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Calculations of the Atomic Structure for Fe XVII Lines

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Energy levels, line strengths, oscillator strengths, radiative decay rates and fine structure collision strengths are presented for sixteen-times ionized iron (Fe XVII). The atomic data are calculated with the AUTOSTRUCTURE code, where relativistic corrections are introduced according to the Breit–Pauli distorted wave approach. The calculations of atomic data for 89 fine-structure levels generated from eleven configurations $2s^22p^6$, $2s^22p^5$ ($3s$, $3p$, $3d$), $2s^22p^5$ ($4s$, $4p$, $4d$, $4f$) and $2s^12p^6$ ($3s$, $3p$, $3d$) of the Ne-like Fe ion are presented. Fine structure collision strengths for transitions from the ground and the first four excited levels are presented at four electron energies: 75, 125, 175, and 250 Ry. These atomic structure data are compared with the available experimental and theoretical results.

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1. Introduction

The most important parameters in atomic spectroscopy are the oscillator strengths and radiative decay rates. The obtained values for the oscillator strengths and radiative decay rates include some important information about the selection of relevant transitions, temperature and atomic concentrations. Many research and technology areas such as astrophysics, plasma physics, thermonuclear fusion researches and isotope separation by laser are based mainly on the atomic data and therefore many research groups have worked to obtain such useful data using atomic spectroscopy. Radiative decay rates and collision strengths are required for the spectral analysis and modeling of non-local thermodynamic equilibrium plasma. Oscillator strengths are also crucial for the study of laboratory and solar spectra [1].

The sixteen-times ionized iron, Fe XVII, belongs to the neon isoelectronic sequence. The ground configuration of Fe XVII has a stable closed L-shell structure (neon core) rendering Fe XVII the dominant Fe ion species in many laboratory and cosmic plasma. Owing to its importance Fe XVII has also become a benchmark ion, and one of the most extensively studied for its spectral diagnostic potential in plasma- and astrophysics [2]. A number of works dealing with the atomic structure of Fe XVII exist in the literature. Loulergue and Nussbaumer [3] was the earlier to research theoretically the Fe XVII collision strengths and radiative transition probabilities for $n = 3$ and $n = 4$ configurations. Many other representative studies of the Fe XVII spectrum were conducted [3–14].

The aim of this work is to use another method to do this research. We have calculated the line strengths, oscillator strengths, radiative decay rates, and fine structure collision strengths for Fe XVII by the Breit–Pauli distorted wave approach [15–18], and the results are compared with Ref. [9]. The atomic structure has been calculated for the 89 levels arising from the configurations $2s^22p^6$, $2s^22p^5$ ($3s$, $3p$, $3d$), $2s^22p^5$ ($4s$, $4p$, $4d$, $4f$) and $2s^12p^6$ ($3s$, $3p$, $3d$). Collision strengths have been computed for transitions from the ground and the four first excited levels to all the levels. The incoming electron energies used in our calculations are 75, 125, 175, and 250 Ry. We chose more levels than in Ref. [9], theoretically these calculations are closer to the experimental values.

2. Theory

AUTOSTRUCTURE code [18] describes the free-bound electron and photon collision processes by use of the Breit–Pauli distorted wave method. The details of the theory about line strengths, oscillator strengths, radiative decay rates and fine structure collision strengths can be found in Refs. [15–18] and we outline it concisely in present work.

The oscillator strengths (f_{ij}) and radiative rate (A_{ji}, in s^{-1}) for an electric dipole transition $i \to j$ are related by the following expression [15]:

$$f_{ij} = \frac{1}{g_j}\frac{E_i - E_j}{3}S(i,j), \quad E_j < E_i, \tag{1}$$

$$A_{ji} = (2.6774 \times 10^9)(E_i - E_j)^3\frac{1}{g_i}S(i,j), \tag{2}$$

where E_j and E_i are the lower and upper energy levels, respectively, expressed in units rydberg (Ry), and g_i and g_j are the statistical weight of i and j states, respectively. The electric dipole line strengths are defined by [18]:

$$S(i,j) = |\langle i\,\lfloor P\rfloor\, j\rangle|^2 \ \text{where}\ P = \sum_{p=1}^{N} r_p, \tag{3}$$

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and r_p is the one-electron vectors.

The fully-resolved partial collision strength is related to its corresponding T-matrix element by [18]:

$$\Omega_{\nu\gamma,\nu'\gamma'} = \omega_\gamma \left| T_{\nu\gamma,\nu'\gamma'} \right|^2 , \tag{4}$$

where ν is a target state label; γ is the set of all other quantum numbers which defines the scattering; and ω_γ $(= \omega_{\gamma'})$ is the total statistical weight of the scattering symmetry (viz. $(2J+1)$ for the Breit–Pauli jK-coupling).

3. Calculation procedure

We have used eleven configurations: $1s^2 2s^2 2p^6$, $2s^2 2p^5$ ($3s$, $3p$, $3d$), $2s^2 2p^5$ ($4s$, $4p$, $4d$, $4f$) and $2s^1 2p^6$ ($3s$, $3p$, $3d$) to study the atomic structure of Fe XVII. This set of configurations gives rise to 89 fine-structure levels listed in Table I (all at the end). The calculations have been performed using AUTOSTRUCTURE code [18], where the wave functions are determined by diagonalization of the Breit–Pauli Hamiltonian using orbital calculated in the scaled Thomas–Fermi–Dirac–Amaldi potentials.

4. Results and discussion

4.1. Energy levels, line strengths oscillator strengths and radiative rates

In Table I, we list the energy levels and compare with the experimental data in Ref. [19] and with the results from GRASP in Ref. [9]. As shown in Table I, the percentage errors between our calculations and the NIST atomic spectra database [19] are no more than 0.5%, the results are in good agreement with the experimental data, and better than Ref. [9] generally.

In Table II, we present the oscillator strengths, line strengths and radiative decay rates for allowed electric dipole transitions beginning with the ground and the four first excited levels, which were calculated using AUTOSTRUCTURE [18]. Comparisons have also been made with our calculations and the results of other methods in Ref. [9].

4.2. Collision strengths

We use the Breit–Pauli distorted wave approach (AUTOSTRUCTURE code) [18] to study the electron scattering calculations in jK-coupling for the Fe XVII ion. We calculated the fine structure-collision strengths from the ground level $(1s^2 2s^2)2p^{6\,1}S_0$ and from the first four excited levels $2p^5 3s\,^3P^\circ_2$, $2p^5 3s\,^1P^\circ_1$, $2p^5 3s\,^3P^\circ_0$ and $2p^5 3s\,^3P^\circ_1$ to all other levels for electron energies from 75, 125, 175, and 250 Ry. The results of ours and Ref. [9] together are shown in Table III.

4. Conclusion

We have calculated the energy levels, oscillator strengths, line strengths and radiative decay rates for the Ne-like ion Fe XVII using AUTOSTRUCTURE [18]. We have used eleven configurations: $1s^2 2s^2 2p^6$, $2s^2 2p^5$ ($3s$, $3p$, $3d$), $2s^2 2p^5$ ($4s$, $4p$, $4d$, $4f$) and $2s^1 2p^6$ ($3s$, $3p$, $3d$), yielding 89 fine structure levels. The atomic structure has been investigated using the AUTOSTRUCTURE code. We have compared our level energies, oscillator strengths and radiative decay rates with others results. We find that the agreement is much better for fine structure levels. We have further calculated fine structure collision strengths in the Breit–Pauli distorted wave approximation at four electron energies: 75, 125, 175, and 250 Ry.

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TABLE I

Energies in [Ry] of fine-structure level Fe XVII. E_{NIST} — Ref. [19], E_{GRASP} — Ref. [9], Δ — error relative to E_{NIST} [%].

