12E+10	5.52E+10
5-15	320.51	2.45E-01	3.52E-01	3.44E-01	2.06E-01	1.59E+10	1.99E+10	2.07E+10	1.36E+10
1-52	83.910	9.40E-01	9.89E-01	9.55E-01	9.21E-01	8.91E+11	9.46E+11	9.11E+11	8.76E+11
2-52	83.988	4.59E-01	4.68E-01	4.56E-01	4.58E-01	4.35E+11	4.47E+11	4.34E+11	4.34E+11

2-53 83.959 2.07E+00 2.16E+00 2.10E+00 2.03E+00 1.97E+12 2.06E+12 2.00E+12 1.93E+12

3-52 84.117 8.43E-03 7.30E-03 7.39E-03 9.03E-03 7.95E+09 6.94E+09 7.01E+09 8.54E+09

3-53 84.087 2.08E-01 1.92E-01 1.87E-01 2.21E-01 1.97E+11 1.83E+11 1.78E+11 2.09E+11

3-54 84.025 3.31E+00 3.46E+00 3.37E+00 3.26E+00 3.13E+12 3.30E+12 3.20E+12 3.10E+12

1-56 83.511 1.21E-01 1.04E-01 1.03E-01 1.21E-01 1.16E+11 1.01E+11 9.90E+10 1.16E+11

2-57 83.560 2.69E-01 2.66E-01 2.56E-01 2.62E-01 2.56E+11 2.56E+11 2.46E+11 2.52E+11

2-56 83.588 3.38E-01 3.54E-01 3.38E-01 3.27E-01 3.24E+11 3.41E+11 3.25E+11 3.14E+11

2-55 83.637 2.93E-02 1.25E-02 1.32E-02 3.39E-02 2.79E+10 1.20E+10 1.27E+10 3.25E+10

3-56 83.715 3.66E-01 3.65E-01 3.53E-01 3.57E-01 3.48E+11 3.50E+11 3.38E+11 3.41E+11

3-55 83.764 1.38E+00 1.41E+00 1.37E+00 1.34E+00 1.32E+12 1.36E+12 1.31E+12 1.28E+12

12-36 - - 5.70E-03 2.22E-03 2.35E-03 - 7.63E+08 1.08E+09 1.12E+09

10-36 - - 1.18E-02 6.95E-03 8.30E-03 - 1.58E+09 3.38E+09 3.95E+09

11-36 - - 2.15E-02 1.16E-02 1.65E-02 - 2.94E+09 5.66E+09 7.83E+09

10-30 - - 1.18E-02 5.00E-05 1.80E-03 - 1.49E+09 2.51E+07 8.69E+08

12-29 - - 1.00E-02 7.35E-05 2.04E-03 - 1.27E+09 3.67E+07 9.83E+08

10-29 - - 6.20E-03 1.22E-04 2.20E-03 - 7.91E+08 6.11E+07 1.06E+09

10-28 - - 1.03E-02 1.12E-06 9.30E-04 - 1.31E+09 5.56E+05 4.47E+08

11-30 - - 4.81E-02 7.82E-05 4.33E-03 - 6.16E+09 3.92E+07 2.09E+09

11-29 - - 1.87E-02 9.85E-05 6.31E-05 - 2.40E+09 4.92E+07 3.04E+07

10-34	-	-	5.92E-02	4.19E-03	6.57E-03	-	8.26E+09
	1.99E+09	3.06E+09					
12-33	-	-	2.97E-02	1.80E-03	2.88E-03	-	4.16E+09
	8.55E+08	1.34E+09					
11-35	-	-	1.28E-01	7.91E-03	1.28E-02	-	1.80E+10
	3.78E+09	6.00E+09					
10-33	-	-	7.80E-03	1.01E-03	1.91E-03	-	1.09E+09
	4.80E+08	8.86E+08					
11-34	-	-	2.06E-02	1.27E-03	2.31E-03	-	2.92E+09
	6.04E+08	1.07E+09					
11-33	-	-	1.50E-03	1.58E-04	2.49E-04	-	2.19E+08
	7.50E+07	1.16E+08					

The same as Table 9 for Al VIII.

