Planetary Nebulae in our Galaxy and Beyond
Proceedings IAU Symposium No. 234, 2006
M. J. Barlow & R. H. Méndez, eds.

doi:10.1017/S1743921306002997

Iron Project: atomic data for IR lines

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Abstract. The Iron Project is an international consortium dedicated to the computation of atomic data for astrophysical applications. Although the project has been mainly concerned with ions in the iron group, the earlier papers gave priority to calculations of A-values and electron impact collision strengths for infrared transitions. In the present report we include a compilation of these data which will become useful in the spectral modelling of planetary nebulae.

Keywords. Atomic data, infrared: general.

1. Introduction

The present report includes a compilation of radiative transition probabilities, A, and electron impact effective collision strengths, $\Upsilon(T)$, for the modelling of infrared transitions. They were calculated in the earlier stages of the Iron Project (IP, Hummer *et al.* 1993), a productive international collaboration dedicated to the computation of atomic data for astrophysical applications. To date comprising over 60 papers, the documentation, published in the A&A series "Atomic data from the IRON Project", and the data sets can be downloaded from the `TIPbase`‖ online atomic database at the Centre de Données astronomiques de Strasbourg, France. In the IP considerable attention has been given to issues affecting data accuracy, using powerful numerical methods, well researched ionic target models and thorough data analyses. In Section 2 we give a brief description of the methods, followed by an explanation in Section 3 of the tables and their contents. These tables are also available in electronic form from `TIPbase`.

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2. Numerical Methods

The A-values herein listed have been computed with an upgraded version of the atomic structure code SUPERSTRUCTURE (Eissner *et al.* 1974, Nussbaumer & Storey 1974). The ionic wavefunctions take the form of configuration-interaction expansions of the type

$$\Psi = \sum_i \phi_i c_i \tag{2.1}$$

where the basis functions ϕ_i are constructed from single-electron orbitals generated in a Thomas–Fermi–Dirac model potential. Relativistic effects are taken into account with a Breit–Pauli hamiltonian; semi-empirical term-energy corrections are introduced before diagonalisation in order to improve wavefunction accuracy; and the transition probabilities are computed with the experimental level energy separations.

Electron collision rates for transitions between two ionic levels, i and j say ($j > i$), can be expressed in cm^3 s^{-1}

$$q(j,i;T) = \frac{8.631\times10^{-6}\Upsilon(j,i;T)}{\omega(j)T^{1/2}} \quad \text{and} \quad q(i,j) = \frac{\omega(j)}{\omega(i)}\exp\left[-\frac{\Delta E(i,j)}{\kappa T}\right]q(j,i) \tag{2.2}$$

where $\omega(j)$ and $\omega(i)$ are the statistical weights of the upper and lower levels, respectively, $\Delta E(i,j)$ is the level energy separation, T the electron temperature in K and κ is the Boltzmann constant. The effective collision strength $\Upsilon(j,i;T)$ is obtained by integrating the collision strength $\Omega(i,j;E)$ over a Maxwellian distribution. Collision strengths for fine-structure levels have been computed in the close-coupling approximation with the R-matrix method (Berrington *et al.* 1978, Seaton 1985), followed by an algebraic recoupling of the LS reactance matrices to intermediate coupling that can include target relativistic effects (Saraph 1978, Griffin *et al.* 1998); or alternatively, by the Breit–Pauli R-matrix method (Scott & Burke 1980, Scott & Taylor 1982). In these schemes, the wavefunction for an ionic target + electron system is expanded in terms of the target eigenfunctions

$$\Psi = \mathcal{A}\sum_i \chi_i\theta_i + \sum_j c_j\Phi_j \tag{2.3}$$

where $\mathcal{A}$ is the antisymmetrisation operator, χ_i are the target eigenfunctions, θ_i the electron functions, and Φ_j are bound-state type functions of the total system introduced to compensate for orthogonality conditions imposed on the θ_i and to render short-range correlations. In most cases, target level energies are corrected with the experimental values before hamiltonian diagonalisation.

3. Table contents

Table 1: For ions with nuclear charge Z and electron number N, experimental energy levels, $E(Z,N,i)$, are tabulated from the following sources. $E(6\text{–}8,N,i)$: Moore (1993). $E(10\text{–}16,5\text{–}8,i)$: Edlén (1983a, 1983b, 1985). $E(10,9,i)$: Kelly (1987). $E(11\text{–}16,9\text{–}17,i)$: Martin & Zalubas (1979, 1980, 1981, 1983) and Martin *et al.* (1990). $E(18,9\text{–}17,i)$: Shirai *et al.* (1999). $E(20,9\text{–}17,i)$: Sugar & Corliss (1985).
Table 2: A-values, $A(Z,N,j,i)$, and effective collision strengths, $\Upsilon(Z,N,j,i;T)$, for the B, F, Al and Cl sequences. $A(6\text{–}16,5,2,1)$: Galavís *et al.* (1998). $\Upsilon(6\text{–}7,5,2,1)$: Blum & Pradhan (1992). $\Upsilon(8,5,2,1)$: Zhang *et al.* (1994). $\Upsilon(10,5,2,1)$: Mitnik *et al.* (2001). $\Upsilon(12\text{–}16,5,2,1)$: Zhang *et al.* (1994). $\Upsilon(10,9,2,1)$: Griffin *et al.* (2001). $\Upsilon(11\text{–}16,9,2,1)$: Saraph & Tully (1994) and Berrington *et al.* (1998). $\Upsilon(14,13,2,1)$: Dufton & Kingston (1991) (these data are not associated with the IP but are included for completion).

https://doi.org/10.1017/S1743921306002997 Published online by Cambridge University Press

$\Upsilon(16\text{–}20, 13, 2, 1)$: Saraph & Storey (1996, 1999). $\Upsilon(18\text{–}20, 17, 2, 1)$: Pelan & Berrington (1995). $A(Z, N, 2, 1)$ for $N = 9$, $N = 13$ and $N = 17$ have been computed for this work.
Table 3: A-values and effective collision strengths for the C sequence. $A(7\text{–}16, 6, j, i)$: Galavís *et al.* (1997). $\Upsilon(7\text{–}16, 6, j, i)$: Lennon & Burke (1994).
Table 4: A-values and effective collision strengths for the O sequence. $A(10\text{-}18, 8, j, i)$: Galavís *et al.* (1997). $\Upsilon(10\text{–}18, 8, j, i)$: Butler & Zeippen (1994).
Table 5: A-values and effective collision strengths for the Si and S sequences. $A(16\text{–}20, 14, j, i)$: Mendoza & Zeippen (1982). $A(18\text{–}20, 16, j, i)$: Mendoza & Zeippen (1983). $\Upsilon(16\text{–}20, 14, j, i)$ and $\Upsilon(18\text{–}20, 16, j, i)$: Galavís *et al.* (1995).
Note: Effective collision strengths for Fe II are given by Pradhan & Zhang (1993) and Zhang & Pradhan (1995) and for Ni II by Bautista (2004). Collisional data for neutral species have not been calculated in the IP. We nevertheless recommend the following sources. $\Upsilon(6, 6, j, i)$: Johnson *et al.* (1987) and Zatsarinny *et al.* (2005). $\Upsilon(8, 8, j, i)$: Bell *et al.* (1998) and Zatsarinny & Tayal (2003). $\Upsilon(16, 16, j, i)$: Tayal (2004).