i	conf.	level	E	E_{NIST}	E_{GRASP}	Δ
1	$2s^22p^6$	$^1S_0$	0.0000	0.0000	0.0000	0.0000
2	$2s^22p^53s$	$^3P^\circ_2$	53.2971	—	53.1622	—
3	$2s^22p^53s$	$^1P^\circ_1$	53.4481	—	53.3059	—
4	$2s^22p^53s$	$^3P^\circ_0$	54.2861	—	54.0917	—
5	$2s^22p^53s$	$^3P^\circ_1$	54.3535	—	54.1813	—
6	$2s^22p^53p$	$^3S_1$	55.5339	55.527602	55.3881	0.01
7	$2s^22p^53p$	$^3D_2$	55.8015	55.784944	55.6551	0.03
8	$2s^22p^53p$	$^3D_3$	55.9347	55.903773	55.7720	0.06
9	$2s^22p^53p$	$^1P_1$	56.0159	55.986881	55.8596	0.05
10	$2s^22p^53p$	$^3P_2$	56.1549	56.120108	55.9902	0.06
11	$2s^22p^53p$	$^3P_0$	56.5956	56.519061	56.4021	0.14
12	$2s^22p^53p$	$^3D_1$	56.7722	56.671971	56.5441	0.18
13	$2s^22p^53p$	$^3P_1$	57.0210	56.910541	56.7801	0.19
14	$2s^22p^53p$	$^1D_2$	57.0584	56.938335	56.8086	0.21
15	$2s^22p^53p$	$^1S_0$	58.1442	57.896532	57.9529	0.43
16	$2s^22p^53d$	$^3P^\circ_0$	58.9267	58.904120	58.7676	0.04
17	$2s^22p^53d$	$^3P^\circ_1$	59.0075	58.97538	58.8392	0.05
18	$2s^22p^53d$	$^3P^\circ_2$	59.1575	59.10843	58.9758	0.08
19	$2s^22p^53d$	$^3F^\circ_4$	59.1701	59.112344	58.9842	0.10
20	$2s^22p^53d$	$^3F^\circ_3$	59.2111	59.168843	59.0447	0.07
21	$2s^22p^53d$	$^1D^\circ_2$	59.3398	59.29341	59.1739	0.08
22	$2s^22p^53d$	$^3D^\circ_3$	59.4370	59.372238	59.2541	0.11
23	$2s^22p^53d$	$^3D^\circ_1$	59.7942	59.70804	59.6062	0.14
24	$2s^22p^53d$	$^3F^\circ_2$	60.2124	60.092230	59.9701	0.21
25	$2s^22p^53d$	$^3D^\circ_2$	60.2871	60.152282	60.0286	0.22
26	$2s^22p^53d$	$^1F^\circ_3$	60.3355	60.190556	60.0705	0.24
27	$2s^22p^53d$	$^1P^\circ_1$	60.8835	60.690	60.6356	0.32
28	$2s2p^63s$	$^3S_1$	63.3867	—	63.2048	—
29	$2s2p^63s$	$^1S_0$	63.9130	63.880	63.6956	0.05
30	$2s2p^63p$	$^3P^\circ_0$	65.8092	—	65.6263	—
31	$2s2p^63p$	$^3P^\circ_1$	65.8471	65.60120	65.6594	0.37
32	$2s2p^63p$	$^3P^\circ_2$	66.0364	—	65.8295	—
33	$2s2p^63p$	$^1P^\circ_1$	66.1829	65.92379	65.9717	0.39
34	$2s2p^63d$	$^3D_1$	69.1182	—	68.9168	—
35	$2s2p^63d$	$^3D_2$	69.1380	—	68.9268	—
36	$2s2p^63d$	$^3D_3$	69.1722	—	68.9459	—
37	$2s2p^63d$	$^1D_2$	69.5302	—	69.3192	—
38	$2s^22p^54s$	$^3P^\circ_2$	71.8494	—	71.6515	—
39	$2s^22p^54s$	$^1P^\circ_1$	71.8956	—	71.6987	—
40	$2s^22p^54s$	$^3S_1$	72.7800	—	72.5806	—
41	$2s^22p^54p$	$^3P^\circ_0$	72.8403	—	72.5829	—
42	$2s^22p^54s$	$^3P^\circ_1$	72.8593	—	72.6071	—
43	$2s^22p^54p$	$^3D_2$	72.8837	—	72.6448	—
44	$2s^22p^54p$	$^3D_3$	72.8986	—	72.6937	—
45	$2s^22p^54p$	$^1P_1$	72.9249	—	72.7239	—
46	$2s^22p^54p$	$^3P_2$	72.9693	—	72.6969	—
47	$2s^22p^54p$	$^3P_0$	73.2624	—	73.0629	—
48	$2s^22p^54p$	$^3D_1$	73.8324	—	73.5564	—
49	$2s^22p^54p$	$^3P_1$	73.9259	—	73.6435	—
50	$2s^22p^54p$	$^1D_2$	73.9437	—	73.6597	—
51	$2s^22p^54d$	$^3P^\circ_0$	74.0087	—	73.8051	—
52	$2s^22p^54d$	$^3P^\circ_1$	74.0430	73.9584	73.8374	0.11
53	$2s^22p^54d$	$^3F^\circ_4$	74.0895	74.02769	73.8771	0.08
54	$2s^22p^54d$	$^3P^\circ_2$	74.0992	—	73.8903	—
55	$2s^22p^54d$	$^3F^\circ_3$	74.1026	—	73.8992	—
56	$2s^22p^54p$	$^1S_0$	74.1478	—	73.9250	—
57	$2s^22p^54d$	$^1D^\circ_2$	74.1646	74.28376	73.9453	0.16
58	$2s^22p^54d$	$^3D^\circ_3$	74.1812	74.04774	73.9733	0.18
59	$2s^22p^54d$	$^3D^\circ_1$	74.3763	74.3047	74.1736	0.10
60	$2s^22p^54f$	$^3D_1$	74.6677	—	74.4536	—
61	$2s^22p^54f$	$^1G_4$	74.6709	—	74.4546	—
62	$2s^22p^54f$	$^3G_5$	74.6751	—	74.4559	—
63	$2s^22p^54f$	$^3D_2$	74.6809	—	74.4639	—
64	$2s^22p^54f$	$^3F_3$	74.7066	—	74.4888	—
65	$2s^22p^54f$	$^1D_2$	74.7101	—	74.4929	—
66	$2s^22p^54f$	$^1F_3$	74.7127	—	74.4955	—
67	$2s^22p^54f$	$^3F_4$	74.7207	—	74.5012	—
68	$2s^22p^54d$	$^3F^\circ_2$	75.1024	—	74.8209	—
69	$2s^22p^54d$	$^3D^\circ_2$	75.1276	—	74.8396	—
70	$2s^22p^54d$	$^1F^\circ_3$	75.1508	—	74.8622	—
71	$2s^22p^54d$	$^1P^\circ_1$	75.3063	75.1704	75.0349	0.18
72	$2s^22p^54f$	$^3G_3$	75.6934	—	75.4005	—
73	$2s^22p^54f$	$^3G_4$	75.7052	—	75.4087	—
74	$2s^22p^54f$	$^3D_3$	75.7116	—	75.4171	—
75	$2s^22p^54f$	$^3F_2$	75.7133	—	75.4180	—
76	$2s2p^64s$	$^3S_1$	81.8020	—	81.5593	—
77	$2s2p^64s$	$^1S_0$	81.9739	—	81.7322	—
78	$2s2p^64p$	$^3P^\circ_0$	82.7768	—	82.5375	—
79	$2s2p^64p$	$^3P^\circ_1$	82.7897	82.5243	82.5493	0.32
80	$2s2p^64p$	$^3P^\circ_2$	82.8673	—	82.6183	—
81	$2s2p^64p$	$^1P^\circ_1$	82.9128	82.6701	82.6654	0.29
82	$2s2p^64d$	$^3D_1$	84.0215	—	83.7747	—
83	$2s2p^64d$	$^3D_2$	84.0296	—	83.7793	—
84	$2s2p^64d$	$^3D_3$	84.0441	—	83.7880	—
85	$2s2p^64d$	$^1D_2$	84.1664	—	83.9205	—
86	$2s2p^64f$	$^3F^\circ_2$	84.6011	—	84.3381	—
87	$2s2p^64f$	$^3F^\circ_3$	84.6036	—	84.3394	—
88	$2s2p^64f$	$^3F^\circ_4$	84.6101	—	84.3430	—
89	$2s2p^64f$	$^1F^\circ_3$	84.6198	—	84.3538	—

TABLE I (cont.)

Energies in [Ry] of fine-structure level Fe XVII. E_{NIST} — Ref. [19], E_{GRASP} — Ref. [9], Δ — error relative to E_{NIST} [%].

TABLE II

Line strengths, S, oscillator strengths, f, and radiative rates, A, of Fe XVII for electric dipole transitions compared with Ref. [9] and relative differences Δ to Ref. [9].