Transition	lambda (A)	gf(NIST)	gf(CW)	gf(AS)	gf(FFT)	gA(NIST)	gA(CW)	gA(AS)	gA(FFT)
3-14	250.14	5.20E-01	6.97E-01	6.99E-01	5.20E-01	5.55E+10	7.11E+10	7.75E+10	5.63E+10
2-14	248.45	3.09E-01	4.08E-01	4.10E-01	3.03E-01	3.33E+10	4.22E+10	4.61E+10	3.32E+10
1-14	247.42	1.05E-01	1.35E-01	1.36E-01	9.99E-02	1.14E+10	1.41E+10	1.54E+10	1.11E+10
3-11	328.20	3.30E-01	3.02E-01	2.94E-01	3.31E-01	2.04E+10	1.73E+10	1.75E+10	2.09E+10
3-10	328.20	9.91E-02	8.81E-02	8.66E-02	9.94E-02	6.15E+09	5.06E+09	5.15E+09	6.29E+09
2-11	325.31	8.99E-02	7.58E-02	7.51E-02	8.98E-02	5.70E+09	4.45E+09	4.56E+09	5.79E+09
2-10	325.31	7.33E-02	6.88E-02	6.68E-02	7.36E-02	4.62E+09	4.03E+09	4.06E+09	4.74E+09
2-12	325.31	8.45E-02	7.60E-02	7.45E-02	8.48E-02	5.33E+09	4.45E+09	4.52E+09	5.46E+09
1-10	323.51	8.05E-02	7.05E-02	6.94E-02	8.05E-02	5.13E+09	4.18E+09	4.26E+09	5.24E+09
3-18	75.78	2.56E-01	2.70E-01	2.48E-01	2.59E-01	2.98E+11	3.17E+11	2.90E+11	3.02E+11
3-17	75.99	8.55E-02	8.97E-02	8.35E-02	8.60E-02	9.90E+10	1.05E+11	9.74E+10	9.97E+10
2-18	75.62	8.55E-02	9.11E-02	8.24E-02	8.65E-02	9.95E+10	1.08E+11	9.70E+10	1.01E+11
2-17	75.83	4.98E-02	5.21E-02	4.82E-02	5.02E-02	5.79E+10	6.12E+10	5.64E+10	5.85E+10
2-16	75.89	6.81E-02	7.16E-02	6.62E-02	6.84E-02	7.87E+10	8.39E+10	7.73E+10	7.95E+10
1-17	75.73	6.73E-02	7.10E-02	6.49E-02	6.78E-02	7.83E+10	8.36E+10	7.61E+10	7.91E+10
4-13	285.47	9.55E-01	1.32E+00	1.31E+00	9.61E-01	7.80E+10	1.05E+11	1.11E+11	8.02E+10
4-15	251.35	5.85E-01	5.24E-01	5.29E-01	5.83E-01	6.18E+10	5.22E+10	5.73E+10	6.26E+10
5-15	287.10	1.89E-01	3.21E-01	3.16E-01	1.91E-01	1.53E+10	2.26E+10	2.35E+10	1.58E+10
1-52	67.360	1.00E+00	1.05E+00	1.02E+00	9.87E-01	1.48E+12	1.56E+12	1.51E+12	1.46E+12
2-52	67.437	4.41E-01	4.45E-01	4.37E-01	4.42E-01	6.45E+11	6.59E+11	6.46E+11	6.50E+11

2-53 67.407 2.17E+00 2.23E+00 2.18E+00 2.13E+00 3.18E+12 3.30E+12 3.23E+12 3.14E+12

3-52 67.561 4.45E-03 3.50E-03 3.75E-03 5.03E-03 6.51E+09 5.22E+09 5.52E+09 7.37E+09

3-53 67.530 1.38E-01 1.24E-01 1.21E-01 1.53E-01 2.02E+11 1.83E+11 1.78E+11 2.25E+11

3-54 67.464 3.43E+00 3.56E+00 3.48E+00 3.39E+00 5.03E+12 5.27E+12 5.14E+12 4.98E+12

1-56 67.044 9.59E-02 8.03E-02 8.04E-02 9.73E-02 1.43E+11 1.20E+11 1.20E+11 1.45E+11

2-57 67.096 2.78E-01 4.04E-01 2.66E-01 2.73E-01 4.12E+11 6.03E+11 3.96E+11 4.06E+11

2-56 67.121 3.87E-01 4.04E-01 3.86E-01 3.75E-01 5.73E+11 6.03E+11 5.76E+11 5.58E+11

2-55 67.165 3.33E-03 3.81E-01 2.63E-08 5.48E-03 4.94E+09 5.67E+11 3.92E+04 8.14E+09

3-56 67.244 3.83E-01 1.53E+00 3.70E-01 3.76E-01 5.64E+11 2.27E+12 5.49E+11 5.56E+11

3-55 67.288 1.51E+00 1.53E+00 1.49E+00 1.46E+00 2.22E+12 2.27E+12 2.21E+12 2.17E+12

12-36 - - 5.50E-03 1.70E-03 1.82E-03 - 1.21E+09 1.38E+09 1.45E+09

10-36 - - 1.05E-02 5.46E-03 7.01E-03 - 2.34E+09 4.44E+09 5.58E+09

11-36 - - 1.91E-02 9.12E-03 1.48E-02 - 4.31E+09 7.42E+09 1.18E+10

10-30 - - 1.13E-02 9.08E-05 1.97E-03 - 2.36E+09 7.58E+07 1.59E+09

12-29 - - 9.20E-03 8.90E-05 2.35E-03 - 1.94E+09 7.41E+07 1.89E+09

10-29 - - 5.50E-03 1.50E-04 7.01E-03 - 1.17E+09 1.25E+08 5.58E+09

10-28 - - 9.90E-03 4.26E-07 9.13E-04 - 2.11E+09 3.54E+05 7.33E+08

11-30 - - 4.77E-02 5.91E-05 4.58E-03 - 1.02E+10 4.94E+07 3.69E+09

11-29 - - 1.93E-02 1.57E-04 6.35E-07 - 4.14E+09 1.31E+08 5.11E+05

10-34	-	-	5.41E-02	9.67E-04	6.06E-03	-	1.24E+10
	7.72E+08	4.73E+09					
12-33	-	-	2.63E-02	1.37E-03	2.61E-03	-	6.05E+09
	1.09E+09	2.03E+09					
11-35	-	-	1.19E-01	6.23E-03	1.20E-02	-	2.74E+10
	5.00E+09	9.43E+09					
10-33	-	-	3.60E-03	1.77E-04	1.58E-03	-	8.34E+08
	1.41E+08	1.23E+09					
11-34	-	-	1.84E-02	3.28E-03	2.18E-03	-	4.27E+09
	2.61E+09	1.70E+09					
11-33	-	-	1.50E-03	6.25E-04	3.07E-04	-	3.50E+08
	4.97E+08	2.39E+08					

The same as Table 9 for Si IX.

