Compilation of Wavelengths, Energy Levels, and Transition Probabilities for Ba I and Ba II

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Energy levels, wavelengths, and transition probabilities for the first and second spectra of barium, Ba I and Ba II, have been compiled. Wavelengths of observed transitions and energy levels derived from those wavelengths have been obtained from a critical evaluation of the available literature. Measured and calculated transition probabilities for some of the observed transitions have been obtained from the recent compilation of Klose *et al.* [J. Z. Klose *et al.*, J. Phys. Chem. Ref. Data **31**, 217 (2002)]. © *2004 by the U.S. Secretary of Commerce on behalf of the United States. All rights reserved.*
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Key words: Ba; Ba$^+$; barium; spectrum; wavelength; energy level; transition probabilities; atomic data; Ba I; Ba II.

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1. Introduction

The last major compilation of energy levels for neutral and singly ionized barium was published in 1958 by Moore in *Atomic Energy Levels* (AEL).[1] Since then, knowledge of the energy level structure of neutral barium has expanded considerably as a result of a number of laser investigations of Rydberg series. In addition, Karlsson and Litzén[2] have derived new values for nearly all of the low-lying levels in both neutral and singly ionized barium. These new values are based on their extensive measurements of Ba I and Ba II emission wavelengths from a hollow-cathode discharge source using high-precision Fourier transform spectroscopy. There is no recent compilation of Ba I and Ba II wavelengths, but the work of Karlsson and Litzén is comprehensive enough to effectively fill this void for Ba I. On the other hand, useful data on the emission wavelengths of Ba II are scattered over several sources, some dating back to the 1930s.

Through a critical review of the published literature, I have compiled a consistent and extensive set of data on the energy levels and emission wavelengths for both neutral and singly ionized barium. I have also included, when available, transition probabilities obtained from the recent compilation of Klose *et al.*[3]

The large quantity of experimental data has made it necessary to limit the scope of this compilation in a few important ways. First, the energy levels have been limited to those with principal quantum number $n \leqslant 25$ for $6snl$ configurations, and to those below the $6s$ ionization limit for doubly excited configurations. This choice eliminates a large quantity of data on bound levels with very high principal quantum numbers ($n > 25$) as well as auto-ionizing levels, but is inclusive enough to cover the needs for almost all applications involving weakly ionized gas discharges. A second limitation is the decision to compile only wavelengths obtained from emission spectra. This omits the many transitions observed in absorption using ultraviolet spectrographs and using multistep laser excitation of Rydberg series. References for data not included here are given in Secs. 1 and 2.

Another important limitation is related to the isotopic composition of Ba. Natural barium consists of seven isotopes, with ^{138}Ba having an abundance of 72%. The isotopic splitting is too small to have been resolved in most experi-

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ments. However, high-resolution laser spectroscopy has yielded a considerable amount of data for individual isotopes. These data are not directly comparable to results for naturally abundant barium. Therefore, isotope-specific data are not included in this compilation, but references are given.

2. Ba I

Table 1 contains the energy levels compiled for neutral barium, including nearly complete series, up to $n=25$, for the $6sns$ and $6snd$ configurations. A clear majority of the levels of the $6snp$ and $6sng$ configurations and about half of the levels of the $6snf$ configurations, again up to $n=25$, have been compiled. Seventy-seven levels of $5dnl$ configurations and four levels of the $6p^2$ configuration are also presented.

Table 1 is arranged with two purposes in mind. First, the lower-lying energy levels are grouped according to configuration, with each configuration appearing in order of increasing energy. This provides a clear view of the level structure most important in weakly ionized gas discharge applications. Second, levels lying above approximately 41 000 cm^{-1} are grouped in series of $6snl$ configurations with a common value of l. This arrangement facilitates a view of each Rydberg series as a single unit.