i	$\rightarrow j$	transition	S	f	f [9]	Δ [%]	A [s^{-1}]	A [s^{-1}] [9]	Δ [%]
3	1	$^1P^\circ_1 -^1 S_0$	0.006805	1.210×10^{-1}	1.258×10^{-1}	-3.8	9.211×10^{11}	9.572×10^{11}	-3.8
5	1	$^3P^\circ_1 -^1 S_0$	0.005826	1.055×10^{-1}	1.070×10^{-1}	-1.4	8.334×10^{11}	8.408×10^{11}	-0.9
6	2	$^3S_1 -^3 P^\circ_2$	0.360577	2.675×10^{-1}	5.096×10^{-2}	424.9	3.549×10^{9}	3.380×10^{9}	5.0
6	3	$^3S_1 -^1 P^\circ_1$	0.011411	7.898×10^{-3}	3.671×10^{-3}	115.1	9.119×10^{7}	1.278×10^{8}	-28.6
6	4	$^3S_1 -^3 P^\circ_0$	0.004248	1.666×10^{-3}	2.231×10^{-3}	-25.3	6.174×10^{6}	1.006×10^{7}	-38.6
6	5	$^3S_1 -^3 P^\circ_1$	0.005964	2.151×10^{-3}	9.423×10^{-4}	128.3	6.738×10^{6}	1102×10^{7}	-99.9
7	2	$^3D_2 -^3 P^\circ_2$	0.325496	2.690×10^{-1}	5.206×10^{-2}	416.7	2.655×10^{9}	2.599×10^{9}	2.2
7	3	$^3D_2 -^1 P^\circ_1$	0.366531	2.846×10^{-1}	9512×10^{-2}	-99.7	2.482×10^{9}	2.530×10^{9}	-1.9
7	5	$^3D_2 -^3 P^\circ_1$	0.000095	4.234×10^{-5}	1.886×10^{-5}	124.5	1.212×10^{5}	1.974×10^{5}	-38.6
8	2	$^3D_3 -^3 P^\circ_2$	0.960620	8.369×10^{-1}	1.646×10^{-1}	408.4	6.559×10^{9}	6.432×10^{9}	2.0
9	2	$^1P_1 -^3 P^\circ_2$	0.016609	1.491×10^{-2}	3.830×10^{-3}	289.3	2.894×10^{8}	3.731×10^{8}	-22.4
9	3	$^1P_1 -^1 P^\circ_1$	0.390629	3.312×10^{-1}	1.085×10^{-1}	205.3	5.737×10^{9}	5.681×10^{9}	1.0
9	4	$^1P_1 -^3 P^\circ_0$	0.000725	3.970×10^{-4}	6.905×10^{-4}	-42.5	2.871×10^{6}	5.789×10^{6}	-50.4
9	5	$^1P_1 -^3 P^\circ_1$	0.000117	6.056×10^{-5}	1.734×10^{-5}	249.3	3.889×10^{5}	3.109×10^{5}	25.1
10	2	$^3P_2 -^3 P^\circ_2$	0.374377	3.531×10^{-1}	7.039×10^{-3}	4916.3	4.540×10^{9}	4.522×10^{9}	0.4
10	3	$^3P_2 -^1 P^\circ_1$	0.324976	2.903×10^{-1}	9.423×10^{-2}	208.1	3.350×10^{9}	3.272×10^{9}	2.4
10	5	$^3P_2 -^3 P^\circ_1$	0.005989	3.364×10^{-3}	1.555×10^{-3}	116.3	1.535×10^{7}	2.453×10^{7}	-37.4
11	3	$^3P_0 -^1 P^\circ_1$	0.099168	1.040×10^{-1}	3.389×10^{-2}	206.9	8.274×10^{9}	7828×10^{9}	-99.9
11	5	$^3P_0 -^3 P^\circ_1$	0.043557	3.125×10^{-2}	1.034×10^{-2}	202.2	1.162×10^{9}	1.228×10^{9}	-5.4
12	2	$^3D_1 -^3 P^\circ_2$	0.000421	4.902×10^{-4}	7.722×10^{-4}	-36.5	1.598×10^{7}	1.182×10^{7}	35.2
12	3	$^3D_1 -^1 P^\circ_1$	0.000788	8.772×10^{-4}	4.606×10^{-4}	90.4	2.620×10^{7}	3.879×10^{7}	-32.5
12	4	$^3D_1 -^3 P^\circ_0$	0.159758	1.299×10^{-1}	1.308×10^{-1}	-0.7	2.070×10^{9}	2.108×10^{9}	-1.8
12	5	$^3D_1 -^3 P^\circ_1$	0.247290	1.933×10^{-1}	6.289×10^{-2}	207.4	2.846×10^{9}	2.820×10^{9}	0.9
13	2	$^3P_1 -^3 P^\circ_2$	0.018368	2.288×10^{-2}	5.168×10^{-2}	-55.7	8.553×10^{8}	9.056×10^{8}	-5.6
13	3	$^3P_1 -^1 P^\circ_1$	0.000076	9.122×10^{-5}	4.123×10^{-5}	121.2	3.143×10^{6}	4.085×10^{6}	-23.1
13	4	$^3P_1 -^3 P^\circ_0$	0.245338	2.198×10^{-1}	2.124×10^{-1}	3.5	4.250×10^{9}	4.114×10^{9}	3.3
13	5	$^3P_1 -^3 P^\circ_1$	0.147739	1.277×10^{-1}	4.302×10^{-2}	196.8	2.298×10^{9}	2.334×10^{9}	-1.5
14	2	$^1D_2 -^3 P^\circ_2$	0.003581	4.507×10^{-3}	1.099×10^{-3}	310.1	1.032×10^{8}	1.173×10^{8}	-12.0
14	3	$^1D_2 -^1 P^\circ_1$	0.003242	3.918×10^{-3}	1.511×10^{-3}	159.3	8.275×10^{7}	8.936×10^{7}	-7.4
14	5	$^1D_2 -^3 P^\circ_1$	0.686692	6.022×10^{-1}	1.976×10^{-1}	204.8	6.697×10^{9}	6.574×10^{9}	1.9
15	3	$^1S_0 -^1 P^\circ_1$	0.052382	8.474×10^{-2}	2.685×10^{-2}	215.6	1.603×10^{10}	1.397×10^{10}	14.7
15	5	$^1S_0 -^3 P^\circ_1$	0.106376	1.368×10^{-1}	4.460×10^{-2}	206.7	1.636×10^{10}	1.529×10^{10}	7.0
16	6	$^3P^\circ_0 -^3 S_1$	0.116746	1.323×10^{-1}	4.126×10^{-2}	220.6	1.229×10^{10}	1.135×10^{10}	8.3
16	9	$^3P^\circ_0 -^1 P_1$	0.003306	3.233×10^{-3}	1.478×10^{-3}	118.7	2.234×10^{8}	3.012×10^{8}	-25.8
16	12	$^3P^\circ_0 -^3 D_1$	0.000087	6.209×10^{-5}	2.159×10^{-5}	187.6	2.278×10^{6}	2.572×10^{6}	-11.4
16	13	$^3P^\circ_0 -^3 P_1$	0.005654	3.561×10^{-3}	1.461×10^{-3}	143.7	1.021×10^{8}	1.391×10^{9}	-92.7
17	1	$^3P^\circ_1 -^1 S_0$	0.000453	8.882×10^{-3}	9.935×10^{-3}	-10.6	8.246×10^{10}	$9.209\ \times10^{10}$	-10.4
17	6	$^3P^\circ_1 -^3 S_1$	0.276571	3.209×10^{-1}	1.006×10^{-1}	219.0	1.041×10^{10}	9.627×10^{9}	8.1
17	7	$^3P^\circ_1 -^3 D_2$	0.030058	3.233×10^{-2}	5.844×10^{-3}	453.2	9.017×10^{8}	7.932×10^{8}	13.7
17	9	$^3P^\circ_1 -^1 P_1$	0.001258	1.264×10^{-3}	6.182×10^{-4}	104.5	3.072×10^{7}	4.409×10^{7}	-30.3
17	10	$^3P^\circ_1 -^3 P_2$	0.053183	5.100×10^{-2}	9.929×10^{-3}	413.6	1.130×10^{9}	1.079×10^{9}	4.7
17	11	$^3P^\circ_1 -^3 P_0$	0.010727	8.617×10^{-3}	1.052×10^{-2}	-18.1	1.340×10^{8}	1.673×10^{8}	-19.9
17	12	$^3P^\circ_1 -^3 D_1$	0.000001	7.313×10^{-7}	7.710×10^{-6}	-90.5	9.626×10^{3}	3.262×10^{5}	-97.0
17	13	$^3P^\circ_1 -^3 P_1$	0.004411	2.896×10^{-3}	1.230×10^{-3}	135.4	3.007×10^{7}	4.189×10^{7}	-28.2
17	14	$^3P^\circ_1 -^1 D_2$	0.003468	2.232×10^{-3}	5.162×10^{-4}	332.4	2.229×10^{7}	2.849×10^{7}	-21.8
17	15	$^3P^\circ_1 -^1 S_0$	0.000002	5.174×10^{-7}	3.069×10^{-7}	68.6	6.859×10^{2}	6.455×10^{2}	6.3
18	6	$^3P^\circ_2 -^3 S_1$	0.229121	2.771×10^{-1}	8.918×10^{-2}	210.7	5.859×10^{9}	5.532×10^{9}	5.9
18	7	$^3P^\circ_2 -^3 D_2$	0.061477	6.916×10^{-2}	1.012×10^{-2}	583.4	1.265×10^{9}	8.954×10^{8}	41.3
18	8	$^3P^\circ_2 -^3 D_3$	0.021673	2.341×10^{-2}	2.913×10^{-3}	703.6	3.948×10^{8}	3.362×10^{8}	17.4
18	9	$^3P^\circ_2 -^1 P_1$	0.054492	5.742×10^{-2}	2.154×10^{-2}	166.6	9.217×10^{8}	1.008×10^{9}	-8.6
18	10	$^3P^\circ_2 -^3 P_2$	0.266985	2.692×10^{-1}	5.181×10^{-2}	419.6	3.956×10^{9}	3.709×10^{9}	6.7
18	12	$^3P^\circ_2 -^3 D_1$	0.001285	1.013×10^{-3}	4.580×10^{-4}	121.2	9.098×10^{6}	1.305×10^{7}	-30.3
18	13	$^3P^\circ_2 -^3 P_1$	0.001738	1.226×10^{-3}	5.938×10^{-4}	106.5	8.829×10^{6}	1.380×10^{7}	-36.0
18	14	$^3P^\circ_2 -^1 D_2$	0.005370	3.721×10^{-3}	1.062×10^{-3}	250.4	2.583×10^{7}	4.005×10^{7}	-35.5
19	8	$^3F^\circ_4 -^3 D_3$	1.178300	1.277	1.756×10^{-1}	627.2	1.206×10^{10}	1.132×10^{10}	6.5

TABLE II (cont.)

Line strengths, S, oscillator strengths, f, and radiative rates, A, of Fe XVII for electric dipole transitions compared with Ref. [9] and relative differences Δ to Ref. [9].