Transition	lambda (A)	gf(NIST)	gf(CW)	gf(AS)	gf(FFT)	gA(NIST)	gA(CW)	gA(AS)	gA(FFT)
3-14	227.00	4.80E-01	6.38E-01	6.41E-01	4.81E-01	6.21E+10	7.87E+10	8.58E+10	6.34E+10
2-14	225.02	2.76E-01	3.70E-01	3.72E-01	2.77E-01	3.63E+10	4.65E+10	5.08E+10	3.72E+10
1-14	223.74	9.10E-02	1.22E-01	1.23E-01	9.12E-02	1.21E+10	1.56E+10	1.70E+10	1.24E+10
3-11	296.12	3.10E-01	2.83E-01	2.76E-01	3.12E-01	2.36E+10	2.00E+10	2.02E+10	2.43E+10
3-10	296.21	8.99E-02	7.90E-02	7.80E-02	9.04E-02	6.84E+09	5.58E+09	5.69E+09	7.04E+09
2-11	292.76	7.93E-02	6.47E-02	6.46E-02	7.91E-02	6.15E+09	4.69E+09	4.84E+09	6.30E+09
2-10	292.86	7.11E-02	6.71E-02	6.51E-02	7.16E-02	5.52E+09	4.86E+09	4.88E+09	5.70E+09
2-12	292.80	7.80E-02	7.01E-02	6.89E-02	7.90E-02	6.07E+09	5.07E+09	5.16E+09	6.29E+09
1-10	290.69	7.36E-02	6.35E-02	6.27E-02	7.37E-02	5.82E+09	4.67E+09	4.77E+09	5.95E+09
3-18	61.65	2.49E-01	2.59E-01	2.40E-01	2.52E-01	4.38E+11	4.59E+11	4.24E+11	4.43E+11
3-17	61.84	8.39E-02	8.63E-02	8.13E-02	8.36E-02	1.47E+11	1.52E+11	1.43E+11	1.46E+11
2-18	61.50	8.34E-02	8.78E-02	7.99E-02	8.40E-02	1.47E+11	1.57E+11	1.42E+11	1.48E+11
2-17	61.70	4.80E-02	4.92E-02	4.61E-02	4.81E-02	8.43E+10	8.72E+10	8.15E+10	8.45E+10
2-16	-	-	6.86E-02	6.41E-02	6.62E-02	-	1.21E+11	1.13E+11	1.16E+11
1-17	61.60	6.55E-02	6.77E-02	6.24E-02	6.53E-02	1.15E+11	1.20E+11	1.11E+11	1.15E+11
4-13	258.08	8.85E-01	1.21E+00	1.20E+00	8.93E-01	8.85E+10	1.17E+11	1.24E+11	9.13E+10
4-15	227.36	5.35E-01	4.78E-01	4.83E-01	5.36E-01	6.93E+10	5.81E+10	6.37E+10	7.04E+10
5-15	259.77	1.76E-01	2.96E-01	2.92E-01	1.79E-01	1.74E+10	2.53E+10	2.64E+10	1.80E+10
1-52	55.305	1.06E+00	1.10E+00	1.07E+00	1.04E+00	2.30E+12	2.41E+12	2.34E+12	2.26E+12
2-52	55.383	4.17E-01	4.19E-01	4.14E-01	4.21E-01	9.09E+11	9.18E+11	9.07E+11	9.15E+11