Karlsson and Litzén,[2] from their observations of a Ba hollow-cathode discharge, derived new values for the energies of 55 even-parity and 47 odd-parity low-lying levels. The differences between the measured wave numbers and the wave numbers calculated from the derived energy levels, for nearly 300 observed lines, have a standard deviation of only 0.002 cm^{-1}.

Interest in using multichannel quantum defect theory (MQDT) to describe the perturbation of Rydberg series in neutral Ba has lead to a great deal of experimental work on high-lying energy levels. This work has mostly taken the form of multistep laser absorption to probe $6snl$ configurations as well as the doubly excited $5dnl$ and $6p^2$ configurations that perturb them. The levels observed extend from moderate to very high values of n. There is considerable overlap in the data from all this work, so some discussion of the experimental details is warranted.

For the high-lying energy levels, this compilation draws primarily on the three sources listed below.

(1) Rubbmark *et al.*[4] observed the $6sns\,^1S_0$ series for $n=9$ to 31, the $6snd\,^3D_2$ series for $n=11$ to 28, and the $6snd\,^1D_2$ series for $n=41$ to 52. Rydberg series were observed by selectively exciting the $6s6p\,^1P_1$ resonance level with a laser, followed by broadband absorption to a Rydberg level. The absorption spectra were dispersed by a grating and recorded on photographic plates. Lines of Cd, Hg, and Ne from spectral lamps provided absolute calibration for absorption wavelengths. The wave number of the absorption transition was then added to the energy of the intermediate level to determine the energy of the observed level. Rubbmark *et al.* used 18 060.251 cm^{-1} for the $6s6p\,^1P_1$ level value, 0.010 cm^{-1} smaller than the value reported by Karlsson and Litzén.[2] To maintain consistency with Karlsson and Litzén, all the level values taken from Rubbmark *et al.* have been increased by 0.010 cm^{-1}. The average uncertainty of the reported level values relative to the $6s6p\,^1P_1$ level is 0.1 cm^{-1}.

(2) Camus *et al.*[5] used two-step laser excitation to Rydberg levels of Ba in a gas discharge. Working in a discharge instead of a simple vapor allowed them to pump from the well-populated $6s5d$ metastable levels with $J=1$, 2, or 3 to Rydberg levels with $J=0$, 1, 2, 3, 4, or 5. They observed, using the optogalvanic effect, $6sns$, $6snd$, and $6sng$ levels, as well as all levels of the $5d6d$ configuration (all below the 6*s* ionization limit) and all levels of the $5d7d$ configuration (15 levels below the 6*s* ionization limit). Absolute calibration of the laser wavelength at the observed transitions was achieved by counting the number of Fabry–Pérot fringes observed between resonance with a known Ba transition and the measured transition. The transition wave number was then added to the value of the intermediate level to determine the value of the observed level. Since the intermediate level values used differ slightly from those obtained recently by Karlsson and Litzén,[2] the $J=1$ levels taken from Camus *et al.* have been corrected upward by 0.03 cm^{-1} and the $J=3$, 4, and 5 levels have been corrected upward by 0.02 cm^{-1}. The averaged estimated uncertainty in the measured level values compared to in the intermediate levels is 0.10 cm^{-1}.

(3) Armstrong *et al.*[6] used three-laser excitation from the ground state to Rydberg levels. Collisional ionization from the high levels was detected as an indication of resonance. The $6snp$ series was examined as well as some $6snf\,^3F_2$ and $6sng\,^1G_4$ levels. Level values were determined by counting the number of Fabry–Pérot fringes between resonance with known $6snp\,^1P_1$ levels and the observed levels. Absolute energies of some $6snp\,^1P_1$ levels were determined by comparison to well-known transitions in Na. Resonance absorption transitions in both Na $(3s-np)$ and Ba $(6s^2-6snp\,^1P_1)$ were observed simultaneously by directing a frequency-doubled laser beam through two separate vapors. Extensive multichannel quantum defect theory analysis of the data was also given. Typical uncertainties in the reported level values are on the order of 0.1 cm^{-1}, except for the $^1G_4$ states where it is 0.34 cm^{-1}.