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Table 1. Energy levels ($a \pm b \equiv a \times 10^{\pm b}$)

(Z,N,i)	State	E (Ryd)	(Z,N,i)	State	E (Ryd)	(Z,N,i)	State	E (Ryd)
(6, 5, 1)	2p $^2P^o_{1/2}$	0.00000	(13, 6, 5)	2p^2 $^1S_0$	8.77049−1	(12, 9, 1)	2p^5 $^2P^o_{3/2}$	0.00000
(6, 5, 2)	2p $^2P^o_{3/2}$	5.77950−4	(14, 6, 1)	2p^2 $^3P_0$	0.00000	(12, 9, 2)	2p^5 $^2P^o_{1/2}$	2.03035−2
(7, 5, 1)	2p $^2P^o_{1/2}$	0.00000	(14, 6, 2)	2p^2 $^3P_1$	2.32013−2	(13, 9, 1)	2p^5 $^2P^o_{3/2}$	0.00000
(7, 5, 2)	2p $^2P^o_{3/2}$	1.58932−3	(14, 6, 3)	2p^2 $^3P_2$	5.84589−2	(13, 9, 2)	2p^5 $^2P^o_{1/2}$	3.13665−2
(8, 5, 1)	2p $^2P^o_{1/2}$	0.00000	(14, 6, 4)	2p^2 $^1D_2$	4.82316−1	(14, 9, 1)	2p^5 $^2P^o_{3/2}$	0.00000
(8, 5, 2)	2p $^2P^o_{3/2}$	3.51670−3	(14, 6, 5)	2p^2 $^1S_0$	9.82292−1	(14, 9, 2)	2p^5 $^2P^o_{1/2}$	4.63844−2
(10, 5, 1)	2p $^2P^o_{1/2}$	0.00000	(16, 6, 1)	2p^2 $^3P_0$	0.00000	(16, 9, 1)	2p^5 $^2P^o_{3/2}$	0.00000
(10, 5, 2)	2p $^2P^o_{3/2}$	1.19197−2	(16, 6, 2)	2p^2 $^3P_1$	4.74596−2	(16, 9, 2)	2p^5 $^2P^o_{1/2}$	9.19029−2
(12, 5, 1)	2p $^2P^o_{1/2}$	0.00000	(16, 6, 3)	2p^2 $^3P_2$	1.12890−1	(14, 13, 1)	3p $^2P^o_{1/2}$	0.00000
(12, 5, 2)	2p $^2P^o_{3/2}$	3.00907−2	(16, 6, 4)	2p^2 $^1D_2$	6.11899−1	(14, 13, 2)	3p $^2P^o_{3/2}$	2.61750−3
(13, 5, 1)	2p $^2P^o_{1/2}$	0.00000	(16, 6, 5)	2p^2 $^1S_0$	1.21136+0	(16, 13, 1)	3p $^2P^o_{1/2}$	0.00000
(13, 5, 2)	2p $^2P^o_{3/2}$	4.45619−2	(10, 8, 1)	2p^4 $^3P_2$	0.00000	(16, 13, 2)	3p $^2P^o_{3/2}$	8.67022−3
(14, 5, 1)	2p $^2P^o_{1/2}$	0.00000	(10, 8, 2)	2p^4 $^3P_1$	5.85961−3	(18, 13, 1)	3p $^2P^o_{1/2}$	0.00000
(14, 5, 2)	2p $^2P^o_{3/2}$	6.36988−2	(10, 8, 3)	2p^4 $^3P_0$	8.39300−3	(18, 13, 2)	3p $^2P^o_{3/2}$	2.01129−2
(16, 5, 1)	2p $^2P^o_{1/2}$	0.00000	(10, 8, 4)	2p^4 $^1D_2$	2.35487−1	(20, 13, 1)	3p $^2P^o_{1/2}$	0.00000
(16, 5, 2)	2p $^2P^o_{3/2}$	1.19706−1	(10, 8, 5)	2p^4 $^1S_0$	5.08054−1	(20, 13, 2)	3p $^2P^o_{3/2}$	3.92607−2
(7, 6, 1)	2p^2 $^3P_0$	0.00000	(11, 8, 1)	2p^4 $^3P_2$	0.00000	(16, 14, 1)	3p^2 $^3P_0$	0.00000
(7, 6, 2)	2p^2 $^3P_1$	4.43804−4	(11, 8, 2)	2p^4 $^3P_1$	1.00880−2	(16, 14, 2)	3p^2 $^3P_1$	2.72191−3
(7, 6, 3)	2p^2 $^3P_2$	1.19198−3	(11, 8, 3)	2p^4 $^3P_0$	1.43619−2	(16, 14, 3)	3p^2 $^3P_2$	7.59171−3
(7, 6, 4)	2p^2 $^1D_2$	1.39578−1	(11, 8, 4)	2p^4 $^1D_2$	2.81051−1	(16, 14, 4)	3p^2 $^1D_2$	1.03182−1
(7, 6, 5)	2p^2 $^1S_0$	2.97895−1	(11, 8, 5)	2p^4 $^1S_0$	6.05971−1	(16, 14, 5)	3p^2 $^1S_0$	2.47513−1
(8, 6, 1)	2p^2 $^3P_0$	0.00000	(12, 8, 1)	2p^4 $^3P_2$	0.00000	(18, 14, 1)	3p^2 $^3P_0$	0.00000
(8, 6, 2)	2p^2 $^3P_1$	1.03139−3	(12, 8, 2)	2p^4 $^3P_1$	1.62483−2	(18, 14, 2)	3p^2 $^3P_1$	6.97338−3
(8, 6, 3)	2p^2 $^3P_2$	2.79016−3	(12, 8, 3)	2p^4 $^3P_0$	2.29736−2	(18, 14, 3)	3p^2 $^3P_2$	1.84890−2
(8, 6, 4)	2p^2 $^1D_2$	1.84750−1	(12, 8, 4)	2p^4 $^1D_2$	3.27380−1	(18, 14, 4)	3p^2 $^1D_2$	1.48529−1
(8, 6, 5)	2p^2 $^1S_0$	3.93551−1	(12, 8, 5)	2p^4 $^1S_0$	7.04307−1	(18, 14, 5)	3p^2 $^1S_0$	3.45484−1
(10, 6, 1)	2p^2 $^3P_0$	0.00000	(13, 8, 1)	2p^4 $^3P_2$	0.00000	(20, 14, 1)	3p^2 $^3P_0$	0.00000
(10, 6, 2)	2p^2 $^3P_1$	3.76364−3	(13, 8, 2)	2p^4 $^3P_1$	2.49054−2	(20, 14, 2)	3p^2 $^3P_1$	1.48074−2
(10, 6, 3)	2p^2 $^3P_2$	1.01245−2	(13, 8, 3)	2p^4 $^3P_0$	3.48749−2	(20, 14, 3)	3p^2 $^3P_2$	3.71018−2
(10, 6, 4)	2p^2 $^1D_2$	2.76039−1	(13, 8, 4)	2p^4 $^1D_2$	3.74967−1	(20, 14, 4)	3p^2 $^1D_2$	1.99242−1
(10, 6, 5)	2p^2 $^1S_0$	5.82452−1	(13, 8, 5)	2p^4 $^1S_0$	8.03809−1	(20, 14, 5)	3p^2 $^1S_0$	4.46357−1
(11, 6, 1)	2p^2 $^3P_0$	0.00000	(14, 8, 1)	2p^4 $^3P_2$	0.00000	(18, 16, 1)	3p^4 $^3P_2$	0.00000
(11, 6, 2)	2p^2 $^3P_1$	6.36080−3	(14, 8, 2)	2p^4 $^3P_1$	3.67066−2	(18, 16, 2)	3p^4 $^3P_1$	1.01351−2
(11, 6, 3)	2p^2 $^3P_2$	1.69318−2	(14, 8, 3)	2p^4 $^3P_0$	5.07403−2	(18, 16, 3)	3p^4 $^3P_0$	1.43092−2
(11, 6, 4)	2p^2 $^1D_2$	3.23562−1	(14, 8, 4)	2p^4 $^1D_2$	4.24367−1	(18, 16, 4)	3p^4 $^1D_2$	1.27670−1
(11, 6, 5)	2p^2 $^1S_0$	6.78208−1	(14, 8, 5)	2p^4 $^1S_0$	9.05298−1	(18, 16, 5)	3p^4 $^1S_0$	3.03144−1
(12, 6, 1)	2p^2 $^3P_0$	0.00000	(16, 8, 1)	2p^4 $^3P_2$	0.00000	(20, 16, 1)	3p^4 $^3P_2$	0.00000
(12, 6, 2)	2p^2 $^3P_1$	1.01882−2	(16, 8, 2)	2p^4 $^3P_1$	7.27659−2	(20, 16, 2)	3p^4 $^3P_1$	2.19135−2
(12, 6, 3)	2p^2 $^3P_2$	2.67281−2	(16, 8, 3)	2p^4 $^3P_0$	9.70334−2	(20, 16, 3)	3p^4 $^3P_0$	2.98499−2
(12, 6, 4)	2p^2 $^1D_2$	3.73236−1	(16, 8, 4)	2p^4 $^1D_2$	5.31232−1	(20, 16, 4)	3p^4 $^1D_2$	1.71597−1
(12, 6, 5)	2p^2 $^1S_0$	7.76080−1	(16, 8, 5)	2p^4 $^1S_0$	1.11814+0	(20, 16, 5)	3p^4 $^1S_0$	3.99473−1
(13, 6, 1)	2p^2 $^3P_0$	0.00000	(10, 9, 1)	2p^5 $^2P^o_{3/2}$	0.00000	(18, 17, 1)	3p^5 $^2P^o_{3/2}$	0.00000
(13, 6, 2)	2p^2 $^3P_1$	1.56286−2	(10, 9, 2)	2p^5 $^2P^o_{1/2}$	7.11117−3	(18, 17, 2)	3p^5 $^2P^o_{1/2}$	1.30457−2
(13, 6, 3)	2p^2 $^3P_2$	4.02697−2	(11, 9, 1)	2p^5 $^2P^o_{3/2}$	0.00000	(20, 17, 1)	3p^5 $^2P^o_{3/2}$	0.00000
(13, 6, 4)	2p^2 $^1D_2$	4.25835−1	(11, 9, 2)	2p^5 $^2P^o_{1/2}$	1.24509−2	(20, 17, 2)	3p^5 $^2P^o_{1/2}$	2.84155−2