2-53 55.356 2.21E+00 2.24E+00 2.21E+00 2.18E+00 4.82E+12 4.92E+12 4.85E+12 4.75E+12

3-52 55.502 1.77E-03 1.10E-03 1.33E-03 2.21E-03 3.81E+09 2.48E+09 2.89E+09 4.79E+09

3-53 55.475 8.39E-02 7.29E-02 7.07E-02 9.91E-02 1.82E+11 1.59E+11 1.54E+11 2.15E+11

3-54 55.401 3.52E+00 3.63E+00 3.57E+00 3.47E+00 7.63E+12 7.96E+12 7.81E+12 7.55E+12

1-56 55.039 7.40E-02 5.92E-02 6.02E-02 7.61E-02 1.63E+11 1.31E+11 1.33E+11 1.68E+11

2-57 55.094 2.85E-01 2.82E-01 2.73E-01 2.80E-01 6.26E+11 6.24E+11 6.04E+11 6.14E+11

2-56 55.116 4.32E-01 4.51E-01 4.32E-01 4.18E-01 9.48E+11 9.98E+11 9.56E+11 9.17E+11

2-55 55.154 3.87E-03 1.35E-02 1.20E-02 7.86E-04 8.50E+09 2.99E+10 2.66E+10 1.72E+09

3-56 55.234 3.95E-01 3.93E-01 3.82E-01 3.88E-01 8.64E+11 8.65E+11 8.42E+11 8.48E+11

3-55 55.272 1.60E+00 1.61E+00 1.58E+00 1.55E+00 3.49E+12 3.55E+12 3.47E+12 3.39E+12

12-36 - - 1.04E-03 1.32E-03 1.33E-03 - 1.34E+09 1.68E+09 1.67E+09

10-36 - - 3.44E-03 4.37E-03 5.84E-03 - 4.45E+09 5.59E+09 7.31E+09

11-36 - - 5.57E-03 7.24E-03 1.33E-02 - 7.19E+09 9.26E+09 1.67E+10

10-30 - - 6.27E-05 6.77E-05 2.12E-03 - 8.29E+07 5.32E+07 2.69E+09

12-29 - - 9.59E-05 1.05E-04 2.64E-03 - 1.27E+08 1.37E+08 3.34E+09

10-29 - - 1.70E-04 1.97E-04 3.27E-03 - 2.25E+08 2.57E+08 4.14E+09

10-28 - - 9.27E-07 9.61E-09 8.64E-04 - 1.22E+06 3.75E+04 1.09E+09

11-30 - - 1.02E-04 1.01E-04 4.74E-03 - 1.36E+08 7.96E+07 6.02E+09

11-29 - - 1.47E-04 2.21E-04 5.72E-05 - 1.94E+08 2.88E+08 7.24E+07

10-34	-	-	1.85E-03	2.63E-03	5.64E-03	-	2.36E+09	4.33E+08 6.95E+09
12-33	-	-	7.55E-04	1.06E-03	2.36E-03	-	9.58E+08	1.33E+09 2.90E+09
11-35	-	-	3.51E-03	5.05E-03	1.14E-02	-	4.49E+09	6.38E+09 1.41E+10
10-33	-	-	1.62E-04	3.45E-04	1.25E-03	-	2.06E+08	4.33E+08 1.53E+09
11-34	-	-	4.75E-04	7.56E-04	2.09E-03	-	6.04E+08	9.50E+08 2.57E+09
11-33	-	-	1.92E-04	2.18E-04	4.07E-04	-	2.44E+08	2.73E+08 5.01E+08

The same as Table 9 for P X.

Transition	lambda (A)	gf(NIST)	gf(CW)	gf(AS)	gf(FFT)	gA(NIST)	gA(CW)	gA(AS)	gA(FFT)
3-14	207.66	4.66E-01	5.89E-01	5.93E-01	4.49E-01	7.20E+10	8.66E+10	9.44E+10	7.09E+10
2-14	205.38	2.84E-01	3.37E-01	3.41E-01	2.55E-01	4.50E+10	5.08E+10	5.56E+10	4.11E+10
1-14	203.84	9.33E-02	1.12E-01	1.13E-01	8.38E-02	1.50E+10	1.71E+10	1.86E+10	1.37E+10
3-11	269.47	3.16E-01	2.68E-01	2.62E-01	2.96E-01	2.90E+10	2.29E+10	2.31E+10	2.79E+10
3-10	269.64	-	7.09E-02	7.03E-02	8.23E-02	-	6.05E+09	6.20E+09	7.74E+09
2-11	265.64	1.05E-01	5.47E-02	5.51E-02	6.91E-02	1.00E+10	4.83E+09	5.02E+09	6.70E+09
2-10	265.80	-	6.65E-02	6.44E-02	7.06E-02	-	5.86E+09	5.86E+09	6.84E+09
2-12	269.63	-	6.52E-02	6.41E-02	7.40E-02	-	5.73E+09	5.83E+09	7.16E+09
1-10	263.22	-	5.73E-02	5.68E-02	6.76E-02	-	5.15E+09	5.27E+09	6.67E+09
3-18	-	-	2.50E-01	2.33E-01	2.45E-01	-	6.43E+11	5.98E+11	6.26E+11
3-17	-	-	8.40E-02	7.97E-02	4.92E-02	-	2.15E+11	2.03E+11	2.08E+11
2-18	-	-	8.52E-02	7.79E-02	1.37E-01	-	2.21E+11	2.01E+11	2.11E+11
2-17	-	-	4.66E-02	4.42E-02	4.61E-02	-	1.20E+11	1.13E+11	1.18E+11
2-16	-	-	6.62E-02	6.24E-02	2.15E-02	-	1.70E+11	1.60E+11	1.64E+11
1-17	-	-	6.50E-02	6.02E-02	1.90E-01	-	1.68E+11	1.55E+11	1.62E+11
4-13	235.26	9.12E-01	1.12E+00	1.11E+00	8.33E-01	1.10E+11	1.29E+11	1.37E+11	1.03E+11
4-15	207.34	5.42E-01	4.40E-01	4.45E-01	4.96E-01	8.40E+10	6.41E+10	7.03E+10	7.85E+10
5-15	236.95	1.91E-01	2.74E-01	2.71E-01	1.68E-01	2.28E+10	2.81E+10	2.94E+10	2.04E+10
1-52	46.236	-	1.14E+00	1.11E+00	1.09E+00	-	3.57E+12	3.48E+12	3.40E+12
2-52	46.315	-	1.00E-04	3.89E-01	3.95E-01	-	2.88E+08	1.22E+12	1.23E+12
2-53	46.285	-	2.21E+00	2.20E+00	2.18E+00	-	6.94E+12	6.90E+12	6.81E+12