Additional sources[7–10] of data overlap the three sources cited above. In general there is good agreement among all the sources. The exceptions are typically related to ambiguity regarding the most appropriate designation to be used for some of the levels. For example, Karlsson and Litzén[2] observed a level at 37 041.198 cm^{-1}, which they labeled $6s9s\,^1S_0$. However, both Rubbmark *et al.*[4] and Lu *et al.*[8] have determined that the $6s9s\,^1S_0$ level is near 37 234.2 cm^{-1}. No other designation is obvious for the level measured by Karlsson and Litzén. Therefore it is omitted in Table 1. The $5d^2\,^1S_0$ level has been determined by combining Cahuzac's[11] observed 55 636 Å wavelength and Palenius's[10] $5d^2\,^1S_0-5d6p\,^1P_1$ classification with Karlsson and Litzén's value for the $5d6p\,^1P_1$ level. The energy values for the $6s8p\,^3P_{0,2}$ levels were recently determined by Li *et al.*[12]

Eighty-one states from the doubly excited configurations $5dns$, $5dnp$, $5dnd$, $5dnf$, and $6p^2$ are known. Conspicuously absent is the $^1G_4$ level from the $5d^2$ configuration with a predicted value of 24 300 cm^{-1}. According to Camus,[5] the leading percentages in the $5d6d$ and $5d7d$ configurations are almost all higher in jj coupling than in LS coupling. However, I follow Camus in using the LS designations for ease of comparison with other work. Only the three $5d4f$ states observed by Armstrong *et al.*[6] are given jj-coupling labels.

Table 1 contains some Landé g factors derived by Moore[1] from published data.

There is a considerable amount of data of more specialized interest that are not included in Table 1. Data for bound levels with $n>25$,[4–9,13,14] for levels with high angular momentum (up to $l=7$),[15] for auto-ionizing levels,[16,17] and for ^{138}Ba,[18–26] can be found in the literature.

Table 2 contains the compiled wavelengths of neutral Ba. These wavelengths are exclusively from the observations of emission from a hollow-cathode glow discharge by Karlsson and Litzén.[2] The transitions probed by laser and broadband absorption are much less prominent in most laboratory and astrophysical plasmas and have not been included here. Table 2 also contains transition probabilities for many of the observed emission lines. These transition probabilities have been compiled by Klose *et al.*[3] from a number of sources.[27–33]

Post *et al.*[20] determined the ionization energy of neutral Ba by measuring the level values of the $6snp\,^3P_0$ series ($n>11$) and applying MQDT analysis. The observed Rydberg levels were laser excited from the $6s5d\,^3D_1$ level. More recently, Karlsson and Litzén[2] used their new value for the $6s5d\,^3D_1$ level to slightly refine the value of Post *et al.* for the ionization energy. The new result for the ionization energy of barium is 42 034.91 cm^{-1}.

3. Ba II

The energy levels for singly ionized barium are in Table 3. The low-lying level values are taken from the Fourier transform spectroscopy observations of Karlsson and Litzén[2] which have already been described in the preceding text. Roig and Tondello[34] observed several high-lying nf and np levels using broadband absorption in a Ba vapor created by flash pyrolysis. Boulmer *et al.*[35] observed ns and nd Rydberg levels using laser photoionization of an atomic beam followed by laser two-photon excitation of the levels of interest. Detection of the excited atoms was achieved by microwave field ionization. Rasmussen[36] measured the wavelengths of more than 50 lines emitted from a hollow cathode dosed with BaCl$_2$. Twenty-one level values are obtained by combining Rasmussen's wavelengths and classifications with lower level energy values from Karlsson and Litzén.[2] A few Landé g factors derived by Moore[1] from published and unpublished data are included in the present compilation.

