Critically Evaluated Atomic Transition Probabilities for Ba I and Ba II

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Atomic transition probabilities for allowed and forbidden lines of Ba I and Ba II are tabulated, based on a critical evaluation of recent literature sources. The data are presented in multiplet format and are ordered by increasing excitation energies.

Key words: allowed transitions; barium; Ba I; Ba II; forbidden transitions; oscillator strengths; transition probabilities.

Contents

List of Symbols

Symbols for indication of data accuracy

A	uncertainties within 3%,
B	uncertainties within 10%,
C	uncertainties within 25%,
D	uncertainties within 50%.

Symbols used for the table headings

E_i:	lower energy level,
E_k:	upper energy level,
g_i:	statistical weight of the lower level,
g_k:	statistical weight of the upper level,
A_{ki}:	atomic transition probability for spontaneous emission,
f_{ik}:	(absorption) oscillator strength,
S:	line strength.

Abbreviations appearing in the column labeled *Source* (allowed lines only)

LS: LS coupling rules have been applied.

Abbreviations appearing in the column labeled *Type* (forbidden lines only):

M1:	Magnetic dipole transitions,
E2:	Electric quadrupole transitions.

Special symbols used in the wavelength and energy level columns

Numbers in italics indicate multiplet values, i.e., weighted averages of line values.

Notation for exponents

In all tables, we have shown the power of 10 by the exponential notation. For example, 3.88E−3 stands for 3.88×10^{-3}.

1. Introduction

Updated tables of critically evaluated atomic transition probabilities for Ba I and Ba II are presented. Our tables are arranged in the same format as the comprehensive NIST tables on atomic transition probabilities. The compilations have been carried out in response to new as well as continuing interests in these spectra. For example, the lighting industry is considering barium as the emitting agent in fluorescent tubes and needs such spectral data for modeling the discharges.

Earlier transition probability tables on Ba I and Ba II were published by the National Bureau of Standards in 1969,[1] and one of us (Wolfgang L. Wiese) participated in that compilation. We stated then in the introductory comments that ''aside from the principal resonance line and several other lines of the resonance series, the oscillator strength situation for Ba I is quite poor and needs drastic improvement.'' This assessment proved indeed to be correct, as is borne out by the results of several more recent experiments, which differ significantly from the earlier compiled data, sometimes by factors of 2 or more. But the recent results are now generally in good agreement with each other, so that this compilation is based entirely on these new data.

1.1. Useful Relations

(1) Statistical weight g:

The statistical weight of a level is related to the total angular momentum or quantum number J_L of that level (initial or final state of a line) by

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$$g_L = 2J_L + 1.$$

Similarly, the statistical weight of a term (initial or final state of a multiplet) is denoted by

$$g_M = (2L+1)(2S+1),$$

where L is the resultant orbital angular momentum and S is the resultant spin angular momentum.

(2) Line strength S:

$$S(i,k) = \sum_{J_i, J_k} S(J_i, J_k)$$

or

$$S(\mathrm{Multiplet}) = \sum S(\mathrm{line}),$$

where k denotes the upper term and i the lower term.

(3) Conversions: For electric dipole (E1-allowed) transitions,

$$A_{ki} = \frac{6.6703\times 10^{15}}{g_k\ \lambda^2}\frac{g_i}{}f_{ik} = \frac{2.0261\times 10^{18}}{g_k\ \lambda^3}S.$$

For magnetic dipole (M1-forbidden) transitions,

$$A_{ki} = \frac{2.6974\times 10^{13}}{g_k\lambda^3}S.$$

For electric quadrupole (E2-forbidden) transitions,

$$A_{ki} = \frac{1.1199\times 10^{18}}{g_k\lambda^5}S.$$

For these conversions, the line strength (S) is given in atomic units. The transition probability (A_{ki}) is in units of s^{-1}, and the f value is dimensionless. The wavelength (λ) is given in Å units, and g_i and g_k are the statistical weights of the lower and upper level, respectively. For more detail on these units and conversion factors, we refer the reader to our recent NIST publication: *Atomic Transition Probabilities of Carbon, Nitrogen, and Oxygen, A Critical Data Compilation*, W. L. Wiese, J. R. Fuhr, and T. M. Deters, J. Phys. Chem. Ref. Data, Monograph No. 7 (1996).

2. Ba I

Ground State: $1s^22s^22p^63s^23p^63d^{10}4s^24p^64d^{10}5s^25p^66s^2\ ^1S_0$
Ionization Energy: 5.2117 eV = 42 035.2 cm^{-1}

2.1. Allowed Transitions

List of Tabulated Lines

Wavelength (Å)	No.	Wavelength (Å)	No.	Wavelength (Å)	No.	Wavelength (Å)	No.
in air		2427.41	9	4192.20	76	7059.94	50
		2438.81	8	4193.81	75	7120.33	51
2380.66	43	2452.33	7	4195.59	74	7195.23	62
2380.75	42	2472.74	6	4323.00	68	7213.60	51
2380.86	41	3071.58	5	4402.54	66	7280.30	50
2380.97	40	3501.11	4	4488.98	67	7392.41	62
2381.08	39	3889.33	3	4493.64	68	7417.54	51
2381.21	38	4132.43	2	4573.85	66	7488.08	50
2381.34	37	4175.69	104	4579.64	66	7528.18	106
2381.48	36	4175.91	103	4599.72	65	7610.48	58
2381.63	35	4176.12	102	4619.92	64	7672.09	50
2381.79	34	4176.36	101	4700.42	64	7780.48	50
2381.97	33	4176.60	100	4726.43	61	7877.80	70
2382.15	32	4176.86	99	4902.85	64	7905.75	62
2382.36	31	4177.15	98	5169.53	54	8147.70	109
2382.57	30	4177.44	97	5519.04	63	8560.00	57
2382.80	29	4177.74	96	5535.48	1	8654.08	56
2383.06	28	4178.07	95	5777.62	63	9370.12	56
2383.34	27	4178.43	94	5784.04	73	9645.60	112
2383.63	26	4178.80	93	5800.23	63	9704.31	112
2383.96	25	4179.20	92	5826.27	60	9821.48	111
2384.32	24	4179.64	91	5971.70	53	10 370.3	113
2384.71	23	4180.09	90	5997.09	53	10 540.1	108
2385.15	22	4180.57	89	6019.47	53	10 649.1	113
2385.62	21	4181.09	88	6063.11	53	11 075.7	49
2386.15	20	4181.66	87	6083.39	73	11 303.0	49
2386.74	19	4182.27	86	6129.23	72	11 373.7	113
2387.40	18	4182.94	85	6309.36	71	12 342.3	69
2388.13	17	4183.64	84	6341.68	52	14 723.1	115
2388.96	16	4184.40	83	6450.85	52	14 999.9	55
2399.39	15	4185.25	82	6498.76	52	17 186.9	114
2402.07	14	4186.16	81	6527.31	52	18 202.8	107
2405.30	13	4187.15	80	6595.33	52	21 567.7	110
2409.23	12	4188.25	79	6675.27	52	30 685.3	105
2414.08	11	4189.44	78	6693.84	52		
2420.11	10	4190.76	77	6986.80	59		

Several experiments[2–6] have been recently carried out with improved techniques and are estimated to yield results that are significantly more accurate than those available for our earlier compilation.[1] The recent experimental results typically have uncertainties estimated to be within ± 25%. Indeed, two independent experiments for the same lines by Niggli and Huber,[3] and Garcia and Campos,[6] both normalized to lifetime data, produced very good agreement.

Huber and co-workers[2–5] have done a series of branching-ratio measurements in emission with a hollow-cathode discharge, and obtained the spectra with a Fourier transform spectrometer. By combining their emission data with available lifetime and absorption data, absolute transition probabilities were determined.

Similar measurements, taken with a conventional grating monochromator have been performed by Garcia and Campos.[6] The agreement with the experiments by Huber and co-workers[2–5] ranges from excellent to satisfactory. The best agreement—typically about 5%–10%—is obtained when both results have been normalized to lifetime data.

Less impressive agreement is obtained for lines which have been normalized according to line strength sum rules or the Ladenburg rule.[6]

For Ba I, a fair number of lifetime measurements exist, many done with the Hanle effect or zero field level crossing technique. We cite only the references utilized in this tabulation.[7–10] More lifetime data, including some for Rydberg levels, are available, but could not be applied by us to derive oscillator strengths, since the pertinent branching ratios are missing. The lifetimes generally have been measured by selective photon excitation of a barium atomic beam using interference filters. Thus, cascading effects have been eliminated, and collisional effects and radiative imprisonment have been checked and reduced to insignificance by varying the density of the discharge. The lifetime results are thus expected to be of very high quality, with the most accurate result obtained by Kelly and Mathur[10] for the $6s^2\ {}^1\mathrm{S}-6s6p\ {}^1\mathrm{P}^\mathrm{o}$ resonance line (quoted uncertainty $\pm 1\%$), which is in complete agreement with a pulsed dye-laser, time-resolved fluorescence measurement by Schenck *et al.*,[12] and earlier Hanle-effect measurements by Dickie and Kelly,[17] Swagel and Lurio,[18] and Hulpke *et al.*[19]

Oscillator strengths for Rydberg transitions of the $6s^2-6snp$ resonance series have been measured from $n=16-42$ by Connerade *et al.*[13] and from $n=28-60$ by Mende and Kock.[14,15] In addition, Mende and Kock have provided data for the $6s6p-6snd$ series for $n=30-60$. Connerade *et al.* applied the technique of magneto-optical rotation, while Mende and Kock used a photoionization technique with tunable lasers. In both experiments, the oscillator strengths were measured on a relative basis, and fair-to-good agreement is obtained on a relative scale.