$i \to j$		transition	S	f	f [9]	Δ [%]	A [s^{-1}]	A [s^{-1}] [9]	Δ [%]
20	7	${}^3F_3^\circ - {}^3D_2$	0.768720	8.773×10^{-1}	1.694×10^{-1}	417.9	1.180×10^{10}	1.117×10^{10}	5.6
20	8	${}^3F_3^\circ - {}^3D_3$	0.138359	1.517×10^{-1}	2.131×10^{-2}	611.9	1.883×10^{9}	1.883×10^{9}	0.0
20	10	${}^3F_3^\circ - {}^3P_2$	0.010743	1.101×10^{-2}	1.608×10^{-3}	584.7	1.193×10^{8}	8.606×10^{7}	38.6
20	14	${}^3F_3^\circ - {}^1D_2$	0.000584	4.143×10^{-4}	1.486×10^{-4}	178.8	2.152×10^{6}	4.263×10^{6}	-49.5
21	6	${}^1D_2^\circ - {}^3S_1$	0.010517	1.333×10^{-2}	4.869×10^{-3}	173.8	3.095×10^{8}	3.363×10^{8}	-8.0
21	7	${}^1D_2^\circ - {}^3D_2$	0.212048	2.509×10^{-1}	5.101×10^{-2}	391.9	5.076×10^{9}	5.073×10^{9}	0.1
21	8	${}^1D_2^\circ - {}^3D_3$	0.010192	1.160×10^{-2}	1.849×10^{-3}	527.4	2.173×10^{8}	2.407×10^{8}	-9.7
21	9	${}^1D_2^\circ - {}^1P_1$	0.432207	4.805×10^{-1}	1.515×10^{-1}	217.2	8.587×10^{9}	8.018×10^{9}	7.1
21	10	${}^1D_2^\circ - {}^3P_2$	0.001948	2.077×10^{-3}	3.357×10^{-5}	6087.1	3.414×10^{7}	2.733×10^{6}	1149.2
21	12	${}^1D_2^\circ - {}^3D_1$	0.000267	2.256×10^{-4}	1.643×10^{-4}	37.3	2.337×10^{6}	5.476×10^{6}	-57.3
21	13	${}^1D_2^\circ - {}^3P_1$	0.000315	2.404×10^{-4}	1.577×10^{-4}	52.4	2.027×10^{6}	4.355×10^{6}	-53.5
21	14	${}^1D_2^\circ - {}^1D_2$	0.000008	5.696×10^{-6}	3.385×10^{-8}	16727.2	4.645×10^{4}	1.521×10^{3}	2953.9
22	7	${}^3D_3^\circ - {}^3D_2$	0.004838	5.872×10^{-3}	1.661×10^{-3}	253.5	8.936×10^{7}	1.235×10^{8}	-27.6
22	8	${}^3D_3^\circ - {}^3D_3$	0.175503	2.052×10^{-1}	2.784×10^{-2}	637.1	2.896×10^{9}	2.711×10^{9}	6.8
22	10	${}^3D_3^\circ - {}^3P_2$	0.753275	8.264×10^{-1}	1.619×10^{-1}	410.4	1.027×10^{10}	9.892×10^{9}	3.8
22	14	${}^3D_3^\circ - {}^1D_2$	0.001065	8.327×10^{-4}	2.239×10^{-4}	271.9	5.257×10^{6}	7.684×10^{6}	-31.6
23	1	${}^3D_1^\circ - {}^1S_0$	0.035714	7.102×10^{-1}	6.179×10^{-1}	14.9	6.768×10^{12}	$5.878\ \times10^{12}$	15.2
23	6	${}^3D_1^\circ - {}^3S_1$	0.000885	1.256×10^{-3}	3.874×10^{-4}	224.2	6.088×10^{7}	5.536×10^{7}	10.0
23	7	${}^3D_1^\circ - {}^3D_2$	0.011975	1.598×10^{-2}	3.474×10^{-3}	360.0	6.853×10^{8}	7.260×10^{8}	-5.6
23	9	${}^3D_1^\circ - {}^1P_1$	0.159760	2.018×10^{-1}	6.550×10^{-2}	208.1	7.754×10^{9}	7.386×10^{9}	5.0
23	10	${}^3D_1^\circ - {}^3P_2$	0.000040	4.830×10^{-5}	3.676×10^{-5}	31.4	1.725×10^{6}	6.434×10^{6}	-73.2
23	11	${}^3D_1^\circ - {}^3P_0$	0.192335	2.042×10^{-1}	2.049×10^{-1}	-0.3	5.548×10^{9}	5.633×10^{9}	-1.5
23	12	${}^3D_1^\circ - {}^3D_1$	0.006642	6.626×10^{-3}	2.303×10^{-3}	187.7	1.589×10^{8}	1.735×10^{8}	-8.4
23	13	${}^3D_1^\circ - {}^3P_1$	0.008310	7.603×10^{-3}	3.176×10^{-3}	139.4	1.534×10^{8}	2.038×10^{8}	-24.7
23	14	${}^3D_1^\circ - {}^1D_2$	0.004148	3.742×10^{-3}	7.056×10^{-4}	430.3	7.339×10^{7}	7.393×10^{7}	-0.7
23	15	${}^3D_1^\circ - {}^1S_0$	0.010848	5.347×10^{-3}	5.096×10^{-3}	4.9	3.131×10^{7}	3.730×10^{7}	-16.1
24	6	${}^3F_2^\circ - {}^3S_1$	0.000442	6.952×10^{-4}	2.389×10^{-4}	191.0	2.485×10^{7}	2.418×10^{7}	2.8
24	7	${}^3F_2^\circ - {}^3D_2$	0.001518	2.259×10^{-3}	7.479×10^{-4}	202.0	7.232×10^{7}	1.119×10^{8}	-35.4
24	8	${}^3F_2^\circ - {}^3D_3$	0.000048	6.953×10^{-5}	2.884×10^{-5}	141.1	2.094×10^{6}	5.716×10^{6}	-63.4
24	9	${}^3F_2^\circ - {}^1P_1$	0.000025	3.553×10^{-5}	4.674×10^{-5}	-24.0	1.031×10^{6}	3.806×10^{6}	-72.9
24	10	${}^3F_2^\circ - {}^3P_2$	0.000538	7.376×10^{-4}	1.018×10^{-4}	624.6	2.006×10^{7}	1.296×10^{7}	54.8
24	12	${}^3F_2^\circ - {}^3D_1$	0.556563	6.408×10^{-1}	2.065×10^{-1}	210.3	1.228×10^{10}	1.168×10^{10}	5.1
24	13	${}^3F_2^\circ - {}^3P_1$	0.012998	1.389×10^{-2}	6.237×10^{-3}	122.7	2.295×10^{8}	3.059×10^{8}	-25.0
24	14	${}^3F_2^\circ - {}^1D_2$	0.088693	9.366×10^{-2}	1.710×10^{-2}	447.7	1.510×10^{9}	1.373×10^{9}	10.0
25	6	${}^3D_2^\circ - {}^3S_1$	0.001771	2.826×10^{-3}	7.596×10^{-4}	272.0	1.040×10^{8}	7.884×10^{7}	31.9
25	7	${}^3D_2^\circ - {}^3D_2$	0.003974	6.006×10^{-3}	1.445×10^{-3}	315.6	1.984×10^{8}	2.220×10^{8}	-10.6
25	8	${}^3D_2^\circ - {}^3D_3$	0.004413	6.472×10^{-3}	9.740×10^{-4}	564.5	2.013×10^{8}	1.984×10^{8}	1.5
25	9	${}^3D_2^\circ - {}^1P_1$	0.000506	7.282×10^{-4}	3.592×10^{-4}	102.7	2.184×10^{7}	3.009×10^{7}	-27.4
25	10	${}^3D_2^\circ - {}^3P_2$	0.014710	2.052×10^{-2}	5.197×10^{-3}	294.8	5.770×10^{8}	6.808×10^{8}	-15.2
25	12	${}^3D_2^\circ - {}^3D_1$	0.000091	1.072×10^{-4}	3.867×10^{-4}	-72.3	2.140×10^{6}	2.263×10^{6}	-5.4
25	13	${}^3D_2^\circ - {}^3P_1$	0.565435	6.176×10^{-1}	1.966×10^{-1}	214.1	1.065×10^{10}	1.000×10^{10}	6.5
25	14	${}^3D_2^\circ - {}^1D_2$	0.067972	7.337×10^{-2}	1.506×10^{-2}	387.2	1.236×10^{9}	1.254×10^{9}	-1.4
26	7	${}^1F_3^\circ - {}^3D_2$	0.000045	6.851×10^{-5}	7.180×10^{-5}	-4.6	1.652×10^{6}	8.031×10^{6}	-79.4
26	8	${}^1F_3^\circ - {}^3D_3$	0.004020	5.963×10^{-3}	1.090×10^{-3}	447.1	1.355×10^{8}	1.618×10^{8}	-16.3
26	10	${}^1F_3^\circ - {}^3P_2$	0.000427	6.032×10^{-4}	1.320×10^{-4}	357.0	1.241×10^{7}	1.261×10^{7}	-1.6
26	14	${}^1F_3^\circ - {}^1D_2$	0.919093	1.007	1.959×10^{-1}	414.0	1.249×10^{10}	1.196×10^{10}	4.4
27	1	${}^1P_1^\circ - {}^1S_0$	0.122793	2.487	2.556	-2.7	2.459×10^{13}	2.516×10^{13}	-2.3
27	6	${}^1P_1^\circ - {}^3S_1$	0.000029	5.166×10^{-5}	4.881×10^{-5}	5.8	3.974×10^{6}	1.808×10^{7}	-78.0
27	7	${}^1P_1^\circ - {}^3D_2$	0.000598	1.018×10^{-3}	1.298×10^{-4}	684.3	7.108×10^{7}	4.311×10^{7}	64.9
27	9	${}^1P_1^\circ - {}^1P_1$	0.016802	2.741×10^{-2}	1.101×10^{-2}	149.0	1.757×10^{9}	2.017×10^{9}	-12.9
27	10	${}^1P_1^\circ - {}^3P_2$	0.000256	4.067×10^{-4}	1.246×10^{-4}	226.4	2.463×10^{7}	3.598×10^{7}	-31.5
27	11	${}^1P_1^\circ - {}^3P_0$	0.016345	2.337×10^{-2}	1.631×10^{-2}	43.3	1.152×10^{9}	7.826×10^{8}	47.2
27	12	${}^1P_1^\circ - {}^3D_1$	0.096840	1.322×10^{-1}	4.347×10^{-2}	204.1	5.943×10^{9}	5.846×10^{9}	1.7
27	13	${}^1P_1^\circ - {}^3P_1$	0.060231	7.728×10^{-2}	2.613×10^{-2}	195.8	3.066×10^{9}	3.120×10^{9}	-1.7
27	14	${}^1P_1^\circ - {}^1D_2$	0.003913	4.970×10^{-3}	9.284×10^{-4}	435.3	1.932×10^{8}	1.820×10^{8}	6.2
27	15	${}^1P_1^\circ - {}^1S_0$	0.174243	1.500×10^{-1}	1.654×10^{-1}	-9.3	2.681×10^{9}	3.186×10^{9}	-15.9