3-52	46.430	-	1.00E-04	1.69E-04	4.49E-04	-	2.88E+08	5.27E+08	1.39E+09
3-53	46.400	-	4.10E-02	3.84E-02	5.56E-02	-	1.28E+11	1.20E+11	1.72E+11
3-54	46.329	-	3.68E+00	3.62E+00	3.54E+00	-	1.15E+13	1.13E+13	1.10E+13
1-56	46.002	-	4.22E-02	4.36E-02	5.52E-02	-	1.34E+11	1.38E+11	1.75E+11
2-57	-	-	2.88E-01	2.79E-01	2.88E-01	-	9.11E+11	8.84E+11	9.06E+11
2-56	46.081	-	4.94E-01	4.74E-01	4.67E-01	-	1.56E+12	1.50E+12	1.47E+12
2-55	46.117	-	4.51E-02	4.23E-02	2.00E-02	-	1.43E+11	1.34E+11	6.30E+10
3-56	46.195	-	4.00E-01	3.91E-01	3.99E-01	-	1.26E+12	1.23E+12	1.25E+12
3-55	46.231	-	1.66E+00	1.64E+00	1.63E+00	-	5.23E+12	5.14E+12	5.09E+12
12-36	-	-	5.00E-03	1.02E-03	9.01E-04	-	2.54E+09	1.95E+09	1.69E+09
10-36	-	-	8.60E-03	3.52E-03	4.76E-03	-	4.38E+09	6.75E+09	8.94E+09
11-36	-	-	1.46E-02	5.76E-03	1.17E-02	-	7.64E+09	1.10E+10	2.21E+10
10-30	-	-	1.03E-02	7.66E-05	2.26E-03	-	5.07E+09	1.50E+08	4.29E+09
12-29	-	-	7.40E-03	1.21E-04	2.91E-03	-	3.65E+09	2.37E+08	5.51E+09
10-29	-	-	4.20E-03	2.43E-04	3.86E-03	-	2.05E+09	4.74E+08	7.33E+09
10-28	-	-	9.50E-03	9.50E-03	7.92E-04	-	4.70E+09	5.79E+05	1.50E+09
11-30	-	-	4.69E-02	1.11E-04	4.86E-03	-	2.35E+10	2.18E+08	9.26E+09
11-29	-	-	2.11E-02	3.12E-04	2.78E-04	-	1.06E+10	6.10E+08	5.27E+08
10-34	-	-	4.82E-02	2.16E-03	5.28E-03	-	2.55E+10	4.07E+09	9.77E+09

12-33	-	-	2.10E-02	8.41E-04	2.11E-03	-	1.11E+10	1.58E+09	3.90E+09	
11-35	-	-	1.06E-01	4.18E-03	1.09E-02	-	5.61E+10	7.94E+09	2.03E+10	
10-33	-	-	3.52E-05	1.61E-04	9.07E-04	-	1.86E+07	3.02E+08	1.67E+09	
11-34	-	-	1.47E-02	6.03E-04	2.02E-03	-	7.94E+09	1.14E+09	3.74E+09	
11-33	-	-	1.60E-03	2.79E-04	5.64E-04	-	8.50E+08	5.26E+08	3.38E-04	

The same as Table 9 for S XI.

Transition	lambda (A)	gf(NIST)	gf(CW)	gf(AS)	gf(FFT)	gA(NIST)	gA(CW)	gA(AS)	gA(FFT)
3-14	191.27	4.17E-01	5.48E-01	5.52E-01	4.18E-01	7.59E+10	9.47E+10	1.03E+11	7.68E+10
2-14	188.67	2.32E-01	3.09E-01	3.13E-01	2.33E-01	4.35E+10	5.51E+10	6.03E+10	4.40E+10
1-14	186.84	7.62E-02	1.02E-01	1.03E-01	7.65E-02	1.46E+10	1.86E+10	2.03E+10	1.47E+10
3-11	246.89	2.79E-01	2.56E-01	2.50E-01	2.80E-01	3.05E+10	2.61E+10	2.63E+10	3.09E+10
3-10	247.16	7.35E-02	6.35E-02	6.33E-02	7.40E-02	8.04E+09	6.45E+09	6.64E+09	8.15E+09
2-11	242.59	5.87E-02	4.56E-02	4.64E-02	5.92E-02	6.70E+09	4.83E+09	5.08E+09	6.76E+09
2-10	242.85	6.97E-02	6.69E-02	6.46E-02	6.99E-02	7.86E+09	7.07E+09	7.04E+09	7.97E+09
2-12	242.87	6.87E-02	6.10E-02	6.01E-02	6.90E-02	7.77E+09	6.43E+09	6.55E+09	7.87E+09
1-10	239.82	6.11E-02	5.17E-02	5.16E-02	6.14E-02	7.08E+09	5.61E+09	5.77E+09	7.18E+09
3-18	43.12	2.38E-01	2.41E-01	2.26E-01	2.38E-01	8.55E+11	8.73E+11	8.18E+11	8.56E+11
3-17	43.33	8.05E-02	8.24E-02	7.87E-02	8.07E-02	2.87E+11	2.96E+11	2.82E+11	2.88E+11
2-18	42.99	8.09E-02	8.30E-02	7.62E-02	8.11E-02	2.92E+11	3.03E+11	2.77E+11	2.93E+11
2-17	43.20	4.38E-02	4.42E-02	4.23E-02	4.37E-02	1.56E+11	1.60E+11	1.53E+11	1.57E+11
2-16	-	-	6.41E-02	6.09E-02	6.27E-02	-	2.31E+11	2.19E+11	2.24E+11
1-17	43.10	6.17E-02	6.27E-02	5.83E-02	6.17E-02	2.21E+11	2.27E+11	2.11E+11	2.22E+11
4-13	215.97	7.69E-01	1.03E+00	1.03E+00	7.73E-01	1.10E+11	1.42E+11	1.51E+11	1.11E+11
4-15	190.36	4.56E-01	4.09E-01	4.14E-01	4.59E-01	8.40E+10	7.06E+10	7.73E+10	8.49E+10
5-15	217.60	1.55E-01	2.55E-01	2.53E-01	1.56E-01	2.18E+10	3.10E+10	3.25E+10	2.21E+10
1-52	39.24	1.12E+00	1.16E+00	1.14E+00	1.12E+00	4.83E+12	5.08E+12	4.96E+12	4.86E+12
2-52	39.32	3.69E-01	3.66E-01	3.65E-01	3.68E-01	1.587E+1	21.59E+12	1.59E+12	1.59E+12