The normalization to absolute values proceeded along two fundamentally different approaches. Connerade *et al.* normalized their values to the oscillator strength data of Parkinson *et al.*[16] for *lower* Rydberg lines, with which they overlap for lines with upper-level principal quantum numbers $n=16-20$. These in turn are normalized to lifetime results[17–19] for the principal resonance line $6s^2-6s6p$. This normalization is basically the same as we use now for Refs. 2–6, and 16. However, a small change arises from the result of Bizzarri and Huber[5] that the contribution of the $6s5d\ {}^1\mathrm{D}-6s6p\ {}^1\mathrm{P}^\mathrm{o}$ transition to the lifetime of the $6s6p\ {}^1\mathrm{P}^\mathrm{o}$ state is actually a factor of 10 smaller than estimated earlier and thus becomes negligible.

Mende and Kock normalized their oscillator strength data for the *highest* Rydberg lines via a photoionization cross section they determined in the same experiment utilizing the principle of spectral continuity across ionization thresholds. Their value for the cross section is in excellent agreement with other experimental and theoretical results. Connerade *et al.* also derived the photoionization cross section from their normalized set of oscillator strengths for the high Rydberg lines. They obtained, however, a value that is almost a factor of 3 higher than all other results. Griesmann *et al.*[20] note that the extrapolation done by Connerade *et al.* involves very high series members with very small oscillator strengths. In fact, the oscillator strength goes through a minimum at about $n=24$, with very small (and uncertain) f values between $n=22$ and $n=27$.[13] This introduces large errors in the photoionization cross section, which is varying strongly in the vicinity of the threshold.

Since the normalization by Mende and Kock is more direct and fully consistent with other data, their data sets have been selected for this tabulation.

Ba I: Allowed Transitions

No.	Transition array	Multiplet	λ_{air} (Å)	λ_{vac} (Å) or σ (cm^{-1})*	E_i (cm^{-1})	E_k (cm^{-1})	g_i–g_k	A_{ki} (10^8 s^{-1})	f_{ik}	S (a.u.)	log gf	Acc.	Source
1.	$6s^2-6s6p$	^{1}S–^{1}P°	5535.48	5537.02	0.000–	18 060.261	1–3	1.19E+0	1.64E+0	2.99E+1	0.215	A$^+$	10
2.	$6s^2-5d6p$	^{1}S–^{3}D°	4132.43	4133.59	0.000–	24 192.033	1–3	1.5E−2	1.1E−2	1.5E−1	−1.95	B	3,6
3.	$6s^2-5d6p$	^{1}S–^{3}P°	3889.33	3890.43	0.000–	25 704.110	1–3	1.1E−2	7.5E−3	9.6E−2	−2.13	C$^+$	6
4.	$6s^2-5d6p$	^{1}S–^{1}P°	3501.11	3502.11	0.000–	28 554.221	1–3	3.5E−1	1.9E−1	2.2E+0	−0.71	B	3
5.	$6s^2-6s7p$	^{1}S–^{1}P°	3071.58	3072.48	0.000–	32 547.033	1–3	4.2E−1	1.8E−1	1.8E+0	−0.74	C	2
6.	$6s^2-6s12p$	^{1}S–^{1}P°	2472.74	2473.49	0.000–	40 428.68	1–3	4.6E−3	1.3E−3	1.0E−2	−2.90	C$^+$	16
7.	$6s^2-6s13p$	^{1}S–^{1}P°	2452.33	2453.07	0.000–	40 765.23	1–3	8.1E−4	2.2E−4	1.8E−3	−3.66	C$^+$	16
8.	$6s^2-6s14p$	^{1}S–^{1}P°	2438.81	2439.55	0.000–	40 991.23	1–3	1.4E−3	3.8E−4	3.1E−3	−3.42	C$^+$	16
9.	$6s^2-6s15p$	^{1}S–^{1}P°	2427.41	2428.15	0.000–	41 183.60	1–3	5.6E−3	1.5E−3	1.2E−2	−2.83	C$^+$	16
10.	$6s^2-6s16p$	^{1}S–^{1}P°	2420.11	2420.85	0.000–	41 307.88	1–3	2.3E−3	6.2E−4	4.9E−3	−3.21	C$^+$	16
11.	$6s^2-6s17p$	^{1}S–^{1}P°	2414.08	2414.81	0.000–	41 411.04	1–3	1.5E−3	4.0E−4	3.2E−3	−3.40	C$^+$	16
12.	$6s^2-6s18p$	^{1}S–^{1}P°	2409.23	2409.96	0.000–	41 494.39	1–3	8.6E−4	2.2E−4	1.8E−3	−3.65	C$^+$	16
13.	$6s^2-6s19p$	^{1}S–^{1}P°	2405.30	2406.03	0.000–	41 562.24	1–3	4.9E−4	1.3E−4	1.0E−3	−3.89	C	16
14.	$6s^2-6s20p$	^{1}S–^{1}P°	2402.07	2402.80	0.000–	41 618.12	1–3	4.6E−4	1.2E−4	9.5E−4	−3.92	C	16
15.	$6s^2-6s21p$	^{1}S–^{1}P°	2399.39	2400.12	0.000–	41 664.66	1–3	1.1E−4	3.0E−5	2.3E−4	−4.53	D	13
16.	$6s^2-6s28p$	^{1}S–^{1}P°	2388.96	2389.69	0.000–	41 846.48	1–3	8.37E−5	2.15E−5	1.69E−4	−4.668	C$^+$	14
17.	$6s^2-6s29p$	^{1}S–^{1}P°	2388.13	2388.86	0.000–	41 860.99	1–3	9.66E−5	2.48E−5	1.95E−4	−4.606	C$^+$	14
18.	$6s^2-6s30p$	^{1}S–^{1}P°	2387.40	2388.12	0.000–	41 873.88	1–3	1.37E−4	3.51E−5	2.76E−4	−4.455	C$^+$	14
19.	$6s^2-6s31p$	^{1}S–^{1}P°	2386.74	2387.47	0.000–	41 885.39	1–3	1.87E−4	4.79E−5	3.76E−4	−4.320	C$^+$	14
20.	$6s^2-6s32p$	^{1}S–^{1}P°	2386.15	2386.88	0.000–	41 895.70	1–3	2.03E−4	5.21E−5	4.09E−4	−4.283	C$^+$	14
21.	$6s^2-6s33p$	^{1}S–^{1}P°	2385.62	2386.35	0.000–	41 905.03	1–3	2.30E−4	5.89E−5	4.63E−4	−4.230	C$^+$	14
22.	$6s^2-6s34p$	^{1}S–^{1}P°	2385.15	2385.87	0.000–	41 913.39	1–3	2.50E−4	6.39E−5	5.02E−4	−4.194	C$^+$	14
23.	$6s^2-6s35p$	^{1}S–^{1}P°	2384.71	2385.44	0.000–	41 921.00	1–3	3.00E−4	7.69E−5	6.04E−4	−4.114	C$^+$	14
24.	$6s^2-6s36p$	^{1}S–^{1}P°	2384.32	2385.05	0.000–	41 927.90	1–3	2.97E−4	7.61E−5	5.98E−4	−4.119	C$^+$	14
25.	$6s^2-6s37p$	^{1}S–^{1}P°	2383.96	2384.69	0.000–	41 934.18	1–3	3.20E−4	8.19E−5	6.43E−4	−4.087	C$^+$	14
26.	$6s^2-6s38p$	^{1}S–^{1}P°	2383.63	2384.36	0.000–	41 939.95	1–3	3.70E−4	9.45E−5	7.42E−4	−4.025	C$^+$	14
27.	$6s^2-6s39p$	^{1}S–^{1}P°	2383.34	2384.06	0.000–	41 945.20	1–3	3.37E−4	8.61E−5	6.76E−4	−4.065	C$^+$	14
28.	$6s^2-6s40p$	^{1}S–^{1}P°	2383.06	2383.79	0.000–	41 950.07	1–3	3.57E−4	9.12E−5	7.16E−4	−4.040	C$^+$	14
29.	$6s^2-6s41p$	^{1}S–^{1}P°	2382.80	2383.53	0.000–	41 954.55	1–3	3.69E−4	9.42E−5	7.39E−4	−4.026	C$^+$	14
30.	$6s^2-6s42p$	^{1}S–^{1}P°	2382.57	2383.30	0.000–	41 958.68	1–3	3.14E−4	8.02E−5	6.29E−4	−4.096	C$^+$	14
31.	$6s^2-6s43p$	^{1}S–^{1}P°	2382.36	2383.08	0.000–	41 962.43	1–3	3.64E−4	9.29E−5	7.29E−4	−4.032	C$^+$	14
32.	$6s^2-6s44p$	^{1}S–^{1}P°	2382.15	2382.88	0.000–	41 966.03	1–3	3.63E−4	9.26E−5	7.26E−4	−4.033	C$^+$	14
33.	$6s^2-6s45p$	^{1}S–^{1}P°	2381.97	2382.69	0.000–	41 969.32	1–3	3.39E−4	8.65E−5	6.79E−4	−4.063	C$^+$	14
34.	$6s^2-6s46p$	^{1}S–^{1}P°	2381.79	2382.52	0.000–	41 972.36	1–3	3.44E−4	8.77E−5	6.88E−4	−4.057	C$^+$	14
35.	$6s^2-6s47p$	^{1}S–^{1}P°	2381.63	2382.36	0.000–	41 975.21	1–3	3.22E−4	8.22E−5	6.45E−4	−4.085	C$^+$	14
36.	$6s^2-6s48p$	^{1}S–^{1}P°	2381.48	2382.21	0.000–	41 977.87	1–3	3.41E−4	8.70E−5	6.82E−4	−4.060	C$^+$	14
37.	$6s^2-6s49p$	^{1}S–^{1}P°	2381.34	2382.07	0.000–	41 980.35	1–3	3.15E−4	8.04E−5	6.31E−4	−4.095	C$^+$	14
38.	$6s^2-6s50p$	^{1}S–^{1}P°	2381.21	2381.93	0.000–	41 982.71	1–3	2.91E−4	7.42E−5	5.82E−4	−4.130	C$^+$	14
39.	$6s^2-6s51p$	^{1}S–^{1}P°	2381.08	2381.81	0.000–	41 984.90	1–3	2.50E−4	6.38E−5	5.00E−4	−4.195	C$^+$	14
40.	$6s^2-6s52p$	^{1}S–^{1}P°	2380.97	2381.69	0.000–	41 986.94	1–3	2.57E−4	6.56E−5	5.14E−4	−4.183	C$^+$	14
41.	$6s^2-6s53p$	^{1}S–^{1}P°	2380.86	2381.58	0.000–	41 988.89	1–3	2.55E−4	6.51E−5	5.10E−4	−4.186	C$^+$	14
42.	$6s^2-6s54p$	^{1}S–^{1}P°	2380.75	2381.48	0.000–	41 990.68	1–3	2.44E−4	6.22E−5	4.88E−4	−4.206	C$^+$	14
43.	$6s^2-6s55p$	^{1}S–^{1}P°	2380.66	2381.38	0.000–	41 992.40	1–3	2.62E−4	6.68E−5	5.24E−4	−4.175	C$^+$	14
44.	$6s^2-6s56p$	^{1}S–^{1}P°			0.000–		1–3		5.47E−5			C$^+$	14