TABLE II (cont.)

Line strengths, S, oscillator strengths, f, and radiative rates, A, of Fe XVII for electric dipole transitions compared with Ref. [9] and relative differences Δ to Ref. [9].

$i \to j$		transition	S	f	f [9]	Δ [%]	A [s^{-1}]	A [s^{-1}] [9]	Δ [%]
28	2	${}^3S_1 -{}^3P_2^\circ$	0.103309	3.475×10^{-1}	7.101×10^{-2}	389.4	9.474×10^{10}	9.588×10^{10}	-1.2
28	3	${}^3S_1 -{}^1P_1^\circ$	0.028073	9.303×10^{-2}	3.247×10^{-2}	186.5	2.462×10^{10}	2.556×10^{10}	-3.7
28	4	${}^3S_1 -{}^3P_0^\circ$	0.021558	6.497×10^{-2}	6.593×10^{-2}	-1.5	1.422×10^{10}	1.467×10^{10}	-3.1
28	5	${}^3S_1 -{}^3P_1^\circ$	0.035624	1.062×10^{-1}	3.508×10^{-2}	202.7	2.277×10^{10}	2.294×10^{10}	-0.7
28	16	${}^3S_1 -{}^3P_0^\circ$	0.000000	3.579×10^{-9}	4.061×10^{-6}	-99.9	1.910×10^{2}	2.141×10^{5}	-99.9
28	17	${}^3S_1 -{}^3P_1^\circ$	0.000001	1.412×10^{-6}	6.965×10^{-6}	-79.7	7.268×10^{4}	1.066×10^{6}	-93.2
28	18	${}^3S_1 -{}^3P_2^\circ$	0.000012	1.659×10^{-5}	1.465×10^{-5}	13.2	7.977×10^{5}	3.508×10^{6}	-77.3
28	21	${}^3S_1 -{}^1D_2^\circ$	0.000001	1.545×10^{-6}	3.003×10^{-7}	414.5	6.829×10^{4}	6.533×10^{4}	4.5
28	23	${}^3S_1 -{}^3D_1^\circ$	0.000001	6.725×10^{-7}	5.778×10^{-7}	16.4	2.346×10^{4}	6.010×10^{4}	-61.0
28	24	${}^3S_1 -{}^3F_2^\circ$	0.000000	4.319×10^{-8}	1.167×10^{-8}	270.1	1.146×10^{3}	1.634×10^{3}	-29.9
28	25	${}^3S_1 -{}^3D_2^\circ$	0.000010	1.019×10^{-5}	5.351×10^{-6}	90.4	2.584×10^{5}	7.227×10^{5}	-64.2
28	27	${}^3S_1 -{}^1P_1^\circ$	0.000000	3.759×10^{-8}	8.864×10^{-8}	-57.6	6.316×10^{2}	4.700×10^{3}	-86.6
29	3	${}^1S_0 -{}^1P_1^\circ$	0.022569	7.858×10^{-2}	2.572×10^{-2}	205.5	6.887×10^{10}	6.689×10^{10}	3.0
29	5	${}^1S_0 -{}^3P_1^\circ$	0.017663	5.564×10^{-2}	1.910×10^{-2}	191.3	3.992×10^{10}	4.166×10^{10}	-4.2
29	17	${}^1S_0 -{}^3P_1^\circ$	0.000012	1.991×10^{-5}	3.942×10^{-6}	405.1	3.821×10^{6}	2.241×10^{6}	70.5
29	23	${}^1S_0 -{}^3D_1^\circ$	0.001243	1.705×10^{-3}	3.749×10^{-4}	354.8	2.317×10^{8}	1.510×10^{8}	53.4
29	27	${}^1S_0 -{}^1P_1^\circ$	0.005460	5.476×10^{-3}	1.577×10^{-3}	247.2	3.982×10^{8}	3.512×10^{8}	13.4
30	6	${}^3P_0^\circ -{}^3S_1$	0.018594	6.363×10^{-2}	1.997×10^{-2}	218.6	5.387×10^{10}	5.044×10^{10}	6.8
30	9	${}^3P_0^\circ -{}^1P_1$	0.018534	6.054×10^{-2}	2.195×10^{-2}	175.8	4.670×10^{10}	5.046×10^{10}	-7.5
30	12	${}^3P_0^\circ -{}^3D_1$	0.019493	5.850×10^{-2}	1.918×10^{-2}	205.0	3.809×10^{10}	3.813×10^{10}	-0.1
30	13	${}^3P_0^\circ -{}^3P_1$	0.001463	4.270×10^{-3}	1.373×10^{-3}	211.0	2.629×10^{9}	2.589×10^{9}	1.5
30	28	${}^3P_0^\circ -{}^3S_1$	0.150475	1.205×10^{-1}	3.993×10^{-2}	201.8	5.580×10^{9}	5.643×10^{9}	-1.1
31	1	${}^3P_1^\circ -{}^1S_0$	0.001333	2.919×10^{-2}	3.548×10^{-2}	-17.7	3.374×10^{11}	4.095×10^{11}	-17.6
31	6	${}^3P_1^\circ -{}^3S_1$	0.015089	5.183×10^{-2}	1.801×10^{-2}	187.8	1.474×10^{10}	1.526×10^{10}	-3.4
31	7	${}^3P_1^\circ -{}^3D_2$	0.094010	3.150×10^{-1}	6.336×10^{-2}	397.2	8.520×10^{10}	8.490×10^{10}	0.4
31	9	${}^3P_1^\circ -{}^1P_1$	0.000134	4.398×10^{-4}	3.961×10^{-5}	1010.3	1.140×10^{8}	3.056×10^{7}	273.0
31	10	${}^3P_1^\circ -{}^3P_2$	0.004536	1.467×10^{-2}	3.040×10^{-3}	382.6	3.696×10^{9}	3.805×10^{9}	-2.9
31	11	${}^3P_1^\circ -{}^3P_0$	0.012360	3.804×10^{-2}	3.672×10^{-2}	3.6	8.686×10^{9}	8.425×10^{9}	3.1
31	12	${}^3P_1^\circ -{}^3D_1$	0.036165	1.090×10^{-1}	3.629×10^{-2}	200.4	2.386×10^{10}	2.422×10^{10}	-1.5
31	13	${}^3P_1^\circ -{}^3P_1$	0.003084	9.041×10^{-3}	2.973×10^{-3}	204.1	1.872×10^{9}	1.860×10^{9}	0.6
31	14	${}^3P_1^\circ -{}^1D_2$	0.001686	4.920×10^{-3}	1.123×10^{-3}	338.1	1.010×10^{9}	1.178×10^{9}	-14.3
31	15	${}^3P_1^\circ -{}^1S_0$	0.010418	2.614×10^{-2}	2.441×10^{-2}	7.1	3.967×10^{9}	3.881×10^{9}	2.2
31	28	${}^3P_1^\circ -{}^3S_1$	0.400637	3.258×10^{-1}	1.088×10^{-1}	199.4	5.190×10^{9}	5.265×10^{9}	-1.4
31	29	${}^3P_1^\circ -{}^1S_0$	0.047320	3.053×10^{-2}	2.846×10^{-2}	7.3	3.063×10^{8}	2.939×10^{8}	4.2
32	6	${}^3P_2^\circ -{}^3S_1$	0.004061	1.421×10^{-2}	6.686×10^{-3}	112.5	2.514×10^{9}	3.513×10^{9}	-28.4
32	7	${}^3P_2^\circ -{}^3D_2$	0.000842	2.875×10^{-3}	9.145×10^{-4}	214.4	4.844×10^{8}	7.604×10^{8}	-36.3
32	8	${}^3P_2^\circ -{}^3D_3$	0.143540	4.836×10^{-1}	7.139×10^{-2}	577.4	7.936×10^{10}	8.121×10^{10}	-2.3
32	9	${}^3P_2^\circ -{}^1P_1$	0.005947	1.988×10^{-2}	6.089×10^{-2}	-67.4	3.212×10^{9}	2.917×10^{9}	10.1
32	10	${}^3P_2^\circ -{}^3P_2$	0.045393	1.497×10^{-1}	2.774×10^{-2}	439.7	2.352×10^{10}	2.157×10^{10}	9.0
32	12	${}^3P_2^\circ -{}^3D_1$	0.001008	3.101×10^{-3}	1.236×10^{-3}	150.9	4.246×10^{8}	5.138×10^{8}	-17.4
32	13	${}^3P_2^\circ -{}^3P_1$	0.033321	9.978×10^{-2}	3.188×10^{-2}	213.0	1.294×10^{10}	1.258×10^{10}	2.9
32	14	${}^3P_2^\circ -{}^1D_2$	0.050777	1.514×10^{-1}	2.981×10^{-2}	407.9	1.946×10^{10}	1.948×10^{10}	-0.1
32	28	${}^3P_2^\circ -{}^3S_1$	0.756498	6.631×10^{-1}	2.190×10^{-1}	202.8	7.366×10^{9}	7.271×10^{9}	1.3
33	1	${}^1P_1^\circ -{}^1S_0$	0.011364	2.502×10^{-1}	2.853×10^{-1}	-12.3	2.921×10^{12}	$3.324\ \times10^{12}$	-31.1
33	6	${}^1P_1^\circ -{}^3S_1$	0.003085	1.094×10^{-2}	3.866×10^{-3}	183.0	3.315×10^{9}	3.478×10^{9}	-4.7
33	7	${}^1P_1^\circ -{}^3D_2$	0.004697	1.626×10^{-2}	3.604×10^{-3}	351.2	4.695×10^{9}	5.134×10^{9}	-8.6
33	9	${}^1P_1^\circ -{}^1P_1$	0.035014	1.187×10^{-1}	3.811×10^{-2}	211.5	3.288×10^{10}	3.130×10^{10}	5.0
33	10	${}^1P_1^\circ -{}^3P_2$	0.044217	1.479×10^{-1}	2.939×10^{-2}	403.2	3.987×10^{10}	3.919×10^{10}	1.7
33	11	${}^1P_1^\circ -{}^3P_0$	0.007705	2.457×10^{-2}	2.283×10^{-2}	7.6	6.023×10^{9}	5.597×10^{9}	7.6
33	12	${}^1P_1^\circ -{}^3D_1$	0.006574	2.054×10^{-2}	7.421×10^{-3}	176.8	4.834×10^{9}	5.298×10^{9}	-8.8
33	13	${}^1P_1^\circ -{}^3P_1$	0.017282	5.258×10^{-2}	1.754×10^{-2}	199.8	1.173×10^{10}	1.190×10^{10}	-1.4
33	14	${}^1P_1^\circ -{}^1D_2$	0.046585	1.411×10^{-1}	2.859×10^{-2}	393.5	3.121×10^{10}	3.214×10^{10}	-2.9
33	15	${}^1P_1^\circ -{}^1S_0$	0.033703	8.831×10^{-2}	9.123×10^{-2}	-3.2	1.461×10^{10}	1.571×10^{10}	-7.0
33	28	${}^1P_1^\circ -{}^3S_1$	0.051504	4.760×10^{-2}	1.480×10^{-2}	221.6	9.798×10^{8}	9.100×10^{8}	7.7
33	29	${}^1P_1^\circ -{}^1S_0$	0.368769	2.789×10^{-1}	2.802×10^{-1}	-0.5	3.844×10^{9}	3.887×10^{9}	-1.1