https://doi.org/10.1017/S1743921306002997 Published online by Cambridge University Press

Table 2. A-values and $\Upsilon(\log T)$ for the B, F, Al and Cl sequences ($a \pm b \equiv a \times 10^{\pm b}$)

(Z, N, j, i)	A (s^{-1})	$\Upsilon(\log T)$									
		3.00	3.30	3.48	3.60	3.70	3.90	4.00	4.20	4.41	4.60
(6, 5, 2, 1)	2.29−6	1.58+0	1.64+0	1.72+0	1.80+0	1.89+0	2.08+0	2.15+0	2.26+0	2.28+0	2.25+0
		3.00	3.30	3.48	3.60	3.70	3.90	4.00	4.20	4.41	4.60
(7, 5, 2, 1)	4.74−5	1.29+0	1.29+0	1.29+0	1.30+0	1.32+0	1.39+0	1.45+0	1.57+0	1.73+0	1.91+0
		2.95	3.43	3.65	3.86	4.13	4.35	4.65	4.91	5.16	5.61
(8, 5, 2, 1)	5.17−4	1.61+0	1.80+0	1.96+0	2.24+0	2.51+0	2.59+0	2.69+0	2.64+0	2.32+0	1.46+0
		3.40	3.70	4.00	4.40	4.70	5.00	5.40	5.70	6.00	6.40
(10, 5, 2, 1)	2.01−2	3.61+0	3.19+0	2.61+0	1.92+0	1.75+0	1.70+0	1.38+0	1.03+0	7.22−1	4.32−1
		3.69	4.17	4.39	4.59	4.87	5.09	5.39	5.64	5.89	6.34
(12, 5, 2, 1)	3.24−1	8.52−1	1.12+0	1.06+0	1.01+0	1.02+0	1.05+0	9.63−1	7.81−1	5.83−1	3.18−1
		3.81	4.28	4.51	4.71	4.98	5.20	5.51	5.76	6.01	6.46
(13, 5, 2, 1)	1.05+0	5.11−1	4.82−1	7.01−1	9.50−1	1.16+0	1.18+0	1.02+0	7.85−1	5.62−1	2.90−1
		3.91	4.39	4.61	4.81	5.09	5.31	5.61	5.86	6.11	6.56
(14, 5, 2, 1)	3.07+0	1.14+0	1.59+0	1.57+0	1.44+0	1.23+0	1.07+0	8.17−1	5.99−1	4.20−1	2.16−1
		4.08	4.56	4.78	4.99	5.26	5.48	5.63	6.04	6.29	6.74
(16, 5, 2, 1)	2.04+1	1.20−1	2.98−1	4.75−1	6.09−1	7.00−1	6.89−1	6.40−1	4.18−1	2.94−1	1.53−1
		3.00	3.30	3.60	3.90	4.00	4.30	4.60	4.90	5.00	5.30
(10, 9, 2, 1)	8.52−3	2.66−1	2.86−1	2.99−1	3.10−1	3.14−1	3.29−1	3.50−1	3.85−1	4.00−1	4.45−1
		3.00	3.25	3.50	3.75	4.00	4.25	4.50	4.75	5.00	
(11, 9, 2, 1)	4.58−2	3.50−1	3.50−1	3.50−1	3.52−1	3.54−1	3.57−1	3.63−1	3.76−1	4.00−1	
		3.00	3.25	3.50	3.75	4.00	4.20	4.40	4.60	4.80	5.00
(12, 9, 2, 1)	1.99−1	3.56−1	3.56−1	3.56−1	3.56−1	3.57−1	3.58−1	3.61−1	3.68−1	3.83−1	4.05−1
		3.00	3.25	3.50	3.75	4.00	4.25	4.40	4.60	4.80	5.00
(13, 9, 2, 1)	7.33−1	3.81−1	3.87−1	4.03−1	4.50−1	5.07−1	5.24−1	5.14−1	4.90−1	4.70−1	4.64−1
		3.00+0	3.25+0	3.50+0	3.75+0	4.00+0	4.25+0	4.50+0	4.56+0	4.76+0	4.96+0
(14, 9, 2, 1)	2.37+0	3.01−1	3.01−1	2.99−1	2.98−1	2.96−1	2.98−1	3.22−1	3.33−1	3.79−1	4.18−1
		3.50	3.75	4.00	4.25	4.50	4.75	4.81	5.01	5.21	5.41
(16, 9, 2, 1)	1.84+1	1.92−1	1.92−1	1.92−1	1.96−1	2.09−1	2.34−1	2.41−1	2.68−1	2.88−1	2.97−1
		3.60	3.80	4.00	4.20	4.40	4.60				
(14, 13, 2, 1)	2.13−4	5.58+0	5.61+0	5.70+0	5.79+0	5.75+0	5.47+0				
		3.00	3.30	3.48	3.60	3.78	4.00	4.15	4.20	4.45	4.60
(16, 13, 2, 1)	7.73−3	6.89+0	7.11+0	7.52+0	7.85+0	8.27+0	8.55+0	8.51+0	8.44+0	7.92+0	7.47+0
		3.00	3.30	3.48	3.60	3.78	4.00	4.15	4.20	4.45	4.60
(18, 13, 2, 1)	9.66−2	3.11+0	3.40+0	3.86+0	4.35+0	5.13+0	5.90+0	6.19+0	6.26+0	6.36+0	6.33+0
		3.00+0	3.30+0	3.48+0	3.60+0	3.78+0	4.00+0	4.15+0	4.20+0	4.45+0	4.60+0
(20, 13, 2, 1)	7.18−1	2.66+0	3.49+0	4.28+0	4.99+0	5.98+0	6.72+0	6.72+0	6.64+0	6.10+0	5.88+0
		3.20	3.40	3.60	3.80	4.00	4.20	4.40	4.60	4.80	5.00
(18, 17, 2, 1)	5.27−2	2.48+0	2.54+0	2.63+0	2.77+0	2.93+0	3.09+0	3.19+0	3.20+0	3.13+0	2.97+0
		4.00	4.20	4.40	4.60	4.80	5.00	5.20	5.40	5.60	6.00
(20, 17, 2, 1)	5.45−1	1.00+0	1.12+0	1.35+0	1.77+0	2.39+0	2.80+0	2.98+0	2.82+0	2.43+0	1.53+0

Table 3. A-values and $\Upsilon(\log T)$ for the C sequence ($a \pm b \equiv a \times 10^{\pm b}$)