Ba I: Allowed Transitions—Continued

No.	Transition array	Multiplet	λ_{air} (Å)	λ_{vac} (Å) or σ (cm^{-1})*	E_i (cm^{-1})	E_k (cm^{-1})	g_i–g_k	A_{ki} (10^8 s^{-1})	f_{ik}	S (a.u.)	log gf	Acc.	Source
45.	$6s^2$–$6s57p$	^{1}S–^{1}P°			0.000–		1–3		5.85E−5			C$^+$	14
46.	$6s^2$–$6s58p$	^{1}S–^{1}P°			0.000–		1–3		5.22E−5			C$^+$	14
47.	$6s^2$–$6s59p$	^{1}S–^{1}P°			0.000–		1–3		4.28E−5			C$^+$	14
48.	$6s^2$–$6s60p$	^{1}S–^{1}P°			0.000–		1–3		4.34E−5			C$^+$	14
49.	$6s5d$–$6s6p$	^{3}D–^{1}P°											
			11 303.0	8844.760 cm^{-1}	9215.501–	18 060.261	5–3	1.1E−3	1.3E−3	2.4E−1	−2.20	C	5
			11 075.7	9026.295 cm^{-1}	9033.966–	18 060.261	3–3	3.1E−5	5.7E−5	6.2E−3	−3.77	D$^+$	5
50.	$6s5d$–$5d6p$	^{3}D–^{3}F°											
			7059.94	7061.89	9596.533–	23 757.049	7–9	5.0E−1	4.8E−1	7.8E+1	0.53	C	6
			7280.30	7282.30	9215.501–	22 947.423	5–7	3.2E−1	3.6E−1	4.3E+1	0.25	C$^+$	3,6
			7672.09	7674.20	9033.966–	22 064.645	3–5	1.52E−1	2.24E−1	1.70E+1	−0.173	C	3
			7488.08	7490.14	9596.533–	22 947.423	7–7	7.3E−2	6.1E−2	1.1E+1	−0.37	C$^+$	3,6
			7780.48	7782.62	9215.501–	22 064.645	5–5	7.6E−2	6.9E−2	8.8E+0	−0.46	C	3
51.	$6s5d$–$5d6p$	^{3}D–^{1}D°											
			7417.54	7419.58	9596.533–	23 074.387	7–5	7.7E−3	4.5E−3	7.8E−1	−1.50	C	3
			7213.60	7215.59	9215.501–	23 074.387	5–5	6.5E−4	5.1E−4	6.0E−2	−2.60	D$^+$	3
			7120.33	7122.29	9033.966–	23 074.387	3–5	1.1E−1	1.4E−1	9.8E+0	−0.38	C	3
52.	$6s5d$–$5d6p$	^{3}D–^{3}D°	*6527.4*	*6529.2*	*9357.01–*	*24 672.83*	15–15	6.15E−1	3.93E−1	1.27E+2	0.771	B	3,6
			6498.76	6500.56	9596.533–	24 979.834	7–7	5.4E−1	3.4E−1	5.1E+1	0.38	C$^+$	6
			6527.31	6529.11	9215.501–	24 531.513	5–5	3.3E−1	2.1E−1	2.3E+1	0.02	B	3,6
			6595.33	6597.15	9033.966–	24 192.033	3–3	3.8E−1	2.5E−1	1.6E+1	−0.13	B$^+$	3,6
			6693.84	6695.69	9596.533–	24 531.513	7–5	1.46E−1	7.01E−2	1.08E+1	−0.309	B	3,6
			6675.27	6677.11	9215.501–	24 192.033	5–3	1.89E−1	7.58E−2	8.33E+0	−0.421	B$^+$	3,6
			6341.68	6343.43	9215.501–	24 979.834	5–7	1.16E−1	9.80E−2	1.02E+1	−0.310	C$^+$	6
			6450.85	6452.63	9033.966–	24 531.513	3–5	1.1E−1	1.1E−1	7.3E+0	−0.46	B	3,6
53.	$6s5d$–$5d6p$	^{3}D–^{3}P°											
			6063.11	6064.79	9215.501–	25 704.110	5–3	5.6E−1	1.9E−1	1.8E+1	−0.03	C$^+$	6
			6019.47	6021.14	9033.966–	25 642.126	3–1	8.1E−1	1.5E−1	8.7E+0	−0.36	C	6
			5971.70	5973.35	9215.501–	25 956.519	5–5	1.62E−1	8.67E−2	8.52E+0	−0.363	C$^+$	6
			5997.09	5998.75	9033.966–	25 704.110	3–3	2.8E−1	1.5E−1	8.9E+0	−0.34	C$^+$	6
54.	$6s5d$–$5d6p$	^{3}D–^{1}P°											
			5169.53	5170.97	9215.501–	28 554.221	5–3	9.0E−4	2.2E−4	1.8E−2	−2.97	D	3
55.	$6s5d$–$6s6p$	^{1}D–^{1}P°	14 999.9	6664.911 cm^{-1}	11 395.350–	18 060.261	5–3	2.5E−3	5.1E−3	1.3E+0	−1.60	B	5
56.	$6s5d$–$5d6p$	^{1}D–^{3}F°											
			8654.08	8656.45	11 395.350–	22 947.423	5–7	3.1E−3	4.9E−3	6.9E−1	−1.61	D$^+$	3
			9370.12	9372.69	11 395.350–	22 064.645	5–5	7.6E−2	1.0E−1	1.5E+1	−0.30	C	3
57.	$6s5d$–$5d6p$	^{1}D–^{1}D°	8560.00	8562.35	11 395.350–	23 074.387	5–5	2.0E−1	2.2E−1	3.1E+1	0.04	C$^+$	3
58.	$6s5d$–$5d6p$	^{1}D–^{3}D°											
			7610.48	7612.57	11 395.350–	24 531.513	5–5	1.1E−2	9.6E−3	1.2E+0	−1.32	C	3
59.	$6s5d$–$5d6p$	^{1}D–^{3}P°											
			6986.80	6988.73	11 395.350–	25 704.110	5–3	5.2E−3	2.3E−3	2.6E−1	−1.94	C$^+$	6
60.	$6s5d$–$5d6p$	^{1}D–^{1}P°	5826.27	5827.89	11 395.350–	28 554.221	5–3	4.5E−1	1.4E−1	1.3E+1	−0.16	B	3
61.	$6s5d$–$6s7p$	^{1}D–^{1}P°	4726.43	4727.76	11 395.350–	32 547.033	5–3	3.3E−1	6.6E−2	5.2E+0	−0.48	C	3
62.	$6s6p$–$6s7s$	^{3}P°–^{3}S	*7644.9*	*7647.0*	*13 083.29–*	26 160.293	9–3	5.03E−1	1.47E−1	3.33E+1	0.122	C$^+$	6
			7905.75	7907.92	13 514.745–	26 160.293	5–3	2.65E−1	1.49E−1	1.94E+1	−0.128	C$^+$	6
			7392.41	7394.44	12 636.623–	26 160.293	3–3	1.81E−1	1.48E−1	1.08E+1	−0.352	C$^+$	6
			7195.23	7197.21	12 266.024–	26 160.293	1–3	5.6E−2	1.3E−1	3.1E+0	−0.88	C$^+$	6
63.	$6s6p$–$6s6d$	^{3}P°–^{3}D											
			5777.62	5779.22	13 514.745–	30 818.115	5–7	8.0E−1	5.6E−1	5.3E+1	0.45	C$^+$	6
			5519.04	5520.58	12 636.623–	30 750.672	3–5	5.7E−1	4.3E−1	2.4E+1	0.11	C$^+$	6
			5800.23	5801.83	13 514.745–	30 750.672	5–5	2.39E−1	1.21E−1	1.15E+1	−0.220	C$^+$	6