Line strengths, S, oscillator strengths, f, and radiative rates, A, of Fe XVII for electric dipole transitions compared with Ref. [9] and relative differences Δ to Ref. [9]. TABLE II (cont.)

$i \to j$		transition	S	f	f [9]	Δ [%]	A [s^{-1}]	A [s^{-1}] [9]	Δ [%]
34	2	${}^3D_1 - {}^3P_2^\circ$	0.000001	3.318×10^{-6}	4.058×10^{-7}	717.6	2.226×10^{6}	1.348×10^{6}	65.1
34	3	${}^3D_1 - {}^1P_1^\circ$	0.000004	1.930×10^{-5}	3.334×10^{-6}	478.9	1.270×10^{7}	6.527×10^{6}	94.6
34	4	${}^3D_1 - {}^3P_0^\circ$	0.000017	8.243×10^{-5}	3.255×10^{-6}	2432.4	4.821×10^{7}	$1.916\ \times10^{6}$	2420.0
34	5	${}^3D_1 - {}^3P_1^\circ$	0.000008	4.032×10^{-5}	3.947×10^{-7}	10115.4	2.328×10^{7}	6.885×10^{5}	3281.3
34	16	${}^3D_1 - {}^3P_0^\circ$	0.011338	3.856×10^{-2}	2.133×10^{-2}	80.8	1.075×10^{10}	5.883×10^{9}	82.7
34	17	${}^3D_1 - {}^3P_1^\circ$	0.021580	7.282×10^{-2}	1.492×10^{-2}	388.1	1.998×10^{10}	1.217×10^{10}	64.2
34	18	${}^3D_1 - {}^3P_2^\circ$	0.008465	2.815×10^{-2}	3.137×10^{-3}	797.4	7.499×10^{9}	4.150×10^{9}	80.7
34	21	${}^3D_1 - {}^1D_2^\circ$	0.050516	1.650×10^{-1}	3.308×10^{-2}	398.8	4.245×10^{10}	4.203×10^{10}	1.0
34	23	${}^3D_1 - {}^3D_1^\circ$	0.021215	6.610×10^{-2}	2.067×10^{-2}	219.8	1.546×10^{10}	1.439×10^{10}	7.4
34	24	${}^3D_1 - {}^3F_2^\circ$	0.043963	1.302×10^{-1}	2.334×10^{-2}	457.8	2.753×10^{10}	2.501×10^{10}	10.1
34	25	${}^3D_1 - {}^3D_2^\circ$	0.001002	2.945×10^{-3}	9.049×10^{-4}	225.5	6.127×10^{8}	9.570×10^{8}	-36.0
34	27	${}^3D_1 - {}^1P_1^\circ$	0.005182	1.424×10^{-2}	3.673×10^{-3}	287.7	2.591×10^{9}	2.023×10^{9}	28.1
34	30	${}^3D_1 - {}^3P_0^\circ$	0.235075	2.614×10^{-1}	2.503×10^{-1}	4.4	7.793×10^{9}	7.255×10^{9}	7.4
34	31	${}^3D_1 - {}^3P_1^\circ$	0.155556	1.710×10^{-1}	5.514×10^{-2}	210.1	4.983×10^{9}	4.699×10^{9}	6.0
34	32	${}^3D_1 - {}^3P_2^\circ$	0.011683	1.210×10^{-2}	2.339×10^{-3}	417.3	3.131×10^{8}	2.985×10^{8}	4.9
34	33	${}^3D_1 - {}^1P_1^\circ$	0.020329	2.009×10^{-2}	6.032×10^{-2}	-66.7	4.731×10^{8}	4.203×10^{8}	12.6
35	2	${}^3D_2 - {}^3P_2^\circ$	0.000010	5.174×10^{-5}	5.308×10^{-6}	874.8	2.088×10^{7}	1.060×10^{7}	97.0
35	3	${}^3D_2 - {}^1P_1^\circ$	0.000015	7.944×10^{-5}	9.309×10^{-6}	753.4	3.145×10^{7}	1.095×10^{7}	187.2
35	5	${}^3D_2 - {}^3P_1^\circ$	0.000020	9.631×10^{-5}	1.708×10^{-7}	56287.6	3.345×10^{7}	1.789×10^{5}	18597.6
35	17	${}^3D_2 - {}^3P_1^\circ$	0.013709	4.635×10^{-2}	8.282×10^{-3}	459.6	7.659×10^{9}	4.062×10^{9}	88.6
35	18	${}^3D_2 - {}^3P_2^\circ$	0.032513	1.083×10^{-1}	1.449×10^{-2}	647.4	1.738×10^{10}	1.153×10^{10}	50.7
35	20	${}^3D_2 - {}^3F_3^\circ$	0.111550	3.698×10^{-1}	4.936×10^{-2}	649.2	5.877×10^{10}	5421×10^{10}	-99.9
35	21	${}^3D_2 - {}^1D_2^\circ$	0.002041	6.681×10^{-3}	8.593×10^{-4}	677.5	1.035×10^{9}	6.565×10^{8}	57.7
35	22	${}^3D_2 - {}^3D_3^\circ$	0.016722	5.422×10^{-2}	7.044×10^{-3}	669.7	8.243×10^{9}	7.411×10^{9}	11.2
35	23	${}^3D_2 - {}^3D_1^\circ$	0.016130	5.036×10^{-2}	1.339×10^{-2}	276.1	7.099×10^{9}	5.607×10^{9}	26.6
35	24	${}^3D_2 - {}^3F_2^\circ$	0.035185	1.044×10^{-1}	1.896×10^{-2}	450.6	1.331×10^{10}	1.222×10^{10}	8.9
35	25	${}^3D_2 - {}^3D_2^\circ$	0.016313	4.804×10^{-2}	9.298×10^{-3}	416.7	6.024×10^{9}	5.914×10^{9}	1.9
35	26	${}^3D_2 - {}^1F_3^\circ$	0.018491	5.415×10^{-2}	7.480×10^{-3}	623.9	6.715×10^{9}	6.597×10^{9}	1.8
35	27	${}^3D_2 - {}^1P_1^\circ$	0.007386	2.034×10^{-2}	4.073×10^{-3}	399.4	2.231×10^{9}	1.350×10^{9}	65.3
35	31	${}^3D_2 - {}^3P_1^\circ$	0.494204	5.466×10^{-1}	1.723×10^{-1}	217.2	9.667×10^{9}	8.867×10^{9}	9.0
35	32	${}^3D_2 - {}^3P_2^\circ$	0.175012	1.825×10^{-1}	3.525×10^{-2}	417.7	2.868×10^{9}	2.716×10^{9}	5.6
35	33	${}^3D_2 - {}^1P_1^\circ$	0.036472	3.629×10^{-2}	1.322×10^{-2}	174.5	5.193×10^{8}	5.563×10^{8}	-6.7
36	2	${}^3D_3 - {}^3P_2^\circ$	0.000057	3.006×10^{-4}	1.693×10^{-5}	1675.5	8.700×10^{7}	2.420×10^{7}	259.5
36	18	${}^3D_3 - {}^3P_2^\circ$	0.016371	5.472×10^{-2}	1.449×10^{-2}	277.6	6.315×10^{9}	1.153×10^{10}	-45.2