(Z, N, j, i)	A (s^{-1})	$\Upsilon(\log T)$									
		3.00	3.20	3.40	3.60	3.80	4.00	4.20	4.40	4.60	5.00
(7, 6, 2, 1)	2.08−6	3.42−1	3.37−1	3.41−1	3.59−1	3.84−1	4.08−1	4.29−1	4.57−1	4.91−1	5.43−1
(7, 6, 3, 1)	0.00+0	2.19−1	2.21−1	2.27−1	2.35−1	2.50−1	2.72−1	3.01−1	3.31−1	3.53−1	3.49−1
(7, 6, 3, 2)	7.46−6	9.19−1	9.18−1	9.34−1	9.77−1	1.04+0	1.12+0	1.21+0	1.32+0	1.41+0	1.46+0
(7, 6, 4, 1)	3.55−7	2.76−1	2.77−1	2.79−1	2.83−1	2.88−1	2.93−1	3.00−1	3.07−1	3.16−1	3.29−1
(7, 6, 4, 2)	1.02−3	8.27−1	8.31−1	8.38−1	8.49−1	8.63−1	8.80−1	9.00−1	9.22−1	9.49−1	9.87−1
(7, 6, 4, 3)	3.01−3	1.38+0	1.38+0	1.40+0	1.41+0	1.44+0	1.47+0	1.50+0	1.54+0	1.58+0	1.64+0
(7, 6, 5, 1)	0.00+0	3.12−2	3.13−2	3.15−2	3.17−2	3.20−2	3.26−2	3.33−2	3.44−2	3.60−2	3.91−2
(7, 6, 5, 2)	3.30−2	9.37−2	9.40−2	9.44−2	9.51−2	9.61−2	9.77−2	9.99−2	1.03−1	1.08−1	1.17−1
(7, 6, 5, 3)	1.31−4	1.56−1	1.57−1	1.57−1	1.59−1	1.60−1	1.63−1	1.67−1	1.72−1	1.80−1	1.96−1
(7, 6, 5, 4)	1.02+0	1.16+0	1.13+0	1.07+0	1.00+0	9.18−1	8.34−1	7.61−1	7.10−1	6.82−1	6.59−1