Ba I: Allowed Transitions—Continued

No.	Transition array	Multiplet	λ_{air} (Å)	λ_{vac} (Å) or σ (cm^{-1})*	E_i (cm^{-1})	E_k (cm^{-1})	g_i-g_k	A_{ki} (10^8 s^{-1})	f_{ik}	S (a.u.)	log gf	Acc.	Source
64.	$6s6p-6s8s$	^{3}P°–^{3}S	*4801.3*	*4802.6*	*13 083.29–*	33 905.358	9–3	1.39E−1	1.60E−2	2.28E+0	−0.842	C$^+$	6
			4902.85	4904.22	13 514.745–	33 905.358	5–3	5.4E−2	1.2E−2	9.4E−1	−1.23	C$^+$	6
			4700.42	4701.74	12 636.623–	33 905.358	3–3	6.1E−2	2.0E−2	9.4E−1	−1.22	C$^+$	6
			4619.92	4621.21	12 266.024–	33 905.358	1–3	2.7E−2	2.6E−2	3.9E−1	−1.59	C$^+$	6
65.	$6s6p-6s8s$	^{3}P°–^{1}S											
			4599.72	4601.01	12 636.623–	34 371.002	3–1	4.07E−1	4.31E−2	1.96E+0	−0.889	B$^+$	4
66.	$6s6p-6p^2$	^{3}P°–^{3}P											
			4579.64	4580.92	13 514.745–	35 344.413	5–5	7.0E−1	2.2E−1	1.7E+1	0.04	C$^+$	4
			4573.85	4575.13	12 636.623–	34 493.904	3–1	1.21E+0	1.27E−1	5.72E+0	−0.421	B	4
			4402.54	4403.78	12 636.623–	35 344.413	3–5	2.7E−1	1.3E−1	5.7E+0	−0.41	C	4
67.	$6s6p-6s7d$	^{3}P°–^{3}D											
			4488.98	4490.24	13 514.745–	35 785.273	5–7	2.8E−1	1.2E−1	8.8E+0	−0.23	C$^+$	6
68.	$6s6p-6s7d$	^{3}P°–^{1}D											
			4493.64	4494.90	13 514.745–	35 762.187	5–5	1.95E−1	5.91E−2	4.37E+0	−0.530	C$^+$	6
			4323.00	4324.22	12 636.623–	35 762.187	3–5	8.8E−2	4.1E−2	1.8E+0	−0.91	C$^+$	6
69.	$6s6p-6s7s$	^{1}P°–^{3}S											
			12 342.3	8100.032 cm^{-1}	18 060.261–	26 160.293	3–3	9.0E−4	2.1E−3	2.5E−1	−2.21	D	6
70.	$6s6p-6s6d$	^{1}P°–^{3}D											
			7877.80	7879.97	18 060.261–	30 750.672	3–5	1.6E−2	2.5E−2	1.9E+0	−1.13	C$^+$	6
71.	$6s6p-6s8s$	^{1}P°–^{3}S											
			6309.36	6311.10	18 060.261–	33 905.358	3–3	2.0E−4	1.2E−4	7.4E−3	−3.45	D	6
72.	$6s6p-6s8s$	^{1}P°–^{1}S	6129.23	6130.93	18 060.261–	34 371.002	3–1	6.0E−2	1.1E−2	6.8E−1	−1.47	C	4
73.	$6s6p-6p^2$	^{1}P°–^{3}P											
			5784.04	5785.65	18 060.261–	35 344.413	3–5	2.1E−1	1.8E−1	1.0E+1	−0.28	C	4
			6083.39	6085.08	18 060.261–	34 493.904	3–1	1.1E−1	2.0E−2	1.2E+0	−1.21	D$^+$	4
74.	$6s6p-6s30d$	^{1}P°–^{1}D	4195.59	4196.77	18 060.261–	41 888.108	3–5	1.78E−3	7.83E−4	3.25E−2	−2.629	C$^+$	15
75.	$6s6p-6s31d$	^{1}P°–^{1}D	4193.81	4194.99	18 060.261–	41 898.206	3–5	1.58E−3	6.96E−4	2.88E−2	−2.680	C$^+$	14
76.	$6s6p-6s32d$	^{1}P°–^{1}D	4192.20	4193.38	18 060.261–	41 907.371	3–5	1.36E−3	5.99E−4	2.48E−2	−2.745	C$^+$	14
77.	$6s6p-6s33d$	^{1}P°–^{1}D	4190.76	4191.94	18 060.261–	41 915.565	3–5	1.28E−3	5.64E−4	2.34E−2	−2.772	C$^+$	14
78.	$6s6p-6s34d$	^{1}P°–^{1}D	4189.44	4190.62	18 060.261–	41 923.102	3–5	1.13E−3	4.95E−4	2.05E−2	−2.828	C$^+$	14
79.	$6s6p-6s35d$	^{1}P°–^{1}D	4188.25	4189.44	18 060.261–	41 929.828	3–5	1.03E−3	4.53E−4	1.87E−2	−2.867	C$^+$	14
80.	$6s6p-6s36d$	^{1}P°–^{1}D	4187.15	4188.33	18 060.261–	41 936.118	3–5	9.90E−4	4.34E−4	1.80E−2	−2.885	C$^+$	14
81.	$6s6p-6s37d$	^{1}P°–^{1}D	4186.16	4187.34	18 060.261–	41 941.795	3–5	9.24E−4	4.05E−4	1.67E−2	−2.915	C$^+$	14
82.	$6s6p-6s38d$	^{1}P°–^{1}D	4185.25	4186.43	18 060.261–	41 946.985	3–5	8.43E−4	3.69E−4	1.53E−2	−2.956	C$^+$	14
83.	$6s6p-6s39d$	^{1}P°–^{1}D	4184.40	4185.58	18 060.261–	41 951.792	3–5	7.93E−4	3.47E−4	1.43E−2	−2.983	C$^+$	14
84.	$6s6p-6s40d$	^{1}P°–^{1}D	4183.64	4184.81	18 060.261–	41 956.183	3–5	6.70E−4	2.93E−4	1.21E−2	−3.056	C$^+$	14
85.	$6s6p-6s41d$	^{1}P°–^{1}D	4182.94	4184.12	18 060.261–	41 960.169	3–5	6.65E−4	2.91E−4	1.20E−2	−3.059	C$^+$	14
86.	$6s6p-6s42d$	^{1}P°–^{1}D	4182.27	4183.45	18 060.261–	41 963.998	3–5	6.11E−4	2.67E−4	1.10E−2	−3.096	C$^+$	14
87.	$6s6p-6s43d$	^{1}P°–^{1}D	4181.66	4182.84	18 060.261–	41 967.449	3–5	5.42E−4	2.37E−4	9.79E−3	−3.148	C$^+$	14
88.	$6s6p-6s44d$	^{1}P°–^{1}D	4181.09	4182.27	18 060.261–	41 970.748	3–5	4.99E−4	2.18E−4	9.00E−3	−3.184	C$^+$	14
89.	$6s6p-6s45d$	^{1}P°–^{1}D	4180.57	4181.75	18 060.261–	41 973.704	3–5	4.55E−4	1.99E−4	8.22E−3	−3.224	C$^+$	14
90.	$6s6p-6s46d$	^{1}P°–^{1}D	4180.09	4181.27	18 060.261–	41 976.443	3–5	4.53E−4	1.98E−4	8.18E−3	−3.226	C$^+$	14
91.	$6s6p-6s47d$	^{1}P°–^{1}D	4179.64	4180.82	18 060.261–	41 979.010	3–5	4.46E−4	1.95E−4	8.05E−3	−3.233	C$^+$	14
92.	$6s6p-6s48d$	^{1}P°–^{1}D	4179.20	4180.38	18 060.261–	41 981.534	3–5	4.31E−4	1.88E−4	7.76E−3	−3.249	C$^+$	14
93.	$6s6p-6s49d$	^{1}P°–^{1}D	4178.80	4179.98	18 060.261–	41 983.849	3–5	4.01E−4	1.75E−4	7.22E−3	−3.280	C$^+$	14
94.	$6s6p-6s50d$	^{1}P°–^{1}D	4178.43	4179.60	18 060.261–	41 985.979	3–5	3.64E−4	1.59E−4	6.56E−3	−3.321	C$^+$	14
95.	$6s6p-6s51d$	^{1}P°–^{1}D	4178.07	4179.25	18 060.261–	41 988.001	3–5	3.07E−4	1.34E−4	5.53E−3	−3.396	C$^+$	14
96.	$6s6p-6s52d$	^{1}P°–^{1}D	4177.74	4178.92	18 060.261–	41 989.892	3–5	3.14E−4	1.37E−4	5.65E−3	−3.386	C$^+$	14
97.	$6s6p-6s53d$	^{1}P°–^{1}D	4177.44	4178.62	18 060.261–	41 991.595	3–5	3.03E−4	1.32E−4	5.45E−3	−3.402	C$^+$	14
98.	$6s6p-6s54d$	^{1}P°–^{1}D	4177.15	4178.32	18 060.261–	41 993.304	3–5	2.77E−4	1.21E−4	4.99E−3	−3.440	C$^+$	14