TABLE III

Fine structure collision strengths, *Ω*, from the ground level $2s^2 2p^6\ ^1S_0$ of Fe XVII compared with Ref. [9] (right colums).

$i \rightarrow j$		75.0 Ry		125.0 Ry		175.0 Ry		250.0 Ry	
1	2	2.634×10^{-3}	1.604×10^{-3}	4.238×10^{-4}	8.532×10^{-4}	2.895×10^{-4}	5.237×10^{-4}	1.779×10^{-4}	2.946×10^{-4}
1	3	4.720×10^{-3}	2.869×10^{-3}	6.661×10^{-3}	5.061×10^{-3}	8.542×10^{-3}	7.034×10^{-3}	7.824×10^{-3}	9.492×10^{-3}
1	4	1.329×10^{-4}	3.177×10^{-4}	8.477×10^{-4}	1.685×10^{-4}	5.793×10^{-4}	1.034×10^{-4}	3.558×10^{-5}	5.814×10^{-5}
1	5	4.115×10^{-3}	2.441×10^{-3}	5.798×10^{-3}	4.138×10^{-3}	7.389×10^{-3}	5.718×10^{-3}	6.770×10^{-3}	7.708×10^{-3}
1	6	1.745×10^{-3}	3.733×10^{-3}	1.111×10^{-3}	2.060×10^{-3}	7.720×10^{-4}	1.312×10^{-3}	4.929×10^{-4}	7.699×10^{-4}
1	7	2.991×10^{-3}	3.586×10^{-3}	3.016×10^{-3}	3.291×10^{-3}	2.988×10^{-3}	3.324×10^{-3}	2.386×10^{-3}	3.488×10^{-3}
1	8	1.582×10^{-4}	3.878×10^{-3}	9.606×10^{-4}	1.980×10^{-3}	6.420×10^{-4}	1.176×10^{-3}	3.896×10^{-4}	6.378×10^{-4}
1	9	5.574×10^{-4}	1.499×10^{-3}	3.303×10^{-4}	7.672×10^{-4}	2.164×10^{-4}	4.581×10^{-4}	1.286×10^{-4}	2.520×10^{-4}
1	10	2.913×10^{-3}	2.965×10^{-3}	3.063×10^{-3}	2.978×10^{-3}	3.105×10^{-3}	3.155×10^{-3}	2.510×10^{-3}	3.432×10^{-3}
1	11	3.197×10^{-3}	2.818×10^{-3}	3.219×10^{-3}	2.946×10^{-3}	3.205×10^{-3}	3.027×10^{-3}	3.103×10^{-3}	3.101×10^{-3}
1	12	6.000×10^{-4}	1.588×10^{-3}	3.595×10^{-4}	8.129×10^{-4}	2.377×10^{-4}	4.837×10^{-4}	1.426×10^{-4}	2.646×10^{-4}
1	13	6.544×10^{-4}	1.665×10^{-3}	3.934×10^{-4}	8.627×10^{-4}	2.613×10^{-4}	5.155×10^{-4}	1.582×10^{-4}	2.827×10^{-4}
1	14	3.464×10^{-3}	3.522×10^{-3}	3.620×10^{-3}	3.463×10^{-3}	3.669×10^{-3}	3.626×10^{-3}	2.981×10^{-3}	3.910×10^{-3}
1	15	4.699×10^{-2}	4.241×10^{-2}	4.825×10^{-2}	4.638×10^{-2}	4.854×10^{-2}	4.859×10^{-2}	4.737×10^{-2}	5.032×10^{-2}
1	16	6.676×10^{-4}	1.752×10^{-3}	3.840×10^{-4}	8.136×10^{-4}	2.467×10^{-4}	4.538×10^{-4}	1.410×10^{-4}	2.356×10^{-4}
1	17	2.436×10^{-3}	5.348×10^{-3}	1.790×10^{-3}	2.940×10^{-3}	1.519×10^{-3}	2.110×10^{-3}	1.144×10^{-3}	1.708×10^{-3}
1	18	2.507×10^{-3}	6.801×10^{-3}	1.429×10^{-3}	3.100×10^{-3}	9.125×10^{-4}	1.710×10^{-3}	5.184×10^{-4}	8.780×10^{-4}
1	19	2.050×10^{-3}	6.037×10^{-3}	1.131×10^{-3}	2.611×10^{-3}	7.062×10^{-4}	1.378×10^{-3}	3.927×10^{-4}	6.747×10^{-4}
1	20	2.891×10^{-3}	4.462×10^{-3}	2.615×10^{-3}	3.093×10^{-3}	2.515×10^{-3}	2.743×10^{-3}	2.238×10^{-3}	2.649×10^{-3}
1	21	7.338×10^{-4}	2.545×10^{-3}	3.834×10^{-4}	1.027×10^{-3}	2.290×10^{-4}	5.244×10^{-4}	1.220×10^{-4}	2.505×10^{-4}
1	22	2.595×10^{-3}	3.171×10^{-3}	2.602×10^{-3}	2.670×10^{-3}	2.650×10^{-3}	2.723×10^{-3}	2.455×10^{-3}	2.907×10^{-3}
1	23	4.253×10^{-2}	2.754×10^{-2}	5.292×10^{-2}	4.012×10^{-2}	6.096×10^{-2}	5.020×10^{-2}	5.517×10^{-2}	6.224×10^{-2}
1	24	9.086×10^{-4}	2.930×10^{-3}	4.904×10^{-4}	1.217×10^{-3}	3.009×10^{-4}	6.339×10^{-4}	1.646×10^{-4}	3.079×10^{-4}
1	25	1.278×10^{-3}	3.775×10^{-3}	7.043×10^{-4}	1.590×10^{-3}	4.385×10^{-4}	8.410×10^{-4}	2.433×10^{-4}	4.157×10^{-4}
1	26	3.048×10^{-3}	3.856×10^{-3}	2.981×10^{-3}	3.076×10^{-3}	3.001×10^{-3}	3.017×10^{-3}	2.756×10^{-3}	3.129×10^{-3}
1	27	1.580×10^{-1}	1.016×10^{-1}	1.978×10^{-1}	1.530×10^{-1}	2.282×10^{-1}	1.934×10^{-1}	2.083×10^{-1}	2.412×10^{-1}
1	28	3.704×10^{-4}	2.190×10^{-3}	2.267×10^{-4}	1.289×10^{-3}	1.554×10^{-4}	8.791×10^{-4}	9.736×10^{-5}	5.808×10^{-4}
1	29	2.018×10^{-2}	1.607×10^{-2}	2.075×10^{-2}	1.810×10^{-2}	2.286×10^{-2}	1.908×10^{-2}	2.912×10^{-2}	1.945×10^{-2}
1	30	1.033×10^{-4}	2.820×10^{-4}	6.638×10^{-5}	1.472×10^{-4}	4.602×10^{-5}	8.850×10^{-5}	2.869×10^{-5}	4.950×10^{-5}
1	31	8.800×10^{-4}	1.089×10^{-3}	1.087×10^{-3}	1.166×10^{-3}	1.271×10^{-3}	1.415×10^{-3}	1.232×10^{-3}	1.826×10^{-3}
1	32	5.188×10^{-4}	1.416×10^{-3}	3.341×10^{-4}	7.309×10^{-4}	2.319×10^{-4}	4.372×10^{-4}	1.448×10^{-4}	2.438×10^{-4}
1	33	5.433×10^{-3}	2.648×10^{-3}	8.091×10^{-3}	5.936×10^{-3}	1.016×10^{-2}	9.066×10^{-3}	1.019×10^{-2}	1.307×10^{-2}
1	34	6.409×10^{-4}	1.885×10^{-3}	3.827×10^{-4}	8.732×10^{-4}	2.545×10^{-4}	4.951×10^{-4}	1.522×10^{-4}	2.615×10^{-4}
1	35	1.161×10^{-3}	3.157×10^{-3}	7.498×10^{-4}	1.492×10^{-3}	5.500×10^{-4}	8.738×10^{-4}	3.756×10^{-4}	4.955×10^{-4}
1	36	1.491×10^{-3}	4.392×10^{-3}	8.904×10^{-4}	2.033×10^{-3}	5.920×10^{-4}	1.150×10^{-3}	3.539×10^{-4}	6.062×10^{-4}
1	37	2.316×10^{-2}	1.421×10^{-2}	2.707×10^{-2}	2.283×10^{-2}	3.016×10^{-2}	2.844×10^{-2}	2.911×10^{-2}	3.380×10^{-2}
1	38	1.985×10^{-4}	7.879×10^{-4}	1.275×10^{-4}	3.581×10^{-4}	8.857×10^{-5}	2.049×10^{-4}	5.514×10^{-5}	1.081×10^{-4}
1	39	6.406×10^{-4}	4.905×10^{-4}	8.899×10^{-4}	6.616×10^{-4}	1.083×10^{-3}	9.015×10^{-4}	1.170×10^{-3}	1.231×10^{-3}
1	40	4.200×10^{-4}	1.235×10^{-3}	2.675×10^{-4}	6.221×10^{-4}	1.870×10^{-4}	3.732×10^{-4}	1.194×10^{-4}	2.095×10^{-4}
1	41	6.141×10^{-4}	1.516×10^{-4}	5.709×10^{-4}	6.962×10^{-5}	5.752×10^{-4}	4.035×10^{-5}	5.260×10^{-4}	2.152×10^{-5}
1	42	4.005×10^{-5}	4.469×10^{-4}	2.569×10^{-5}	4.262×10^{-4}	1.783×10^{-5}	5.951×10^{-4}	1.108×10^{-5}	7.960×10^{-4}
1	43	5.024×10^{-4}	1.161×10^{-3}	6.626×10^{-4}	8.964×10^{-4}	7.898×10^{-4}	6.569×10^{-4}	8.448×10^{-4}	6.249×10^{-4}
1	44	5.265×10^{-4}	1.850×10^{-3}	3.227×10^{-4}	8.533×10^{-4}	2.182×10^{-4}	4.836×10^{-4}	1.339×10^{-4}	2.539×10^{-4}
1	45	1.879×10^{-4}	6.724×10^{-4}	1.121×10^{-4}	3.237×10^{-4}	7.408×10^{-5}	1.817×10^{-4}	4.432×10^{-5}	9.409×10^{-5}
1	46	5.260×10^{-4}	9.034×10^{-4}	5.039×10^{-4}	6.054×10^{-4}	5.197×10^{-4}	5.295×10^{-4}	4.833×10^{-4}	5.228×10^{-4}
1	47	5.534×10^{-3}	4.727×10^{-3}	5.708×10^{-3}	5.380×10^{-3}	5.828×10^{-3}	5.675×10^{-3}	5.850×10^{-3}	5.920×10^{-3}
1	48	2.127×10^{-4}	7.276×10^{-4}	1.292×10^{-4}	3.623×10^{-4}	8.680×10^{-5}	2.072×10^{-4}	5.284×10^{-5}	1.089×10^{-4}
1	49	2.457×10^{-4}	7.929×10^{-4}	1.508×10^{-4}	4.000×10^{-4}	1.022×10^{-4}	2.308×10^{-4}	6.300×10^{-5}	1.229×10^{-4}
1	50	6.397×10^{-4}	1.111×10^{-3}	6.078×10^{-4}	7.418×10^{-4}	6.229×10^{-4}	6.385×10^{-4}	5.774×10^{-4}	6.152×10^{-4}
1	51	2.251×10^{-4}	7.826×10^{-4}	1.324×10^{-4}	3.526×10^{-4}	8.718×10^{-5}	1.929×10^{-4}	5.140×10^{-5}	9.851×10^{-5}
1	52	7.802×10^{-4}	2.233×10^{-3}	5.775×10^{-4}	1.141×10^{-3}	4.908×10^{-4}	7.734×10^{-4}	4.043×10^{-4}	5.904×10^{-4}
1	53	7.261×10^{-4}	3.029×10^{-3}	4.096×10^{-4}	1.227×10^{-3}	2.617×10^{-4}	6.289×10^{-4}	1.497×10^{-4}	2.999×10^{-4}
1	54	7.176×10^{-4}	2.774×10^{-3}	4.134×10^{-4}	1.166×10^{-3}	2.681×10^{-4}	6.189×10^{-4}	1.557×10^{-4}	3.077×10^{-4}
1	55	7.105×10^{-4}	1.782×10^{-3}	6.254×10^{-4}	9.180×10^{-4}	6.169×10^{-4}	7.031×10^{-4}	5.894×10^{-4}	6.326×10^{-4}