2-53 39.30 2.13E+00 2.14E+00 2.15E+00 2.13E+00 9.20E+12 9.31E+12 9.35E+12 9.24E+12

3-52 39.43 2.06E-06 1.00E-04 6.77E-05 2.06E-06 8.82E+06 6.33E+08 2.93E+08 8.88E+06

3-53 39.41 3.14E-02 2.37E-02 2.05E-02 3.14E-02 1.35E+11 1.03E+11 8.88E+10 1.36E+11

3-54 39.32 3.56E+00 3.70E+00 3.66E+00 3.56E+00 1.53E+13 1.61E+13 1.59E+13 1.54E+13

1-56 - - 2.94E-02 3.08E-02 3.96E-02 - 1.30E+11 1.36E+11 1.74E+11

2-57 - - 2.93E-01 2.84E-01 2.91E-01 - 1.29E+12 1.25E+12 1.28E+12

2-56 39.11 5.04E-01 5.33E-01 5.12E-01 5.05E-01 2.20E+12 2.34E+12 2.25E+12 2.21E+12

2-55 39.13 5.25E-02 8.47E-02 8.11E-02 5.26E-02 2.29E+11 3.71E+11 3.56E+11 2.30E+11

3-56 39.22 4.03E-01 4.05E-01 3.97E-01 4.03E-01 1.74E+12 1.77E+12 1.73E+12 1.75E+12

3-55 39.24 1.66E+00 1.69E+00 1.67E+00 1.66E+00 7.15E+12 7.36E+12 7.26E+12 7.20E+12

12-36 - - 4.60E-03 7.76E-04 5.01E-04 - 3.37E+09 2.15E+09 1.37E+09

10-36 - - 7.60E-03 2.84E-03 3.58E-03 - 5.60E+09 7.87E+09 9.76E+09

11-36 - - 1.24E-02 4.56E-03 9.72E-03 - 9.30E+09 1.26E+10 2.65E+10

10-30 - - 9.90E-03 8.60E-05 2.38E-03 - 7.01E+09 2.43E+08 6.56E+09

12-29 - - 6.40E-03 1.38E-04 3.10E-03 - 4.57E+09 3.89E+08 8.52E+09

10-29 - - 3.50E-03 2.94E-04 4.42E-03 - 2.49E+09 8.27E+08 1.21E+10

10-28 - - 9.30E-03 1.58E-06 7.04E-04 - 6.68E+09 4.43E+06 1.93E+09

11-30 - - 4.65E-02 1.22E-04 4.93E-03 - 3.36E+10 3.44E+08 1.36E+10

11-29 - - 2.22E-02 4.23E-04 6.54E-04 - 1.62E+10 1.19E+09 1.80E+09

10-34	-	-	4.67E-02	1.80E-03	4.82E-03	-	3.53E+10	4.90E+09	1.29E+10
12-33	-	-	1.94E-02	6.86E-04	1.81E-03	-	1.47E+10	1.87E+09	4.86E+09
11-35	-	-	1.01E-01	3.52E-03	1.02E-02	-	7.68E+10	9.67E+09	2.76E+10
10-33	-	-	3.00E-04	5.60E-05	5.88E-04	-	1.99E+08	1.52E+08	1.58E+09
11-34	-	-	1.32E-02	4.89E-04	1.93E-03	-	1.02E+10	1.33E+09	5.17E+09
11-33	-	-	1.70E-03	3.55E-04	7.60E-04	-	1.31E+09	9.66E+08	2.04E+09

The same as Table 9 for Cl XII.