Ba I: Allowed Transitions—Continued

No.	Transition array	Multiplet	λ_{air} (Å)	λ_{vac} (Å) or σ (cm^{-1})*	E_i (cm^{-1})	E_k (cm^{-1})	g_i–g_k	A_{ki} (10^8 s^{-1})	f_{ik}	S (a.u.)	log gf	Acc.	Source
99.	$6s6p-6s55d$	$^1P^\circ-^1D$	4176.86	4178.04	18 060.261–	41 994.948	3–5	2.48E−4	1.08E−4	4.46E−3	−3.489	C$^+$	14
100.	$6s6p-6s56d$	$^1P^\circ-^1D$	4176.60	4177.78	18 060.261–	41 996.415	3–5	2.26E−4	9.86E−5	4.07E−3	−3.529	C$^+$	14
101.	$6s6p-6s57d$	$^1P^\circ-^1D$	4176.36	4177.54	18 060.261–	41 997.790	3–5	2.19E−4	9.55E−5	3.94E−3	−3.543	C$^+$	14
102.	$6s6p-6s58d$	$^1P^\circ-^1D$	4176.12	4177.30	18 060.261–	41 999.165	3–5	2.08E−4	9.06E−5	3.74E−3	−3.566	C$^+$	14
103.	$6s6p-6s59d$	$^1P^\circ-^1D$	4175.91	4177.09	18 060.261–	42 000.382	3–5	1.98E−4	8.65E−5	3.57E−3	−3.586	C$^+$	14
104.	$6s6p-6s60d$	$^1P^\circ-^1D$	4175.69	4176.87	18 060.261–	42 001.627	3–5	1.97E−4	8.57E−5	3.54E−3	−3.590	C$^+$	14
105.	$5d^2-5d6p$	$^3F-^3D^\circ$											
			30 685.3	3257.998 cm^{-1}	20 934.035–	24 192.033	5–3	6.5E−3	5.5E−2	2.8E+1	−0.56	D$^-$	3
106.	$5d6p-6p^2$	$^3F^\circ-^3P$											
			7528.18	7530.25	22 064.645–	35 344.413	5–5	2.7E−2	2.3E−2	2.8E+0	−0.94	D$^-$	4
107.	$5d^2-5d6p$	$^1D-^1P^\circ$	18 202.8	5492.170 cm^{-1}	23 062.051–	28 554.221	5–3	1.2E−2	3.6E−2	1.1E+1	−0.75	C$^+$	3
108.	$5d^2-6s7p$	$^1D-^1P^\circ$	10 540.1	9484.982 cm^{-1}	23 062.051–	32 547.033	5–3	1.8E−2	1.8E−2	3.1E+0	−1.05	D	3
109.	$5d6p-6p^2$	$^1D^\circ-^3P$											
			8147.70	8149.94	23 074.387–	35 344.413	5–5	6.3E−2	6.3E−2	8.4E+ 0	−0.50	D$^-$	4
110.	$5d^2-5d6p$	$^3P-^1P^\circ$											
			21 567.7	4635.306 cm^{-1}	23 918.915–	28 554.221	5–3	2.6E−3	1.1E−2	3.9E+0	−1.26	D	3
111.	$5d6p-6s8$	$^3D^\circ-^1S$											
			9821.48	9824.18	24 192.033–	34 371.002	3–1	5.5E−2	2.7E−2	2.6E+0	−1.10	D$^+$	4
112.	$5d6p-6p^2$	$^3D^\circ-^3P$											
			9704.31	9706.97	24 192.033–	34 493.904	3–1	1.6E−1	7.5E−2	7.2E+0	−0.65	C	4
			9645.60	9648.25	24 979.834–	35 344.413	7–5	1.1E−1	1.1E−1	2.4E+1	−0.11	C	4
113.	$5d6p-6p^2$	$^3P^\circ-^3P$											
			10 649.1	9387.894 cm^{-1}	25 956.519–	35 344.413	5–5	2.7E−2	4.6E−2	8.1E+0	−0.64	C	4
			11 373.7	8789.794 cm^{-1}	25 704.110–	34 493.904	3–1	1.3E−1	8.4E−2	9.4E+0	−0.60	C	4
			10 370.3	9640.303 cm^{-1}	25 704.110–	35 344.413	3–5	1.3E−2	3.5E−2	3.6E+0	−0.98	C	4
114.	$5d6p-6s8s$	$^1P^\circ-^1S$	17 186.9	5816.781 cm^{-1}	28 554.221–	34 371.002	3–1	2.7E−2	4.0E−2	6.8E+0	−0.92	D$^+$	4
115.	$5d6p-6p^2$	$^1P^\circ-^3P$											
			14 723.1	6790.192 cm^{-1}	28 554.221–	35 344.413	3–5	8.6E−3	4.7E−2	6.8E+0	−0.85	C	4

*Wavelengths (Å) are always given unless cm^{-1} is indicated.

3. Ba II

Cesium Isoelectronic Sequence
Ground State: $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6 4d^{10} 5s^2 5p^6 6s\ ^2S_{1/2}$
Ionization Energy: 10.0039 eV=80 686.9 cm^{-1}

3.1 Allowed Transitions

List of Tabulated Lines

Wavelength (Å)	No.	Wavelength (Å)	No.	Wavelength (Å)	No.	Wavelength (Å)	No.
in vacuum		2647.26	9	5361.35	21	10 212.8	30
		2771.35	9	5391.59	21	10 709.8	37
1622.43	3	3390.18	23	5413.57	26	10 768.0	43
1630.36	3	3412.44	23	5421.06	21	10 769.7	37
1761.74	6	3413.95	23	5428.84	26	10 993.4	37
1771.10	6	3552.45	22	5480.25	26	11 088.5	43
1786.95	6	3576.28	22	5784.15	32	11 127.5	43
1892.49	15	3578.57	22	5853.67	4	11 519.5	42
1954.28	15	3891.78	8	5981.26	32	11 577.1	29
1955.05	15	4130.65	8	5999.91	32	11 931.9	42
1985.75	14	4166.00	8	6135.60	31	12 475.0	29
1999.55	2	4216.07	35	6141.71	4	13 057.8	16
		4267.92	28	6378.92	31	14 211.5	16
in air		4267.92	28	6496.90	4	17 738.9	36
		4309.26	28	6769.48	25	18 530.7	36
2009.28	13	4325.75	35	6769.48	25	18 530.7	36
2024.06	2	4329.56	35	6874.08	25	18 729.7	41
2052.75	14	4524.93	7	6995.14	38	19 642.6	41
2054.09	14	4554.03	1	7115.03	38	19 845.1	41
2079.98	13	4708.90	34	7115.03	38	22 994.7	40
2153.93	12	4843.48	34	8496.80	44	24 612.5	19
2200.89	11	4847.19	33	8591.43	24	24 699.0	40
2214.76	5	4850.92	34	8661.90	24	25 923.2	19
2232.79	12	4899.93	7	8703.69	44	27 687.2	39
2235.38	12	4934.08	1	8710.77	20	29 058.9	19
2245.69	5	4957.09	27	8719.12	44	30 196.0	39
2254.78	5	4957.09	27	8737.75	20	42 934.7	18
2285.99	11	4997.79	33	8760.61	24	43 294.3	18
2528.41	10	5012.95	27	8897.46	20	47 520.8	18
2634.78	10	5185.06	17	9603.12	30		
2641.37	10	5267.01	17	10 115.0	30		

The radiative lifetimes of the $6p\ ^2P^\circ_{1/2}$ and $6p\ ^2P^\circ_{3/2}$ levels, which decay spontaneously either into the ground state $6s\ ^2S_{1/2}$ or the $5d\ ^2D_{3/2,5/2}$ states, have been determined very precisely by Andrä[21] and Kuske *et al.*[22] in beam-laser experiments. The authors quote uncertainties of ±0.2% and ±1%, respectively. Davidson *et al.*[23] have measured the branching ratios for all transitions from the $6p\ ^2P^\circ_{1/2,3/2}$ levels, and have normalized their relative values to the above mentioned lifetime data.[21,22] We have used these combined experimental results for the $6s$–$6p$ and $5d$–$6p$ transitions. For all other multiplets and lines of Ba II, we employed the extensive calculations by Lindgård and Nielsen[24] based on the (semiempirical) Coulomb approximation. We have selectively used their data and combined them with results of a Coulomb approximation computer program developed at NIST[25] some time ago. The results are indeed very similar, as expected. For each multiplet, the NIST program has the advantage of explicitly providing the amount of cancellation between positive and negative parts in the transition integral. Utilizing this feature, we discarded all transitions having more than 90% cancellation, since their A values are expected to be quite uncertain.