TABLE III (cont.)

Fine structure collision strengths, Ω, from the ground level $2s^22p^6\ {}^1S_0$ of Fe XVII, data from Ref. [9] unavailable.

$i \to j$		75.0 Ry		125.0 Ry		175.0 Ry		250.0 Ry	
1	56	2.653×10^{-4}	—	1.395×10^{-4}	—	8.391×10^{-5}	—	4.500×10^{-5}	—
1	57	9.512×10^{-3}	—	9.838×10^{-3}	—	1.006×10^{-2}	—	1.011×10^{-2}	—
1	58	5.250×10^{-4}	—	4.901×10^{-4}	—	5.064×10^{-4}	—	5.033×10^{-4}	—
1	59	2.421×10^{-2}	—	2.939×10^{-2}	—	3.337×10^{-2}	—	3.431×10^{-2}	—
1	60	6.757×10^{-5}	—	3.345×10^{-5}	—	1.949×10^{-5}	—	9.739×10^{-6}	—
1	61	2.071×10^{-4}	—	2.062×10^{-4}	—	2.247×10^{-4}	—	2.188×10^{-4}	—
1	62	1.108×10^{-4}	—	5.550×10^{-5}	—	3.319×10^{-5}	—	1.750×10^{-5}	—
1	63	5.323×10^{-4}	—	5.991×10^{-4}	—	6.850×10^{-4}	—	6.516×10^{-4}	—
1	64	8.061×10^{-5}	—	3.850×10^{-5}	—	2.193×10^{-5}	—	1.088×10^{-5}	—
1	65	1.476×10^{-3}	—	1.839×10^{-3}	—	2.181×10^{-3}	—	2.112×10^{-3}	—
1	66	5.110×10^{-5}	—	2.365×10^{-5}	—	1.325×10^{-5}	—	6.623×10^{-6}	—
1	67	9.151×10^{-5}	—	7.719×10^{-5}	—	7.864×10^{-5}	—	7.433×10^{-5}	—
1	68	3.562×10^{-4}	—	1.977×10^{-4}	—	1.246×10^{-4}	—	7.033×10^{-5}	—
1	69	5.805×10^{-4}	—	3.307×10^{-4}	—	2.125×10^{-4}	—	1.224×10^{-4}	—
1	70	6.679×10^{-4}	—	6.072×10^{-4}	—	6.115×10^{-4}	—	5.963×10^{-4}	—
1	71	2.679×10^{-2}	—	3.256×10^{-2}	—	3.708×10^{-2}	—	3.846×10^{-2}	—
1	72	5.933×10^{-5}	—	2.903×10^{-5}	—	1.702×10^{-5}	—	8.910×10^{-6}	—
1	73	1.513×10^{-4}	—	1.412×10^{-4}	—	1.485×10^{-4}	—	1.445×10^{-4}	—
1	74	9.744×10^{-4}	—	1.197×10^{-3}	—	1.410×10^{-3}	—	1.387×10^{-3}	—
1	75	1.001×10^{-4}	—	4.874×10^{-5}	—	2.804×10^{-5}	—	1.408×10^{-5}	—
1	76	1.437×10^{-4}	—	8.832×10^{-5}	—	5.979×10^{-5}	—	3.836×10^{-5}	—
1	77	4.146×10^{-3}	—	4.304×10^{-3}	—	4.639×10^{-3}	—	4.914×10^{-3}	—
1	78	3.894×10^{-5}	—	2.477×10^{-5}	—	1.684×10^{-5}	—	1.063×10^{-5}	—
1	79	3.978×10^{-4}	—	4.891×10^{-4}	—	5.970×10^{-4}	—	6.802×10^{-4}	—
1	80	1.946×10^{-4}	—	1.239×10^{-4}	—	8.423×10^{-5}	—	5.320×10^{-5}	—
1	81	1.897×10^{-3}	—	2.697×10^{-3}	—	3.505×10^{-3}	—	4.135×10^{-3}	—
1	82	2.129×10^{-4}	—	1.309×10^{-4}	—	8.761×10^{-5}	—	5.481×10^{-5}	—
1	83	3.866×10^{-4}	—	2.572×10^{-4}	—	1.892×10^{-4}	—	1.404×10^{-4}	—
1	84	4.967×10^{-4}	—	3.053×10^{-4}	—	2.044×10^{-4}	—	1.278×10^{-4}	—
1	85	5.101×10^{-3}	—	6.051×10^{-3}	—	6.593×10^{-3}	—	7.422×10^{-3}	—
1	86	6.277×10^{-5}	—	3.318×10^{-5}	—	1.958×10^{-5}	—	1.094×10^{-5}	—
1	87	1.424×10^{-4}	—	1.155×10^{-4}	—	1.009×10^{-4}	—	1.007×10^{-4}	—
1	88	1.132×10^{-4}	—	5.982×10^{-5}	—	3.530×10^{-5}	—	1.972×10^{-5}	—
1	89	7.424×10^{-4}	—	8.768×10^{-4}	—	9.108×10^{-4}	—	1.042×10^{-3}	—