Table 3. Continued

(Z, N, j, i)	A (s^{-1})	$\Upsilon(\log T)$									
		3.00	3.20	3.40	3.60	3.80	4.00	4.20	4.40	4.60	5.00
(8, 6, 2, 1)	2.66−5	5.04−1	5.10−1	5.13−1	5.18−1	5.30−1	5.45−1	5.59−1	5.68−1	5.79−1	5.93−1
(8, 6, 3, 1)	0.00+0	2.49−1	2.51−1	2.52−1	2.54−1	2.61−1	2.71−1	2.83−1	2.95−1	3.10−1	3.32−1
(8, 6, 3, 2)	9.70−5	1.19+0	1.20+0	1.21+0	1.22+0	1.25+0	1.29+0	1.34+0	1.37+0	1.42+0	1.48+0
(8, 6, 4, 1)	1.69−6	2.47−1	2.43−1	2.38−1	2.35−1	2.40−1	2.54−1	2.72−1	2.87−1	2.97−1	2.95−1
(8, 6, 4, 2)	6.99−3	7.39−1	7.29−1	7.13−1	7.04−1	7.19−1	7.63−1	8.17−1	8.62−1	8.91−1	8.85−1
(8, 6, 4, 3)	2.04−2	1.23+0	1.21+0	1.19+0	1.17+0	1.20+0	1.27+0	1.36+0	1.44+0	1.49+0	1.48+0
(8, 6, 5, 1)	0.00+0	3.05−2	3.04−2	3.01−2	2.99−2	3.05−2	3.25−2	3.53−2	3.78−2	3.96−2	3.97−2
(8, 6, 5, 2)	2.27−1	9.16−2	9.11−2	9.03−2	8.97−2	9.16−2	9.75−2	1.06−1	1.13−1	1.19−1	1.19−1
(8, 6, 5, 3)	6.09−4	1.53−1	1.52−1	1.50−1	1.49−1	1.53−1	1.62−1	1.76−1	1.89−1	1.98−1	1.99−1
(8, 6, 5, 4)	1.56+0	4.23−1	4.26−1	4.35−1	4.65−1	5.23−1	5.81−1	6.10−1	6.09−1	5.97−1	5.72−1
(10, 6, 2, 1)	1.27−3	1.84+0	1.84+0	1.82+0	1.75+0	1.61+0	1.41+0	1.19+0	1.01+0	8.75−1	7.17−1
(10, 6, 3, 1)	4.97−9	3.24+0	3.20+0	2.98+0	2.64+0	2.23+0	1.81+0	1.42+0	1.10+0	8.71−1	6.10−1
(10, 6, 3, 2)	4.59−3	9.60+0	9.51+0	8.99+0	8.14+0	7.04+0	5.83+0	4.68+0	3.72+0	3.05+0	2.26+0
(10, 6, 4, 1)	1.94−5	1.98−1	2.22−1	2.35−1	2.38−1	2.35−1	2.32−1	2.35−1	2.42−1	2.46−1	2.30−1
(10, 6, 4, 2)	1.25−1	5.93−1	6.65−1	7.05−1	7.14−1	7.05−1	6.95−1	7.04−1	7.25−1	7.37−1	6.89−1
(10, 6, 4, 3)	3.50−1	9.88−1	1.11+0	1.17+0	1.19+0	1.17+0	1.16+0	1.17+0	1.21+0	1.23+0	1.15+0
(10, 6, 5, 1)	0.00+0	3.47−2	3.28−2	3.06−2	2.88−2	2.76−2	2.73−2	2.76−2	2.82−2	2.85−2	2.72−2
(10, 6, 5, 2)	3.99+0	1.04−1	9.83−2	9.18−2	8.63−2	8.29−2	8.18−2	8.28−2	8.46−2	8.55−2	8.17−2
(10, 6, 5, 3)	6.29−3	1.74−1	1.64−1	1.53−1	1.44−1	1.38−1	1.36−1	1.38−1	1.41−1	1.42−1	1.36−1
(10, 6, 5, 4)	2.83+0	5.27−1	6.75−1	7.34−1	7.00−1	6.25−1	5.77−1	6.10−1	6.88−1	7.30−1	6.63−1
(11, 6, 2, 1)	6.11−3	7.56−1	6.97−1	6.81−1	7.06−1	7.42−1	7.70−1	7.72−1	7.43−1	6.92−1	5.82−1
(11, 6, 3, 1)	3.79−8	5.33−1	4.84−1	4.71−1	4.90−1	5.14−1	5.21−1	5.08−1	4.81−1	4.50−1	4.00−1
(11, 6, 3, 2)	2.10−2	2.14+0	1.96+0	1.91+0	1.99+0	2.08+0	2.13+0	2.10+0	2.00+0	1.85+0	1.59+0
(11, 6, 4, 1)	5.01−5	2.05−1	1.97−1	1.88−1	1.79−1	1.70−1	1.62−1	1.55−1	1.51−1	1.50−1	1.47−1
(11, 6, 4, 2)	4.13−1	6.15−1	5.90−1	5.63−1	5.36−1	5.10−1	4.86−1	4.66−1	4.54−1	4.49−1	4.42−1
(11, 6, 4, 3)	1.12+0	1.02+0	9.84−1	9.39−1	8.93−1	8.50−1	8.09−1	7.77−1	7.57−1	7.49−1	7.35−1
(11, 6, 5, 1)	0.00+0	1.94−2	1.94−2	1.93−2	1.92−2	1.92−2	1.91−2	1.91−2	1.94−2	1.99−2	2.02−2
(11, 6, 5, 2)	1.28+1	5.83−2	5.82−2	5.80−2	5.78−2	5.75−2	5.72−2	5.73−2	5.82−2	5.96−2	6.05−2
(11, 6, 5, 3)	1.59−2	9.71−2	9.69−2	9.66−2	9.63−2	9.58−2	9.53−2	9.55−2	9.70−2	9.93−2	1.01−1
(11, 6, 5, 4)	3.39+0	9.67−2	9.88−2	1.02−1	1.05−1	1.09−1	1.16−1	1.28−1	1.50−1	1.89−1	2.87−1
(12, 6, 2, 1)	2.51−2	2.59−1	2.64−1	2.63−1	2.65−1	2.86−1	3.37−1	3.95−1	4.33−1	4.48−1	4.39−1
(12, 6, 3, 1)	2.32−7	1.87−1	1.83−1	1.70−1	1.69−1	2.12−1	3.01−1	3.88−1	4.30−1	4.31−1	3.87−1
(12, 6, 3, 2)	8.05−2	7.43−1	7.42−1	7.12−1	7.12−1	8.31−1	1.08+0	1.32+0	1.45+0	1.46+0	1.36+0
(12, 6, 4, 1)	1.16−4	8.00−2	8.05−2	8.26−2	8.60−2	9.01−2	9.50−2	1.01−1	1.08−1	1.15−1	1.18−1
(12, 6, 4, 2)	1.19+0	2.40−1	2.41−1	2.48−1	2.58−1	2.70−1	2.85−1	3.03−1	3.24−1	3.44−1	3.55−1
(12, 6, 4, 3)	3.11+0	4.00−1	4.02−1	4.13−1	4.30−1	4.51−1	4.75−1	5.05−1	5.41−1	5.74−1	5.91−1
(12, 6, 5, 1)	0.00+0	2.19−2	2.37−2	2.46−2	2.39−2	2.22−2	2.05−2	1.95−2	1.90−2	1.86−2	1.74−2
(12, 6, 5, 2)	3.58+1	6.57−2	7.11−2	7.38−2	7.18−2	6.67−2	6.16−2	5.84−2	5.69−2	5.58−2	5.22−2
(12, 6, 5, 3)	3.61−2	1.09−1	1.19−1	1.23−1	1.20−1	1.11−1	1.03−1	9.72−2	9.45−2	9.26−2	8.66−2
(12, 6, 5, 4)	3.96+0	3.17−1	4.18−1	5.10−1	5.41−1	5.09−1	4.46−1	3.90−1	3.73−1	3.86−1	3.90−1
(13, 6, 2, 1)	9.05−2	1.93−1	1.96−1	2.09−1	2.32−1	2.54−1	2.74−1	2.99−1	3.36−1	3.73−1	3.89−1
(13, 6, 3, 1)	1.18−6	7.82−2	8.10−2	8.83−2	1.00−1	1.13−1	1.26−1	1.46−1	1.84−1	2.28−1	2.68−1
(13, 6, 3, 2)	2.66−1	4.15−1	4.25−1	4.57−1	5.13−1	5.71−1	6.23−1	7.00−1	8.27−1	9.65−1	1.06+0
(13, 6, 4, 1)	2.50−4	2.63−1	2.60−1	2.47−1	2.24−1	1.97−1	1.73−1	1.54−1	1.39−1	1.27−1	1.08−1
(13, 6, 4, 2)	3.12+0	7.89−1	7.79−1	7.42−1	6.71−1	5.90−1	5.18−1	4.61−1	4.17−1	3.81−1	3.25−1
(13, 6, 4, 3)	7.75+0	1.31+0	1.30+0	1.24+0	1.12+0	9.83−1	8.63−1	7.69−1	6.95−1	6.35−1	5.41−1
(13, 6, 5, 1)	0.00+0	1.41−2	1.35−2	1.30−2	1.26−2	1.23−2	1.22−2	1.20−2	1.20−2	1.21−2	1.23−2
(13, 6, 5, 2)	8.98+1	4.24−2	4.06−2	3.91−2	3.79−2	3.70−2	3.65−2	3.61−2	3.60−2	3.63−2	3.68−2
(13, 6, 5, 3)	7.60−2	7.07−2	6.77−2	6.52−2	6.31−2	6.17−2	6.08−2	6.02−2	6.00−2	6.05−2	6.13−2
(13, 6, 5, 4)	4.54+0	1.34+0	1.36+0	1.30+0	1.15+0	9.86−1	8.16−1	6.54−1	5.09−1	3.96−1	2.89−1
(14, 6, 2, 1)	2.96−1	3.50−1	5.11−1	7.37−1	9.22−1	9.76−1	9.02−1	7.64−1	6.24−1	5.13−1	3.81−1
(14, 6, 3, 1)	5.24−6	2.64−1	3.63−1	5.18−1	6.54−1	6.98−1	6.45−1	5.44−1	4.44−1	3.66−1	2.75−1
(14, 6, 3, 2)	7.78−1	1.03+0	1.45+0	2.06+0	2.57+0	2.71+0	2.50+0	2.11+0	1.72+0	1.41+0	1.05+0
(14, 6, 4, 1)	5.03−4	6.46−2	6.52−2	6.79−2	7.21−2	7.56−2	7.68−2	7.61−2	7.52−2	7.48−2	7.44−2
(14, 6, 4, 2)	7.53+0	1.94−1	1.96−1	2.04−1	2.16−1	2.27−1	2.30−1	2.28−1	2.26−1	2.24−1	2.23−1
(14, 6, 4, 3)	1.77+1	3.23−1	3.26−1	3.39−1	3.61−1	3.78−1	3.84−1	3.81−1	3.76−1	3.74−1	3.72−1
(14, 6, 5, 1)	0.00+0	8.89−3	8.89−3	8.89−3	8.88−3	8.88−3	8.97−3	9.38−3	1.01−2	1.08−2	1.12−2
(14, 6, 5, 2)	2.06+2	2.67−2	2.67−2	2.67−2	2.66−2	2.66−2	2.69−2	2.81−2	3.03−2	3.24−2	3.36−2
(14, 6, 5, 3)	1.51−1	4.45−2	4.44−2	4.44−2	4.44−2	4.44−2	4.48−2	4.69−2	5.05−2	5.39−2	5.60−2
(14, 6, 5, 4)	5.15+0	6.21−2	6.23−2	6.26−2	6.34−2	6.61−2	7.20−2	7.94−2	8.90−2	1.06−1	1.55−1
(16, 6, 2, 1)	2.52+0	9.77−2	9.81−2	9.99−2	1.06−1	1.16−1	1.28−1	1.43−1	1.62−1	1.86−1	2.18−1
(16, 6, 3, 1)	7.33−5	5.05−2	5.07−2	5.11−2	5.23−2	5.46−2	5.92−2	6.91−2	8.64−2	1.11−1	1.50−1
(16, 6, 3, 2)	4.93+0	2.35−1	2.35−1	2.39−1	2.49−1	2.67−1	2.92−1	3.32−1	3.93−1	4.75−1	5.96−1
(16, 6, 4, 1)	1.77−3	4.65−2	4.85−2	5.00−2	5.24−2	5.76−2	6.37−2	6.80−2	6.90−2	6.71−2	6.03−2
(16, 6, 4, 2)	3.70+1	1.40−1	1.46−1	1.50−1	1.57−1	1.73−1	1.91−1	2.04−1	2.07−1	2.01−1	1.81−1
(16, 6, 4, 3)	7.58+1	2.33−1	2.43−1	2.50−1	2.62−1	2.88−1	3.18−1	3.40−1	3.45−1	3.36−1	3.01−1
(16, 6, 5, 1)	0.00+0	5.93−3	5.95−3	6.09−3	6.48−3	6.95−3	7.22−3	7.18−3	6.97−3	6.77−3	6.60−3
(16, 6, 5, 2)	8.88+2	1.78−2	1.79−2	1.83−2	1.94−2	2.09−2	2.16−2	2.15−2	2.09−2	2.03−2	1.98−2
(16, 6, 5, 3)	5.19−1	2.97−2	2.98−2	3.05−2	3.24−2	3.48−2	3.61−2	3.59−2	3.49−2	3.38−2	3.30−2
(16, 6, 5, 4)	6.48+0	1.08−1	1.17−1	1.58−1	2.72−1	4.28−1	5.41−1	5.59−1	5.01−1	4.09−1	2.62−1

https://doi.org/10.1017/S1743921306002997 Published online by Cambridge University Press