Transition	lambda (A)	gf(NIST)	gf(CW)	gf(AS)	gf(FFT)	gA(NIST)	gA(CW)	gA(AS)	gA(FFT)
3-14	177.13	[4.47E-01]	5.12E-01	5.17E-01	3.96E-01	[9.51E+10]	1.03E+11	1.13E+11	8.49E+10
2-14	174.23	[2.50E-01]	2.85E-01	2.89E-01	2.16E-01	[5.50E+10]	5.94E+10	6.51E+10	4.79E+10
1-14	172.06	[7.25E-02]	9.41E-02	9.54E-02	7.08E-02	[1.63E+10]	2.01E+10	2.20E+10	1.61E+10
3-11	227.45	-	2.46E-01	2.41E-01	2.69E-01	-	2.96E+10	2.99E+10	3.51E+10
3-10	227.83	-	5.67E-02	5.68E-02	6.70E-02	-	6.78E+09	7.02E+09	8.70E+09
2-11	222.69	-	3.72E-02	3.84E-02	5.05E-02	-	4.68E+09	4.99E+09	6.87E+09
2-10	223.06	-	6.82E-02	6.56E-02	7.05E-02	-	8.55E+09	8.49E+09	9.56E+09
2-12	223.14	-	4.67E-02	5.67E-02	6.53E-02	-	6.05E+09	7.32E+09	8.84E+09
1-10	219.51	-	5.74E-02	4.67E-02	5.63E-02	-	7.18E+09	6.25E+09	7.87E+09
3-18	36.87	-	2.33E-01	2.20E-01	1.67E+00	-	1.16E+12	1.09E+12	9.84E+12
3-17	37.05	-	8.12E-02	7.83E-02	4.07E-01	-	4.05E+11	3.84E+11	2.40E+12
2-18	36.74	-	8.15E-02	7.48E-02	9.05E-02	-	4.00E+11	3.73E+11	5.36E+11
2-17	36.92	-	4.19E-02	4.05E-02	5.41E-01	-	2.07E+11	2.00E+11	3.21E+12
2-16	-	-	6.06E-02	5.97E-02	2.96E-01	-	3.01E+11	2.94E+11	1.76E+12
1-17	36.82	-	6.22E-02	5.66E-02	2.80E-02	-	3.06E+11	2.81E+11	1.67E+11
4-13	-	-	9.63E-01	9.64E-01	7.28E-01	-	1.55E+11	1.65E+11	1.23E+11
4-15	-	-	3.82E-01	3.87E-01	4.30E-01	-	7.74E+10	8.47E+10	9.36E+10
5-15	-	-	2.38E-01	2.37E-01	1.48E-01	-	3.40E+10	3.57E+10	2.46E+10
1-52	-	-	1.19E+00	1.16E+00	1.15E+00	-	7.01E+12	6.85E+12	6.76E+12
2-52	-	-	3.43E-01	3.44E-01	3.46E-01	-	2.02E+12	2.02E+12	2.03E+12
2-53	-	-	2.03E+00	2.06E+00	2.05E+00	-	1.19E+13	1.22E+13	1.21E+13
3-52	-	-	1.00E-03	7.29E-04	4.72E-04	-	5.67E+09	4.26E+09	2.75E+09

3-53	-	-	1.61E-02	1.20E-02	1.94E-02	-	9.40E+10	7.04E+10
1.13E+11								
3-54	-	-	3.70E+00	3.67E+00	3.58E+00	-	2.17E+13	2.16E+13
2.10E+13								
1-56	-	-	2.01E-02	2.14E-02	2.80E-02	-	1.20E+11	1.28E+11
1.67E+11								
2-57	-	-	2.97E-01	2.88E-01	2.96E-01	-	1.76E+12	1.71E+12
1.76E+12								
2-56	-	-	5.66E-01	5.44E-01	5.41E-01	-	3.36E+12	3.23E+12
3.21E+12								
2-55	-	-	1.24E-01	1.21E-01	9.05E-02	-	7.38E+11	7.17E+11
5.36E+11								
3-56	-	-	4.07E-01	4.00E-01	4.07E-01	-	2.40E+12	2.36E+12
2.40E+12								
3-55	-	-	1.69E+00	1.67E+00	1.67E+00	-	9.97E+12	9.88E+12
9.84E+12								
12-36	-	-	4.10E-03	5.83E-04	2.46E-04	-	4.23E+09	2.26E+09
9.37E+08								
10-36	-	-	6.70E-03	2.29E-03	2.73E-03	-	6.82E+09	8.84E+09
1.04E+10								
11-36	-	-	1.02E-02	3.54E-03	8.02E-03	-	1.06E+10	1.37E+10
3.06E+10								
10-30	-	-	9.50E-03	9.61E-05	2.50E-03	-	9.37E+09	3.79E+08
9.62E+09								
12-29	-	-	5.50E-03	1.56E-04	3.25E-03	-	5.42E+09	6.11E+08
1.25E+10								
10-29	-	-	2.90E-03	3.50E-04	4.97E-03	-	2.87E+09	1.37E+09
1.91E+10								
10-28	-	-	9.20E-03	4.03E-06	6.01E-04	-	9.25E+09	1.57E+07
2.29E+09								
11-30	-	-	4.60E-02	1.33E-04	4.97E-03	-	4.65E+10	5.25E+08
1.92E+10								
11-29	-	-	2.34E-02	5.51E-04	1.19E-03	-	2.38E+10	2.16E+09
4.57E+09								
10-34	-	-	4.57E-02	1.52E-03	4.54E-03	-	4.80E+10	5.78E+09
1.71E+10								
12-33	-	-	1.86E-02	5.78E-04	1.60E-03	-	1.96E+10	2.20E+09
5.99E+09								

11-35	-	-	9.69E-02	3.01E-03	9.84E-03	-	1.03E+11	1.16E+10	3.73E+10
10-33	-	-	2.81E-02	9.76E-06	3.56E-04	-	3.01E+10	3.71E+07	1.33E+09
11-34	-	-	1.17E-02	4.04E-04	1.89E-03	-	1.27E+10	1.54E+09	7.11E+09
11-33	-	-	1.80E-03	4.38E-04	1.02E-03	-	1.96E+09	1.66E+09	3.83E+09

The same as Table 9 for Ar XIII.