Ba II: Allowed Transitions

No.	Transition array	Multiplet	λ_{air} (Å)	λ_{vac} (Å) or σ (cm^{-1})*	E_i (cm^{-1})	E_k (cm^{-1})	$g_i - g_k$	A_{ki} (10^8 s^{-1})	f_{ik}	S (a.u.)	log gf	Acc.	Source
1.	6s–6p	^{2}S–^{2}P°	*4674.0*	*4675.3*	0.000–	*21 388.79*	2–6	1.06E+0	1.04E+0	3.20E+1	0.318	B	21,22,23
			4554.03	4555.31	0.000–	21 952.404	2–4	1.11E+0	6.91E−1	2.07E+1	0.140	B	23
			4934.08	4935.45	0.000–	20 261.561	2–2	9.53E−1	3.48E−1	1.13E+1	−0.157	B	23
2.	6s–7p	^{2}S–^{2}P°	*2007.2*	*2007.9*	0.000–	*49 804.17*	2–6	7.03E−2	1.27E−2	1.69E−1	−1.594	C	24,25
				1999.55	0.000–	50 011.340	2–4	7.12E−2	8.53E−3	1.12E−1	−1.768	C	LS
			2024.06	2024.71	0.000–	49 389.822	2–2	6.86E−2	4.21E−3	5.62E−2	−2.074	C	LS
3.	6s–8p	^{2}S–^{2}P°		*1625.1*	0.000–	*61 536*	2–6	2.44E−2	2.90E−3	3.11E−2	−2.236	C	24,25
				1622.43	0.000–	61 636	2–4	2.46E−2	1.94E−3	2.07E−2	−2.411	C	LS
				1630.36	0.000–	61 336	2–2	2.42E−2	9.65E−4	1.04E−2	−2.715	C	LS
4.	5d–6p	^{2}D–^{2}P°	*6234.9*	*6236.6*	*5354.43–*	*21 388.79*	10–6	4.13E−1	1.44E−1	2.96E+1	0.159	B	21,22,23
			6141.71	6143.41	5674.807–	21 952.404	6–4	4.12E−1	1.55E−1	1.89E+1	−0.030	B	23
			6496.90	6498.69	4873.852–	20 261.561	4–2	3.10E−1	9.81E−2	8.40E+0	−0.406	B	23
			5853.67	5855.3	4873.852–	21 952.404	4–4	6.00E−2	3.08E−2	2.38E+0	−0.909	B	23
5.	5d–7p	^{2}D–^{2}P°	*2249.0*	*2249.7*	*5354.43–*	*49 804.17*	10–6	1.6E−1	7.1E−3	5.3E−1	−1.15	D	24,25
			2254.78	2255.48	5674.807–	50 011.340	6–4	1.4E−1	7.1E−3	3.2E−1	−1.37	D	LS
			2245.69	2246.38	4873.852–	49 389.822	4–2	1.6E−1	6.0E−3	1.8E−1	−1.62	D	LS
			2214.76	2215.45	4873.852–	50 011.340	4–4	1.6E−2	1.2E−3	3.5E−2	−2.32	D	LS
6.	5d–8p	^{2}D–^{2}P°		*1779.9*	*5354.43–*	*61 536*	10–6	1.0E−1	2.9E−3	1.7E−1	−1.54	D	24,25
				1786.95	5674.807–	61 636	6–4	9.0E−2	2.9E−3	1.0E−1	−1.76	D	LS
				1771.1	4873.852–	61 336	4–2	1.0E−1	2.4E−3	5.6E−2	−2.02	D	LS
				1761.74	4873.852–	61 636	4–4	1.0E−2	4.8E−4	1.1E−2	−2.71	D	LS
7.	6p–7s	^{2}P°–^{2}S	*4768.2*	*4769.5*	*21 388.79–*	42 355.175	6–2	1.70E+0	1.93E−1	1.82E+1	0.064	B	24,25
			4899.93	4901.3	21 952.404–	42 355.175	4–2	1.04E+0	1.88E−1	1.21E+1	−0.124	B	LS
			4524.93	4526.19	20 261.561–	42 355.175	2–2	6.63E−1	2.04E−1	6.07E+0	−0.390	B	LS
8.	6p–6d	^{2}P°–^{2}D	*4050.1*	*4051.2*	*21 388.79–*	*46 072.70*	6–10	2.31E+0	9.49E−1	7.59E+1	0.755	B	24,25
			4130.65	4131.81	21 952.404–	46 154.847	4–6	2.18E+0	8.37E−1	4.55E+1	0.525	B	LS
			3891.78	3892.88	20 261.561–	45 949.472	2–4	2.17E+0	9.87E−1	2.53E+1	0.295	B	LS
			4166.00	4167.18	21 952.404–	45 949.472	4–4	3.54E−1	9.22E−2	5.06E+0	−0.433	B	LS
9.	6p–8s	^{2}P°–^{2}S	*2728.7*	*2729.5*	*21 388.79–*	58 025.211	6–2	6.20E−1	2.31E−2	1.25E+0	−0.858	B	24,25
			2771.35	2772.17	21 952.404–	58 025.211	4–2	3.95E−1	2.27E−2	8.30E−1	−1.041	B	LS
			2647.26	2648.05	20 261.561–	58 025.211	2–2	2.26E−1	2.38E−2	4.15E−1	−1.322	B	LS
10.	6p–7d	^{2}P°–^{2}D	*2598.8*	*2599.5*	*21 388.79–*	*59 857.06*	6–10	7.64E−1	1.29E−1	6.62E+0	−0.111	C	24,25
			2634.78	2635.57	21 952.404–	59 894.928	4–6	7.33E−1	1.15E−1	3.97E+0	−0.339	C	LS
			2528.41	2529.17	20 261.561–	59 800.254	2–4	6.91E−1	1.33E−1	2.21E+0	−0.576	C	LS
			2641.37	2642.16	21 952.404–	59 800.254	4–4	1.21E−1	1.27E−2	4.42E−1	−1.294	C	LS
11.	6p–9s	^{2}P°–^{2}S	*2256.9*	*2257.6*	*21 388.79–*	65 683.646	6–2	3.16E−1	8.04E−3	3.59E−1	−1.316	C+	24,25
			2285.99	2286.69	21 952.404–	65 683.646	4–2	2.03E−1	7.94E−3	2.39E−1	−1.498	C+	LS
			2200.89	2201.57	20 261.561–	65 683.646	2–2	1.13E−1	8.25E−3	1.20E−1	−1.783	C+	LS
12.	6p–8d	^{2}P°–^{2}D	*2206.0*	*2206.7*	*21 388.79–*	*66 704.82*	6–10	3.83E−1	4.66E−2	2.03E+0	−0.554	C	24,25
			2232.79	2233.48	21 952.404–	66 725.591	4–6	3.69E−1	4.14E−2	1.22E+0	−0.781	C	LS
			2153.93	2154.61	20 261.561–	66 673.651	2–4	3.43E−1	4.77E−2	6.76E−1	−1.021	C	LS
			2235.38	2236.07	21 952.404–	66 673.651	4–4	6.13E−2	4.59E−3	1.35E−1	−1.736	C	LS
13.	6p–10s	^{2}P°–^{2}S	*2055.9*	*2056.5*	*21 388.79–*	70 014.584	6–2	1.82E−1	3.86E−3	1.57E−1	−1.636	C+	24,25
			2079.98	2080.64	21 952.404–	70 014.584	4–2	1.17E−1	3.81E−3	1.04E−1	−1.817	C+	LS
			2009.28	2009.93	20 261.561–	70 014.584	2–2	6.51E−2	3.94E−3	5.22E−2	−2.103	C+	LS
14.	6p–9d	^{2}P°–^{2}D	*2029.8*	*2030.4*	*21 388.79–*	*70 639.24*	6–10	2.3E−1	2.3E−2	9.4E−1	−0.85	D	24,25
			2052.75	2053.41	21 952.404–	70 651.905	4–6	2.2E−1	2.1E−2	5.6E−1	−1.08	D	LS
				1985.75	20 261.561–	70 620.247	2–4	2.0E−1	2.4E−2	3.1E−1	−1.32	D	LS
			2054.09	2054.74	21 952.404–	70 620.247	4–4	3.7E−2	2.3E−3	6.3E−2	−2.03	D	LS