Table 4. *A*-values and $\Upsilon(\log T)$ for the O sequence ($a \pm b \equiv a \times 10^{\pm b}$)

(Z, N, j, i)	A (s^{-1})	$\Upsilon(\log T)$									
		3.00	3.20	3.40	3.60	3.80	4.00	4.20	4.40	4.60	5.00
(10, 8, 2, 1)	5.97−3	4.81−1	5.45−1	6.34−1	7.08−1	7.52−1	7.75−1	7.79−1	7.71−1	7.64−1	8.08−1
(10, 8, 3, 1)	2.08−8	1.28−1	1.49−1	1.74−1	1.94−1	2.04−1	2.09−1	2.09−1	2.05−1	2.03−1	2.15−1
(10, 8, 3, 2)	1.16−3	1.54−1	1.68−1	1.94−1	2.18−1	2.35−1	2.44−1	2.48−1	2.47−1	2.46−1	2.59−1
(10, 8, 4, 1)	1.73−1	7.49−1	7.65−1	7.71−1	7.67−1	7.60−1	7.54−1	7.49−1	7.46−1	7.49−1	7.82−1
(10, 8, 4, 2)	5.34−2	4.50−1	4.59−1	4.62−1	4.60−1	4.56−1	4.52−1	4.49−1	4.47−1	4.49−1	4.69−1
(10, 8, 4, 3)	8.27−6	1.50−1	1.53−1	1.54−1	1.54−1	1.52−1	1.51−1	1.50−1	1.49−1	1.50−1	1.56−1
(10, 8, 5, 1)	3.98−3	8.33−2	8.33−2	8.34−2	8.35−2	8.35−2	8.35−2	8.38−2	8.57−2	9.00−2	9.96−2
(10, 8, 5, 2)	2.03+0	5.00−2	5.00−2	5.00−2	5.01−2	5.01−2	5.01−2	5.03−2	5.14−2	5.40−2	5.98−2
(10, 8, 5, 3)	0.00+0	1.67−2	1.67−2	1.67−2	1.67−2	1.67−2	1.67−2	1.68−2	1.71−2	1.80−2	1.99−2
(10, 8, 5, 4)	2.56+0	2.66−1	2.66−1	2.66−1	2.66−1	2.67−1	2.69−1	2.77−1	2.92−1	3.10−1	3.33−1
(11, 8, 2, 1)	3.05−2	6.98−1	7.50−1	7.81−1	7.89−1	7.90−1	8.02−1	8.27−1	8.50−1	8.61−1	9.19−1
(11, 8, 3, 1)	1.60−7	1.78−1	1.94−1	2.02−1	2.03−1	2.02−1	2.05−1	2.13−1	2.21−1	2.25−1	2.50−1
(11, 8, 3, 2)	5.56−3	2.37−1	2.51−1	2.61−1	2.66−1	2.69−1	2.73−1	2.79−1	2.83−1	2.83−1	2.86−1
(11, 8, 4, 1)	6.15−1	6.10−1	6.15−1	6.14−1	6.03−1	5.95−1	6.10−1	6.49−1	6.96−1	7.34−1	7.64−1
(11, 8, 4, 2)	1.84−1	3.66−1	3.69−1	3.68−1	3.62−1	3.57−1	3.66−1	3.90−1	4.18−1	4.40−1	4.58−1
(11, 8, 4, 3)	2.20−5	1.22−1	1.23−1	1.23−1	1.21−1	1.19−1	1.22−1	1.30−1	1.39−1	1.47−1	1.53−1
(11, 8, 5, 1)	1.07−2	1.00−1	9.99−2	9.93−2	9.84−2	9.76−2	9.80−2	9.94−2	1.01−1	1.02−1	1.01−1
(11, 8, 5, 2)	7.15+0	6.02−2	6.00−2	5.96−2	5.90−2	5.86−2	5.88−2	5.97−2	6.06−2	6.12−2	6.09−2
(11, 8, 5, 3)	0.00+0	2.01−2	2.00−2	1.99−2	1.97−2	1.95−2	1.96−2	1.99−2	2.02−2	2.04−2	2.03−2
(11, 8, 5, 4)	3.32+0	2.08−1	2.08−1	2.07−1	2.07−1	2.08−1	2.12−1	2.19−1	2.29−1	2.41−1	2.72−1
(12, 8, 2, 1)	1.27−1	5.01−1	5.10−1	5.54−1	6.37−1	7.48−1	8.52−1	9.08−1	9.32−1	9.74−1	1.06+0
(12, 8, 3, 1)	9.68−7	1.16−1	1.21−1	1.36−1	1.63−1	1.97−1	2.25−1	2.40−1	2.46−1	2.62−1	2.97−1
(12, 8, 3, 2)	2.17−2	1.92−1	1.91−1	1.97−1	2.15−1	2.45−1	2.76−1	2.96−1	3.02−1	3.07−1	3.11−1
(12, 8, 4, 1)	1.87+0	7.27−1	7.20−1	7.20−1	7.23−1	7.26−1	7.32−1	7.42−1	7.42−1	7.26−1	6.76−1
(12, 8, 4, 2)	5.35−1	4.36−1	4.32−1	4.32−1	4.34−1	4.35−1	4.39−1	4.45−1	4.45−1	4.35−1	4.06−1
(12, 8, 4, 3)	5.15−5	1.45−1	1.44−1	1.44−1	1.45−1	1.45−1	1.46−1	1.48−1	1.48−1	1.45−1	1.35−1
(12, 8, 5, 1)	2.50−2	7.10−2	7.60−2	8.30−2	9.00−2	9.20−2	9.10−2	8.80−2	8.50−2	8.40−2	8.40−2
(12, 8, 5, 2)	2.16+1	4.20−2	4.50−2	5.00−2	5.40−2	5.50−2	5.50−2	5.30−2	5.10−2	5.00−2	5.00−2
(12, 8, 5, 3)	0.00+0	1.40−2	1.50−2	1.70−2	1.80−2	1.80−2	1.80−2	1.80−2	1.70−2	1.70−2	1.70−2
(12, 8, 5, 4)	4.09+0	1.81−1	1.82−1	1.82−1	1.82−1	1.81−1	1.82−1	1.86−1	1.99−1	2.21−1	2.78−1
(13, 8, 2, 1)	4.58−1	5.71+0	5.44+0	5.42+0	5.47+0	5.27+0	4.67+0	3.83+0	2.97+0	2.24+0	1.37+0
(13, 8, 3, 1)	4.85−6	2.01+0	1.90+0	1.86+0	1.83+0	1.73+0	1.50+0	1.20+0	9.14−1	6.75−1	3.95−1
(13, 8, 3, 2)	7.05−2	9.50−1	9.36−1	9.93−1	1.08+0	1.11+0	1.04+0	8.97−1	7.30−1	5.78−1	3.82−1
(13, 8, 4, 1)	5.03+0	6.66−1	6.82−1	6.76−1	6.63−1	6.50−1	6.31−1	6.06−1	5.80−1	5.61−1	5.55−1