Transition	lambda (A)	gf(NIST)	gf(CW)	gf(AS)	gf(FFT)	gA(NIST)	gA(CW)	gA(AS)	gA(FFT)
3-14	164.80	[4.43E-01]	5.28E-01	4.87E-01	3.78E-01	[1.09E+11]	1.36E+11	1.22E+11	9.37E+10
2-14	161.61	[2.45E-01]	2.88E-01	2.67E-01	2.01E-01	[6.25E+10]	7.69E+10	6.99E+10	5.19E+10
1-14	159.08	[6.59E-02]	9.53E-02	8.84E-02	6.57E-02	[1.74E+10]	2.62E+10	2.38E+10	1.75E+10
3-11	210.43	-	2.72E-01	2.34E-01	2.60E-01	-	4.38E+10	3.39E+10	3.97E+10
3-10	210.99	-	5.81E-02	5.08E-02	6.04E-02	-	9.29E+09	7.32E+09	9.17E+09
2-11	205.25	-	3.37E-02	3.12E-02	4.25E-02	-	5.70E+09	4.76E+09	6.82E+09
2-10	205.78	-	7.93E-02	6.74E-02	7.20E-02	-	1.33E+10	1.03E+10	1.15E+10
2-12	205.94	-	6.18E-02	5.37E-02	6.21E-02	-	1.04E+10	8.16E+09	9.90E+09
1-10	201.70	-	4.74E-02	4.23E-02	5.15E-02	-	8.26E+09	6.70E+09	8.57E+09
3-18	31.86	-	2.38E-01	2.15E-01	2.26E-01	-	1.71E+12	1.42E+12	1.49E+12
3-17	-	-	8.20E-02	7.86E-02	8.01E-02	-	5.81E+11	5.14E+11	5.22E+11
2-18	-	-	8.26E-02	7.36E-02	7.87E-02	-	5.96E+11	4.91E+11	5.22E+11
2-17	-	-	4.32E-02	3.89E-02	4.00E-02	-	3.08E+11	2.56E+11	2.63E+11
2-16	-	-	6.25E-02	5.86E-02	6.00E-02	-	4.45E+11	3.85E+11	3.93E+11
1-17	-	-	6.28E-02	5.51E-02	5.87E-02	-	4.51E+11	3.66E+11	3.88E+11
4-13	184.90	-	1.01E+00	9.02E-01	6.86E-01	-	2.13E+11	1.79E+11	1.36E+11
4-15	162.96	-	3.89E-01	3.65E-01	4.05E-01	-	1.01E+11	9.26E+10	1.03E+11
5-15	186.38	-	2.57E-01	2.22E-01	1.40E-01	-	4.84E+10	3.90E+10	2.73E+10
1-52	-	-	7.28E-01	1.18E+00	1.17E+00	-	4.50E+12	9.21E+12	9.15E+12
2-52	-	-	1.89E-01	3.25E-01	3.26E-01	-	1.16E+12	2.53E+12	2.53E+12
2-53	-	-	8.12E-01	1.95E+00	1.94E+00	-	5.02E+12	1.52E+13	1.51E+13
3-52	-	-	1.90E-03	1.89E-03	1.57E-03	-	1.14E+10	1.46E+10	1.21E+10

3-53	-	-	2.02E-02	9.14E-03	1.48E-02	-	1.24E+11	7.08E+10	1.15E+11
3-54	-	-	2.04E+00	3.67E+00	3.58E+00	-	1.26E+13	2.85E+13	2.78E+13
1-56	-	-	8.30E-03	1.47E-02	1.96E-02	-	5.21E+10	1.16E+11	1.55E+11
2-57	-	-	1.91E-01	2.92E-01	3.01E-01	-	1.19E+12	2.30E+12	2.37E+12
2-56	-	-	3.78E-01	5.72E-01	5.73E-01	-	2.36E+12	4.50E+12	4.50E+12
2-55	-	-	8.25E-02	1.57E-01	1.28E-01	-	5.14E+11	1.23E+12	1.00E+12
3-56	-	-	2.58E-01	4.00E-01	4.08E-01	-	1.59E+12	3.13E+12	3.19E+12
3-55	-	-	1.04E+00	1.67E+00	1.67E+00	-	6.42E+12	1.30E+13	1.30E+13
12-36	-	-	3.01E-04	4.26E-04	8.12E-05	-	1.60E+09	2.24E+09	4.22E+08
10-36	-	-	1.29E-03	1.81E-03	1.99E-03	-	6.80E+09	9.56E+09	1.03E+10
11-36	-	-	1.74E-03	2.68E-03	6.30E-03	-	9.22E+09	1.41E+10	3.27E+10
10-30	-	-	7.00E-05	1.07E-04	2.60E-03	-	3.77E+08	5.71E+08	1.37E+10
12-29	-	-	1.27E-04	1.73E-04	3.33E-03	-	6.84E+08	9.21E+08	1.75E+10
10-29	-	-	3.01E-04	4.10E-04	5.45E-03	-	1.62E+09	2.19E+09	2.85E+10
10-28	-	-	5.65E-06	7.83E-06	4.91E-04	-	3.01E+07	4.15E+07	2.55E+09
11-30	-	-	8.49E-05	1.45E-04	4.98E-03	-	4.56E+08	7.74E+08	2.61E+10
11-29	-	-	5.11E-04	6.92E-04	1.81E-03	-	2.73E+09	3.69E+09	9.49E+09
10-34	-	-	8.77E-04	1.29E-03	4.28E-03	-	4.58E+09	6.70E+09	2.19E+10
12-33	-	-	1.30E-04	1.98E-04	1.40E-03	-	6.73E+08	1.02E+09	7.17E+09

11-35	-	-	1.70E-03	2.60E-03	9.50E-03	-	8.95E+09
1.36E+10	4.91E+10						
10-33	-	-	2.51E-04	3.69E-04	1.96E-04	-	1.30E+09
1.89E+09	1.00E+09						
11-34	-	-	1.62E-04	3.40E-04	1.86E-03	-	8.45E+08
1.76E+09	9.54E+09						
11-33	-	-	7.80E-05	9.76E-05	1.30E-03	-	4.03E+08
5.00E+08	6.64E+09						