Ba II: Allowed Transitions—Continued

No.	Transition array	Multiplet	λ_{air} (Å)	λ_{vac} (Å) or σ (cm^{-1})*	E_i (cm^{-1})	E_k (cm^{-1})	g_i-g_k	A_{ki} (10^8 s^{-1})	f_{ik}	S (a.u.)	log gf	Acc.	Source
15.	$6p-10d$	^{2}P°–^{2}D		*1933.3*	*21 388.79–*	*73 114.1*	6–10	1.5E−1	1.4E−2	5.3E−1	−1.08	D	24,25
				1954.28	21 952.404–	73 122.23	4–6	1.4E−1	1.2E−2	3.2E−1	−1.31	D	LS
				1892.49	20 261.561–	73 101.90	2–4	1.3E−1	1.4E−2	1.8E−1	−1.55	D	LS
				1955.05	21 952.404–	73 101.90	4–4	2.4E−2	1.4E−3	3.5E−2	−2.26	D	LS
16.	$7s-7p$	^{2}S–^{2}P°	*13 421*	7448.99 cm^{-1}	42 355.175–	*49 804.17*	2–6	1.97E−1	1.60E+0	1.41E+2	0.505	B	24,25
			13 057.8	7656.165 cm^{-1}	42 355.175–	50 011.340	2–4	2.14E−1	1.10E+0	9.42E+1	0.341	B	LS
			14 211.5	7034.647 cm^{-1}	42 355.175–	49 389.822	2–2	1.66E−1	5.03E−1	4.71E+1	0.003	B	LS
17.	$7s-8p$	^{2}S–^{2}P°	*5212.1*	*5213.5*	42 355.175–	*61 536*	2–6	1.1E−2	1.3E−2	4.5E−1	−1.58	D	24,25
			5185.06	5186.5	42 355.175–	61 636	2–4	1.1E−2	8.9E−3	3.0E−1	−1.75	D	LS
			5267.01	5268.47	42 355.175–	61 336	2–2	1.0E−2	4.4E−3	1.5E−1	−2.06	D	LS
18.	$6d-4f$	^{2}D–^{2}F°	*43 197*	2314.33 cm^{-1}	*46 072.70–*	*48 387.03*	10–14	4.73E−3	1.85E−1	2.64E+2	0.268	C	24,25
			42 934.7	2328.485 cm^{-1}	46 154.847–	48 483.332	6–8	4.82E−3	1.78E−1	1.51E+2	0.028	C	LS
			43 294.3	2309.145 cm^{-1}	45 949.472–	48 258.617	4–6	4.39E−3	1.85E−1	1.05E+2	−0.131	C	LS
			47 520.8	2103.770 cm^{-1}	46 154.847–	48 258.617	6–6	2.37E−4	8.02E−3	7.53E+0	−1.317	C	LS
19.	$6d-7p$	^{2}D–^{2}P°	*26 792*	*3731.47* cm^{-1}	*46 072.70–*	*49 804.17*	10–6	3.68E−2	2.38E−1	2.10E+	0.376	B	24,25
			25 923.2	3856.493 cm^{-1}	46 154.847–	50 011.340	6–4	3.66E−2	2.46E−1	1.26E+2	0.169	B	LS
			29 058.9	3440.350 cm^{-1}	45 949.472–	49 389.822	4–2	2.89E−2	1.83E−1	6.99E+1	−0.136	B	LS
			24 612.5	4061.868 cm^{-1}	45 949.472–	50 011.340	4–4	4.75E−3	4.32E−2	1.40E+1	−0.763	B	LS
20.	$6d-5f$	^{2}D–^{2}F°	*8726.8*	*8729.2*	*46 072.70–*	*57 528.53*	10–14	7.84E−1	1.25E+0	3.60E+2	1.098	B	24,25
			8710.77	8713.16	46 154.847–	57 631.739	6–8	7.88E−1	1.20E+0	2.06E+2	0.856	B	LS
			8737.75	8740.15	45 949.472–	57 390.922	4–6	7.29E−1	1.25E+0	1.44E+2	0.700	B	LS
			8897.46	8899.9	46 154.847–	57 390.922	6–6	4.93E−2	5.85E−2	1.03E+1	−0.454	B	LS
21.	$6d-6f$	^{2}D–^{2}F°	*5380.3*	*5381.8*	*46 072.70–*	*64 653.9*	10–14	4.25E−2	2.58E−2	4.58E+0	−0.588	C+	24,25
			5391.59	5393.09	46 154.847–	64 697.08	6–8	4.22E−2	2.45E−2	2.61E+0	−0.832	C+	LS
			5361.35	5362.84	45 949.472–	64 596.31	4–6	4.01E−2	2.59E−2	1.83E+0	−0.984	C+	LS
			5421.06	5422.56	46 154.847–	64 596.31	6–6	2.77E−3	1.22E−3	1.31E−1	−2.135	C+	LS
22.	$6d-9f$	^{2}D–^{2}F°	*3566.8*	*3567.8*	*46 072.70–*	*74 101.2*	10–14	4.10E−3	1.10E−3	1.29E−1	−1.960	C	24,25
			3576.28	3577.3	46 154.847–	74 108.92	6–8	4.07E−3	1.04E−3	7.35E−2	−2.205	C	LS
			3552.45	3553.47	45 949.472–	74 091.00	4–6	3.87E−3	1.10E−3	5.15E−2	−2.357	C	LS
			3578.57	3579.59	46 154.847–	74 091.00	6–6	2.71E−4	5.20E−5	3.68E−3	−3.506	C	LS
23.	$6d-10f$	^{2}D–^{2}F°	*3403.5*	*3404.5*	*46 072.70–*	*75 445*	10–14	4.81E−3	1.17E−3	1.31E−1	−1.932	C	24,25
			3412.44	3413.42	46 154.847–	75 451	6–8	4.77E−3	1.11E−3	7.49E−2	−2.176	C	LS
			3390.18	3391.15	45 949.472–	75 438	4–6	4.54E−3	1.17E−3	5.25E−2	−2.328	C	LS
			3413.95	3414.93	46 154.847–	75 438	6–6	3.18E−4	5.55E−5	3.75E−3	−3.477	C	LS
24.	$4f-7d$	^{2}F°–^{2}D	*8716.0*	*8718.4*	*48 387.03–*	*59 857.06*	14–10	1.25E−2	1.01E−2	4.07E+0	−0.848	C+	24,25
			8760.61	8763.02	48 483.332–	59 894.928	8–6	1.17E−2	1.01E−2	2.33E+0	−1.093	C+	LS
			8661.90	8664.28	48 258.617–	59 800.254	6–4	1.27E−2	9.52E−3	1.63E+0	−1.243	C+	LS
			8591.43	8593.79	48 258.617–	59 894.928	6–6	6.19E−4	6.85E−4	1.16E−1	−2.386	C+	LS
25.	$4f-5g$	^{2}F°–^{2}G	*6828.9*	*6830.7*	*48 387.03–*	63 026.725	14–18	9.44E−1	8.49E−1	2.67E+2	1.075	C	24,25
			6874.08	6875.97	48 483.332–	63 026.725	8–10	9.26E−1	8.20E−1	1.49E+2	0.817	C	LS
			6769.48	6771.35	48 258.617–	63 026.725	6–8	9.35E−1	8.57E−1	1.15E+2	0.711	C	LS
			6769.48	6771.35	48 258.617–	63026.725	8–8	3.46E−2	2.38E−2	4.24E+0	−0.720	C	LS
26.	$4f-8d$	^{2}F°–^{2}D	*5457.7*	*5459.2*	*48 387.03–*	*66 704.82*	14–10	1.89E−3	6.03E−4	1.52E−1	−2.074	C	24,25
			5480.25	5481.78	48 483.332–	66 725.591	8–6	1.78E−3	6.00E−4	8.66E−2	−2.319	C	LS
			5428.84	5430.35	48 258.617–	66 673.651	6–4	1.92E−3	5.65E−4	6.06E−2	−2.470	C	LS
			5413.57	5415.07	48258.617–	66725.591	6–6	9.21E−5	4.05E−5	4.33E−3	−3.614	C	LS
27.	$4f-6g$	^{2}F°–^{2}G	*4988.9*	*4990.3*	*48 387.03–*	68 426.095	14–18	5.22E−1	2.51E−1	5.77E+1	0.545	C	24,25
			5012.95	5014.35	48 483.332–	68 426.095	8–10	5.15E−1	2.43E−1	3.20E+1	0.288	C	LS
			4957.09	4958.48	48 258.617–	68 426.095	6–8	5.13E−1	2.52E−1	2.47E+1	0.180	C	LS
			4957.09	4958.48	48 258.617–	68 426.095	8–8	1.90E−2	7.01E−3	9.15E−1	−1.251	C	LS