(13, 8, 4, 2)	1.37+0	4.00−1	4.09−1	4.05−1	3.98−1	3.90−1	3.79−1	3.63−1	3.48−1	3.36−1	3.33−1
(13, 8, 4, 3)	1.08−4	1.33−1	1.37−1	1.35−1	1.33−1	1.30−1	1.26−1	1.21−1	1.16−1	1.12−1	1.11−1
(13, 8, 5, 1)	5.29−2	4.94−2	5.08−2	5.65−2	6.54−2	7.35−2	7.83−2	8.02−2	8.07−2	8.03−2	7.75−2
(13, 8, 5, 2)	5.76+1	2.96−2	3.05−2	3.39−2	3.92−2	4.41−2	4.70−2	4.81−2	4.84−2	4.82−2	4.65−2
(13, 8, 5, 3)	0.00+0	9.88−3	1.02−2	1.13−2	1.31−2	1.47−2	1.57−2	1.60−2	1.61−2	1.61−2	1.55−2
(13, 8, 5, 4)	4.89+0	2.58−1	3.01−1	3.66−1	4.18−1	4.29−1	4.17−1	4.24−1	4.63−1	4.87−1	4.28−1
(14, 8, 2, 1)	1.47+0	3.14−1	3.44−1	3.82−1	4.17−1	4.41−1	4.61−1	4.86−1	5.14−1	5.58−1	6.95−1
(14, 8, 3, 1)	2.07−5	6.59−2	7.44−2	8.43−2	9.24−2	9.81−2	1.04−1	1.12−1	1.22−1	1.38−1	1.88−1
(14, 8, 3, 2)	1.96−1	1.33−1	1.41−1	1.54−1	1.67−1	1.76−1	1.82−1	1.88−1	1.92−1	1.99−1	2.17−1
(14, 8, 4, 1)	1.23+1	8.21−1	7.87−1	7.42−1	6.89−1	6.36−1	5.87−1	5.48−1	5.17−1	4.93−1	4.57−1
(14, 8, 4, 2)	3.14+0	4.93−1	4.72−1	4.45−1	4.14−1	3.81−1	3.52−1	3.29−1	3.10−1	2.96−1	2.74−1
(14, 8, 4, 3)	2.11−4	1.64−1	1.57−1	1.48−1	1.38−1	1.27−1	1.17−1	1.09−1	1.04−1	9.87−2	9.14−2
(14, 8, 5, 1)	1.03−1	5.70−2	5.74−2	6.00−2	6.63−2	7.34−2	7.69−2	7.58−2	7.22−2	6.82−2	6.23−2
(14, 8, 5, 2)	1.40+2	3.42−2	3.44−2	3.60−2	3.98−2	4.41−2	4.61−2	4.55−2	4.33−2	4.09−2	3.74−2
(14, 8, 5, 3)	0.00+0	1.14−2	1.15−2	1.20−2	1.33−2	1.47−2	1.54−2	1.52−2	1.44−2	1.36−2	1.25−2
(14, 8, 5, 4)	5.72+0	8.87−2	8.89−2	8.95−2	9.05−2	9.20−2	9.34−2	9.48−2	9.81−2	1.07−1	1.50−1
(16, 8, 2, 1)	1.14+1	8.92−1	1.29+0	2.05+0	2.79+0	3.06+0	2.85+0	2.39+0	1.89+0	1.46+0	9.07−1
(16, 8, 3, 1)	2.57−4	2.63−1	4.25−1	7.23−1	9.93−1	1.08+0	9.90−1	8.09−1	6.19−1	4.58−1	2.64−1
(16, 8, 3, 2)	1.01+0	2.44−1	2.70−1	3.46−1	4.44−1	5.03−1	5.01−1	4.59−1	4.04−1	3.46−1	2.51−1
(16, 8, 4, 1)	5.95+1	1.02+0	1.04+0	9.70−1	8.38−1	6.87−1	5.56−1	4.61−1	4.03−1	3.72−1	3.48−1
(16, 8, 4, 2)	1.28+1	6.11−1	6.22−1	5.82−1	5.03−1	4.12−1	3.33−1	2.77−1	2.42−1	2.23−1	2.09−1
(16, 8, 4, 3)	6.59−4	2.04−1	2.07−1	1.94−1	1.68−1	1.37−1	1.11−1	9.22−2	8.05−2	7.43−2	6.95−2
(16, 8, 5, 1)	3.22−1	4.01−2	3.99−2	3.97−2	3.94−2	3.93−2	3.97−2	4.14−2	4.33−2	4.44−2	4.33−2
(16, 8, 5, 2)	6.59+2	2.41−2	2.40−2	2.38−2	2.36−2	2.36−2	2.38−2	2.48−2	2.60−2	2.66−2	2.60−2
(16, 8, 5, 3)	0.00+0	8.02−3	7.99−3	7.94−3	7.88−3	7.85−3	7.95−3	8.27−3	8.67−3	8.88−3	8.65−3
(16, 8, 5, 4)	7.51+0	8.54−2	8.58−2	8.65−2	8.78−2	9.21−2	1.11−1	1.63−1	2.36−1	2.90−1	2.83−1
(18, 8, 2, 1)	6.68+1	2.12−1	2.19−1	2.32−1	2.51−1	2.81−1	3.25−1	3.82−1	4.59−1	5.51−1	6.39−1
(18, 8, 3, 1)	2.13−3	4.82−2	5.04−2	5.46−2	6.08−2	7.01−2	8.28−2	9.72−2	1.15−1	1.40−1	1.70−1
(18, 8, 3, 2)	3.02+0	8.32−2	8.45−2	8.72−2	9.16−2	9.88−2	1.11−1	1.31−1	1.60−1	1.90−1	2.06−1
(18, 8, 4, 1)	2.33+2	1.94−1	1.94−1	1.94−1	1.96−1	2.00−1	2.08−1	2.14−1	2.17−1	2.14−1	2.06−1
(18, 8, 4, 2)	4.02+1	1.16−1	1.16−1	1.16−1	1.17−1	1.20−1	1.25−1	1.29−1	1.30−1	1.28−1	1.24−1
(18, 8, 4, 3)	1.71−3	3.87−2	3.88−2	3.88−2	3.91−2	4.00−2	4.15−2	4.29−2	4.33−2	4.28−2	4.12−2
(18, 8, 5, 1)	8.20−1	2.59−2	2.59−2	2.59−2	2.59−2	2.59−2	2.59−2	2.59−2	2.61−2	2.65−2	2.76−2
(18, 8, 5, 2)	2.50+3	1.55−2	1.55−2	1.55−2	1.55−2	1.55−2	1.55−2	1.55−2	1.56−2	1.59−2	1.65−2
(18, 8, 5, 3)	0.00+0	5.18−3	5.18−3	5.18−3	5.18−3	5.18−3	5.17−3	5.18−3	5.21−3	5.29−3	5.51−3
(18, 8, 5, 4)	9.69+0	4.91−2	4.92−2	4.92−2	4.93−2	4.95−2	5.00−2	5.16−2	5.59−2	6.48−2	9.78−2

Table 5. A-values and $\Upsilon(\log T)$ for the Si and S sequences ($a \pm b \equiv a \times 10^{\pm b}$)

(Z, N, j, i)	A (s^{-1})	$\Upsilon(\log T)$									
		3.00	3.20	3.40	3.60	3.80	4.00	4.20	4.40	4.60	5.00
(16, 14, 2, 1)	4.72−4	1.72+0	1.87+0	2.01+0	2.16+0	2.29+0	2.33+0	2.28+0	2.18+0	2.08+0	1.72+0
(16, 14, 3, 1)	4.61−8	8.03−1	8.10−1	8.66−1	9.58−1	1.04+0	1.11+0	1.21+0	1.33+0	1.41+0	1.31+0
(16, 14, 3, 2)	2.07−3	3.96+0	4.16+0	4.45+0	4.85+0	5.20+0	5.41+0	5.56+0	5.71+0	5.78+0	5.10+0
(16, 14, 4, 1)	5.82−6	6.29−1	7.44−1	8.37−1	8.82−1	8.85−1	8.79−1	8.85−1	8.88−1	8.69−1	7.19−1
(16, 14, 4, 2)	2.21−2	1.89+0	2.23+0	2.51+0	2.65+0	2.65+0	2.64+0	2.65+0	2.66+0	2.61+0	2.16+0
(16, 14, 4, 3)	5.76−2	3.14+0	3.72+0	4.19+0	4.41+0	4.42+0	4.39+0	4.42+0	4.44+0	4.34+0	3.60+0
(16, 14, 5, 1)	0.00+0	1.39−1	1.35−1	1.29−1	1.24−1	1.22−1	1.22−1	1.25−1	1.32−1	1.40−1	1.27−1
(16, 14, 5, 2)	7.96−1	4.17−1	4.06−1	3.88−1	3.73−1	3.66−1	3.66−1	3.75−1	3.96−1	4.19−1	3.82−1
(16, 14, 5, 3)	1.05−2	6.95−1	6.77−1	6.47−1	6.21−1	6.09−1	6.10−1	6.24−1	6.60−1	6.99−1	6.36−1
(16, 14, 5, 4)	2.22+0	9.93−1	9.72−1	9.43−1	9.56−1	1.08+0	1.29+0	1.53+0	1.77+0	1.96+0	2.02+0
(18, 14, 2, 1)	7.99−3	4.23+0	4.02+0	3.80+0	3.56+0	3.29+0	2.96+0	2.60+0	2.25+0	1.98+0	1.68+0
(18, 14, 3, 1)	1.24−6	1.88+0	1.88+0	1.95+0	2.00+0	1.97+0	1.86+0	1.69+0	1.52+0	1.41+0	1.29+0
(18, 14, 3, 2)	2.72−2	9.52+0	9.27+0	9.13+0	8.94+0	8.55+0	7.88+0	7.04+0	6.24+0	5.66+0	5.00+0
(18, 14, 4, 1)	3.50−5	4.79−1	4.10−1	3.80−1	3.64−1	3.52−1	3.49−1	3.64−1	3.99−1	4.47−1	4.95−1
(18, 14, 4, 2)	2.04−1	1.44+0	1.23+0	1.14+0	1.09+0	1.06+0	1.05+0	1.09+0	1.20+0	1.34+0	1.48+0
(18, 14, 4, 3)	4.76−1	2.39+0	2.05+0	1.90+0	1.82+0	1.76+0	1.74+0	1.82+0	2.00+0	2.24+0	2.47+0
(18, 14, 5, 1)	0.00+0	4.47−2	5.16−2	5.71−2	5.98−2	6.09−2	6.19−2	6.48−2	7.06−2	7.74−2	7.91−2
(18, 14, 5, 2)	6.55+0	1.34−1	1.55−1	1.71−1	1.79−1	1.83−1	1.86−1	1.94−1	2.12−1	2.32−1	2.37−1
(18, 14, 5, 3)	5.69−2	2.23−1	2.58−1	2.85−1	2.99−1	3.05−1	3.10−1	3.24−1	3.53−1	3.87−1	3.95−1
(18, 14, 5, 4)	3.29+0	2.05+0	1.86+0	1.74+0	1.68+0	1.64+0	1.62+0	1.63+0	1.68+0	1.74+0	1.74+0
(20, 14, 2, 1)	7.66−2	1.27+0	1.27+0	1.28+0	1.26+0	1.20+0	1.15+0	1.22+0	1.37+0	1.51+0	1.59+0
(20, 14, 3, 1)	1.78−5	9.66−1	1.00+0	1.03+0	1.02+0	9.88−1	9.96−1	1.12+0	1.31+0	1.45+0	1.45+0
(20, 14, 3, 2)	1.95−1	3.76+0	3.84+0	3.93+0	3.88+0	3.72+0	3.68+0	4.04+0	4.66+0	5.15+0	5.25+0
(20, 14, 4, 1)	1.44−4	6.29−1	5.27−1	4.50−1	4.18−1	4.32−1	4.67−1	4.89−1	4.87−1	4.65−1	3.90−1
(20, 14, 4, 2)	1.19+0	1.89+0	1.58+0	1.35+0	1.25+0	1.29+0	1.40+0	1.47+0	1.46+0	1.39+0	1.17+0
(20, 14, 4, 3)	2.41+0	3.15+0	2.63+0	2.25+0	2.09+0	2.16+0	2.33+0	2.45+0	2.43+0	2.32+0	1.95+0
(20, 14, 5, 1)	0.00+0	6.78−2	8.33−2	1.00−1	1.09−1	1.06−1	9.60−2	8.46−2	7.55−2	6.87−2	5.59−2
(20, 14, 5, 2)	3.32+1	2.04−1	2.50−1	3.00−1	3.27−1	3.19−1	2.88−1	2.54−1	2.27−1	2.06−1	1.68−1
(20, 14, 5, 3)	2.19−1	3.39−1	4.17−1	5.01−1	5.46−1	5.32−1	4.80−1	4.23−1	3.78−1	3.43−1	2.79−1
(20, 14, 5, 4)	4.49+0	5.96−1	6.37−1	6.45−1	6.30−1	6.13−1	6.29−1	7.20−1	8.82−1	1.05+0	1.20+0
(18, 16, 2, 1)	3.08−2	3.71+0	3.50+0	3.34+0	3.22+0	3.14+0	3.09+0	3.12+0	3.21+0	3.32+0	3.16+0
(18, 16, 3, 1)	2.37−6	7.23−1	6.95−1	6.76−1	6.65−1	6.60−1	6.71−1	7.15−1	7.81−1	8.54−1	8.98−1
(18, 16, 3, 2)	5.17−3	1.67+0	1.55+0	1.45+0	1.38+0	1.32+0	1.26+0	1.21+0	1.16+0	1.13+0	1.01+0
(18, 16, 4, 1)	3.14−1	2.61+0	2.67+0	2.71+0	2.72+0	2.70+0	2.66+0	2.62+0	2.60+0	2.58+0	2.30+0
(18, 16, 4, 2)	8.23−2	1.57+0	1.60+0	1.63+0	1.63+0	1.62+0	1.60+0	1.57+0	1.56+0	1.55+0	1.39+0
(18, 16, 4, 3)	2.21−5	5.23−1	5.35−1	5.42−1	5.44−1	5.39−1	5.32−1	5.24−1	5.19−1	5.18−1	4.65−1
(18, 16, 5, 1)	4.17−2	4.73−1	4.93−1	4.93−1	4.82−1	4.71−1	4.63−1	4.58−1	4.52−1	4.44−1	3.84−1
(18, 16, 5, 2)	3.91+0	2.84−1	2.96−1	2.96−1	2.89−1	2.83−1	2.78−1	2.75−1	2.71−1	2.64−1	2.21−1
(18, 16, 5, 3)	0.00+0	9.46−2	9.87−2	9.86−2	9.65−2	9.42−2	9.27−2	9.15−2	9.01−2	8.76−2	7.20−2
(18, 16, 5, 4)	2.59+0	1.58+0	1.48+0	1.37+0	1.29+0	1.25+0	1.23+0	1.21+0	1.18+0	1.18+0	1.25+0
(20, 16, 2, 1)	3.10−1	2.65+0	2.37+0	2.22+0	2.18+0	2.22+0	2.30+0	2.44+0	2.68+0	3.00+0	3.35+0
(20, 16, 3, 1)	3.67−5	6.44−1	5.86−1	5.69−1	5.86−1	6.13−1	6.48−1	7.04−1	7.89−1	8.87−1	9.73−1
(20, 16, 3, 2)	3.54−2	9.64−1	8.42−1	7.48−1	6.92−1	6.72−1	6.75−1	6.88−1	7.28−1	8.06−1	9.30−1
(20, 16, 4, 1)	1.90+0	1.77+0	1.61+0	1.52+0	1.53+0	1.60+0	1.71+0	1.86+0	2.05+0	2.22+0	2.13+0
(20, 16, 4, 2)	4.26−1	1.06+0	9.67−1	9.12−1	9.20−1	9.61−1	1.03+0	1.12+0	1.23+0	1.33+0	1.27+0
(20, 16, 4, 3)	8.42−5	3.53−1	3.22−1	3.04−1	3.06−1	3.20−1	3.42−1	3.73−1	4.11−1	4.43−1	4.25−1
(20, 16, 5, 1)	1.45−1	8.13−2	9.11−2	1.10−1	1.50−1	2.11−1	2.90−1	3.83−1	4.58−1	4.83−1	3.96−1
(20, 16, 5, 2)	2.31+1	4.88−2	5.47−2	6.61−2	8.99−2	1.26−1	1.74−1	2.30−1	2.75−1	2.90−1	2.37−1
(20, 16, 5, 3)	0.00+0	1.63−2	1.82−2	2.20−2	3.00−2	4.21−2	5.80−2	7.67−2	9.16−2	9.66−2	7.91−2
(20, 16, 5, 4)	3.73+0	1.10+0	1.21+0	1.29+0	1.34+0	1.36+0	1.35+0	1.36+0	1.38+0	1.40+0	1.27+0