Ba II: Allowed Transitions—Continued

No.	Transition array	Multiplet	λ_{air} (Å)	λ_{vac} (Å) or σ (cm^{-1})*	E_i (cm^{-1})	E_k (cm^{-1})	g_i–g_k	A_{ki} (10^8 s^{-1})	f_{ik}	S (a.u.)	log gf	Acc.	Source
28.	4f–7g	^{2}F°–^{2}G	*4291.4*	*4292.7*	*48 387.03*–	71 682.623	14–18	3.2E−1	1.1E−1	2.2E+1	0.20	D	24,25
			4309.26	4310.48	48 483.332–	71 682.623	8–10	3.1E−1	1.1E−1	1.2E+1	−0.06	D	LS
			4267.92	4269.12	48 258.617–	71 682.623	6–8	3.1E−1	1.1E−1	9.5E+0	−0.17	D	LS
			4267.92	4269.12	48 258.617–	71 682.623	8–8	1.1E−2	3.1E−3	3.5E−1	−1.60	D	LS
29.	7p–8s	^{2}P°–^{2}S	*12 161*	*8221.04* cm^{-1}	*49 804.17*–	58 025.211	6–2	4.53E−1	3.35E−1	8.05E+1	0.303	B	24,25
			12 475.0	8013.871 cm^{-1}	50 011.340–	58 025.211	4–2	2.80E−1	3.27E−1	5.37E+1	0.116	B	LS
			11 577.1	8635.389 cm^{-1}	49 389.822–	58 025.211	2–2	1.75E−1	3.52E−1	2.68E+1	−0.153	B	LS
30.	7p–7d	^{2}P°–^{2}D	*9944.7*	*9947.4*	*49 804.17*–	*59 857.06*	6–10	4.50E−1	1.11E+0	2.18E+2	0.824	B	24,25
			10 115.0	9883.588 cm^{-1}	50 011.340–	59 894.928	4–6	4.27E−1	9.84E−1	1.31E+2	0.595	B	LS
			9603.12	9605.75	49 389.822–	59 800.254	2–4	4.16E−1	1.15E+0	7.28E+1	0.362	B	LS
			10 212.8	9788.914 cm^{-1}	50 011.340–	59 800.254	4–4	6.92E−2	1.08E−1	1.46E+1	−0.364	B	LS
31.	7p–9s	^{2}P°–^{2}S	*6295.7*	*6297.4*	*49 804.17*–	65 683.646	6–2	1.84E−1	3.65E−2	4.54E+0	−0.659	B	24,25
			6378.92	6380.68	50 011.340–	65 683.646	4–2	1.18E−1	3.60E−2	3.03E+0	−0.841	B	LS
			6135.60	6137.29	49 389.822–	65 683.646	2–2	6.64E−2	3.75E−2	1.51E+0	−1.125	B	LS
32.	7p–8d	^{2}P°–^{2}D	*5915.3*	*5916.9*	*49 804.17*–	*66 704.82*	6–10	1.79E−1	1.56E−1	1.83E+1	−0.027	B	24,25
			5981.26	5982.92	50 011.340–	66 725.591	4–6	1.73E−1	1.39E−1	1.10E+1	−0.254	B	LS
			5784.15	5785.75	49 389.822–	66 673.651	2–4	1.59E−1	1.60E−1	6.09E+0	−0.495	B	LS
			5999.91	6001.57	50 011.340–	66 673.651	4–4	2.86E−2	1.54E−2	1.22E+0	−1.210	B	LS
33.	7p–10s	^{2}P°–^{2}S	*4946.6*	*4947.9*	*49 804.17*–	70 014.584	6–2	9.85E−2	1.21E−2	1.18E+0	−1.141	C+	24,25
			4997.79	4999.19	50 011.340–	70 014.584	4–2	6.37E−2	1.19E−2	7.85E−1	−1.321	C+	LS
			4847.19	4848.54	49 389.822–	70 014.584	2–2	3.49E−2	1.23E−2	3.93E−1	−1.609	C+	LS
34.	7p–9d	^{2}P°–^{2}D	*4798.3*	*4799.6*	*49 804.17*–	*70 639.24*	6–10	9.61E−2	5.53E−2	5.24E+0	−0.479	B	24,25
			4843.48	4844.83	50 011.340–	70 651.905	4–6	9.34E−2	4.93E−2	3.15E+0	−0.705	B	LS
			4708.90	4710.22	49 389.822–	70 620.247	2–4	8.47E−2	5.63E−2	1.75E+0	−0.948	B	LS
			4850.92	4852.27	50 011.340–	70 620.247	4–4	1.55E−2	5.47E−3	3.49E−1	−1.660	B	LS
35.	7p–10d	^{2}P°–^{2}D	*4288.8*	*4290.0*	*49 804.17*–	*73 114.1*	6–10	5.80E−2	2.67E−2	2.26E+0	−0.796	B	24,25
			4325.75	4326.96	50 011.340–	73 122.23	4–6	5.65E−2	2.38E−2	1.36E+0	−1.021	B	LS
			4216.07	4217.26	49 389.822–	73 101.90	2–4	5.09E−2	2.71E−2	7.53E−1	−1.266	B	LS
			4329.56	4330.77	50 011.340–	73 101.90	4–4	9.39E−3	2.64E−3	1.51E−1	−1.976	B	LS
36.	5f–5g	^{2}F°–^{2}G	*18 183*	*54 98.19* cm^{-1}	*57 528.53*–	63 026.725	14–18	2.08E−1	1.32E+0	1.11E+3	1.268	B	24,25
			18 530.7	5394.986 cm^{-1}	57 631.739–	63 026.725	8–10	1.96E−1	1.26E+0	6.16E+2	1.004	B	LS
			17 738.9	5635.803 cm^{-1}	57 390.922–	63 026.725	6–8	2.16E−1	1.36E+0	4.76E+2	0.911	B	LS
			18 530.7	5394.986 cm^{-1}	57 631.739–	63 026.725	8–8	7.00E−3	3.61E−2	1.76E+1	−0.540	B	LS
37.	5f–8d	^{2}F°–^{2}D	*10 895*	*9176.28* cm^{-1}	*57 528.53*–	*66 704.82*	14–10	1.97E−3	2.51E−3	1.26E+0	−1.454	C	24,25
			10 993.4	9093.852 cm^{-1}	57 631.739–	66 725.591	8–6	1.83E−3	2.49E−3	7.21E−1	−1.701	C	LS
			10 769.7	9282.729 cm^{-1}	57 390.922–	66 673.651	6–4	2.04E−3	2.37E−3	5.05E−1	−1.847	C	LS
			10 709.8	9334.669 cm^{-1}	57 390.922–	66 725.591	6–6	9.90E−5	1.70E−4	3.60E−2	−2.991	C	LS
38.	5f–7g	^{2}F°–^{2}G	*7063.1*	*7065.1*	*57 528.53*–	71 682.623	14–18	9.0E−3	8.6E−3	2.8E+0	−0.92	D	24,25
			7115.03	7116.99	57 631.739–	71 682.623	8–10	8.8E−3	8.3E−3	1.6E+0	−1.18	D	LS
			6995.14	6997.07	57 390.922–	71 682.623	6–8	8.9E−3	8.7E−3	1.2E+0	−1.28	D	LS
			7115.03	7116.99	57 631.739–	71 682.623	8–8	3.1E−4	2.4E−4	4.5E−2	−2.72	D	LS
39.	8s–8p	^{2}S–^{2}P°	*28 476*	*3511* cm^{-1}	58 025.211–	*61 536*	2–6	5.60E−2	2.05E+0	3.84E+2	0.612	B	24,25
			27 687.2	3611 cm^{-1}	58 025.211–	61 636	2–4	6.10E−2	1.40E+0	2.56E+2	0.448	B	LS
			30 196.0	3311 cm^{-1}	58 025.211–	61 336	2–2	4.70E−2	6.43E−1	1.28E+2	0.109	B	LS
40.	8p–9s	^{2}P°–^{2}S	*24 103*	*4148* cm^{-1}	*61 536*–	65 683.646	6–2	1.61E−1	4.68E−1	2.23E+2	0.448	B	24,25
			24 699.0	4048 cm^{-1}	61 636–	65 683.646	4–2	9.98E−2	4.56E−1	1.49E+2	0.261	B	LS
			22 994.7	4348 cm^{-1}	61 336–	65 683.646	2–2	6.18E−2	4.90E−1	7.43E+1	−0.009	B	LS
41.	8p–8d	^{2}P°–^{2}D	*19 342*	*5169* cm^{-1}	*61 536*–	*66 704.82*	6–10	1.34E−1	1.26E+0	4.80E+2	0.877	B	24,25
			19 642.6	5090 cm^{-1}	61 636–	66 725.591	4–6	1.28E−1	1.11E+0	2.88E+2	0.648	B	LS
			18 729.7	5338 cm^{-1}	61 336–	66 673.651	2–4	1.23E−1	1.30E+0	1.60E+2	0.414	B	LS
			19 845.1	5038 cm^{-1}	61 636–	66 673.651	4–4	2.07E−2	1.22E−1	3.20E+1	−0.310	B	LS

Ba II: Allowed Transitions—Continued

No.	Transition array	Multiplet	λ_{air} (Å)	λ_{vac} (Å) or σ (cm^{-1})*	E_i (cm^{-1})	E_k (cm^{-1})	g_i–g_k	A_{ki} (10^8 s^{-1})	f_{ik}	S (a.u.)	log gf	Acc.	Source
42.	$8p-10s$	^{2}P°–^{2}S	*11 791*	*8479* cm^{-1}	*61 536*–	70 014.584	6–2	6.91E−2	4.80E−2	1.12E+1	−0.541	B	24,25
			11 931.9	8379 cm^{-1}	61 636–	70 014.584	4–2	4.44E−2	4.74E−2	7.46E+0	−0.722	B	LS
			11 519.5	8679 cm^{-1}	61 336–	70 014.584	2–2	2.47E−2	4.91E−2	3.73E+0	−1.008	B	LS
43.	$8p-9d$	^{2}P°–^{2}D	*10 982*	*9103* cm^{-1}	*61 536*–	*70 639.24*	6–10	6.29E−2	1.90E−1	4.11E+1	0.056	B	24,25
			11 088.5	9016 cm^{-1}	61 636–	70 651.905	4–6	6.11E−2	1.69E−1	2.47E+1	−0.170	B	LS
			10 768.0	9284 cm^{-1}	61 336–	70 620.247	2–4	5.56E−2	1.93E−1	1.37E+1	−0.413	B	LS
			11 127.5	8984 cm^{-1}	61 636–	70 620.247	4–4	1.01E−2	1.87E−2	2.74E+0	−1.126	B	LS
44.	$8p-10d$	^{2}P°–^{2}D	*8634.6*	*8637.0*	*61 536*–	*73 114.1*	6–10	3.78E−2	7.05E−2	1.20E+1	−0.374	B	24,25
			8703.69	8706.08	61 636–	73 122.23	4–6	3.69E−2	6.29E−2	7.21E+0	−0.599	B	LS
			8496.80	8499.14	61 336–	73 101.90	2–4	3.31E−2	7.16E−2	4.01E+0	−0.844	B	LS
			8719.12	8721.51	61 636–	73 101.90	4–4	6.12E−3	6.98E−3	8.01E−1	−1.554	B	LS

*Wavelengths (Å) are always given unless cm^{-1} is indicated.

3.2. Forbidden Transitions

A precise measurement of the A value of the extremely weak electric quadrupole transition $6s\,^2\mathrm{S}_{1/2}-5d\,^2\mathrm{D}_{3/2}$ was carried out by Yu *et al.*[26] They determined the lifetime of an appropriately prepared, trapped single Ba$^+$ ion in the $5d\,^2\mathrm{D}_{3/2}$ state (which is about 80 s), using the technique of ‘‘quantum shelving’’ in ultrahigh vacuum.

This research group, by applying the same technique, has also measured the lifetime of the $5d\,^2\mathrm{D}_{5/2}$ level, which is again a long-lived (about 30 s) metastable atomic state.[26,27] Madej and Sankey[28] have independently measured the lifetime of the $5d\,^2\mathrm{D}_{5/2}$ level, and their result agrees quite well with Refs. 26 and 27. The $5d\,^2\mathrm{D}_{5/2}$ level decays via a magnetic dipole (M1) transition to the $5d\,^2\mathrm{D}_{3/2}$ level, as well as via an E2 transition to the $6s\,^2\mathrm{S}_{1/2}$ ground state. The magnetic dipole line between the fine structure levels of the same spectroscopic term has, according to the formulas of Shortley[29] the (nonrelativistic) line strength $S_{\mathrm{M1}}=2.40$. This result, along with the known lifetime of Yu *et al.* for the $5d\,^2\mathrm{D}_{5/2}$ level, has been used to obtain the transition probability of the E2 transition.

Ba II: Forbidden Transitions

No.	Transition array	Multiplet	λ_{air} (Å)	λ_{vac} (Å) or σ (cm^{-1})*	E_i (cm^{-1})	E_k (cm^{-1})	g_i–g_k	Type	A_{ki} (s^{-1})	S (a. u.)	Acc.	Source
1.	$6s-5d$	^{2}S–^{2}D										
			17 616.9	5674.807 cm^{-1}	0.000–	5674.807	2–6	E2	2.54E−2	2.31E+2	B	26,29
			20 512.1	4873.852 cm^{-1}	0.000–	4873.852	2–4	E2	1.25E−2	1.63E+2	B$^+$	26
2.	$5d-5d$	^{2}D–^{2}D										
				800.955 cm^{-1}	4873.852–	5674.807	4–6	M1	5.54E−3	2.40E+0	B	29

*Wavelengths (Å) are always given unless cm^{-1} is indicated.

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