Levels at 77 046 and 77 628 cm^{-1}, designated 11g and 12g by Moore,[1] are not included here. Saunders *et al.*[37] originally designated these levels 10g and 11g, in disagreement with Rasmussen's value of 76 279.68 cm^{-1} for the 10g level.[36] The two emission lines, at 3430.18 and 3472.71 Å, used by Saunders *et al.* to identify their 10g and 11g levels were not observed by either Karlsson and Litzén[2] or by Rasmussen. Not included are autoionizing states of Ba$^+$ observed by Lucatorto *et al.*[38] and by Roig.[39]

Wavelengths for Ba II are in Table 4. They include wavelengths observed in emission by Karlsson and Litzén,[2] Saunders *et al.*,[37] and Rasmussen.[36] Intensities are given for lines observed by Karlsson and Litzén, who noted the anamolous intensities of lines observed by Rasmussen. Rasmussen observed strong lines that were not seen in the hollow-cathode discharge of Karlsson and Litzén, yet he did not observe the resonance lines and some other normally strong lines. The intensities reported by Rasmussen cannot, therefore, be scaled in a way that allows them to be compared with those of Karlsson and Litzén. Saunders *et al.* did not report intensities. Not included in Table 4 are a few infrared lines observed with low resolution by Isaev *et al.*[40] As is the case for Ba I, Ba II wavelengths observed in absorption by, for example, Roig and Tondello[34] and by Boulmer *et al.*,[35] have not been included.

Klose *et al.*[3] compiled a large set of absolute transition probabilities for Ba II, only a few of which were experimentally derived. The latter include values for the $6p\,^2P_{1/2,3/2}-6s\,^2S_{1/2}$ and $6p\,^2P_{1/2,3/2}-5d\,^2D_{3/2,5/2}$ multiplets.[41] Klose *et al.* have obtained many other transition probabilities by combining the Coulomb approximation calculations of Lindgård and Nielson[42] with expected relative intensities based on LS coupling rules.

A new value for the ionization energy (Table 5) of singly ionized barium has been derived by Boulmer *et al.*[35]

TABLE 1. Energy levels of neutral Ba

Configuration	Term	J	Level/cm^{-1}	Reference(s)	Obs g[a]
$6s^2$	$^{1}\mathrm{S}$	0	0.000	2	
$6s5d$	$^{3}\mathrm{D}$	1	9 033.966	2	0.53
	$^{3}\mathrm{D}$	2	9 215.501	2	1.18
	$^{3}\mathrm{D}$	3	9 596.533	2	1.38
	$^{1}\mathrm{D}$	2	11 395.350	2	1.00
$6s6p$	$^{3}\mathrm{P}^{\circ}$	0	12 266.024	2	
	$^{3}\mathrm{P}^{\circ}$	1	12 636.623	2	1.45
	$^{3}\mathrm{P}^{\circ}$	2	13 514.745	2	1.52
	$^{1}\mathrm{P}^{\circ}$	1	18 060.261	2	1.02
$5d^2$	$^{3}\mathrm{F}$	2	20 934.035	2	
	$^{3}\mathrm{F}$	3	21 250.195	2	
	$^{3}\mathrm{F}$	4	21 623.773	2	
	$^{1}\mathrm{D}$	2	23 062.051	2	
	$^{3}\mathrm{P}$	0	23 209.048	2	
	$^{3}\mathrm{P}$	1	23 479.976	2	
	$^{3}\mathrm{P}$	2	23 918.915	2	
	$^{1}\mathrm{S}$	0	26 757.3	10, 11	
$5d6p$	$^{3}\mathrm{F}^{\circ}$	2	22 064.645	2	
	$^{3}\mathrm{F}^{\circ}$	3	22 947.423	2	
	$^{1}\mathrm{D}^{\circ}$	2	23 074.387	2	
	$^{3}\mathrm{F}^{\circ}$	4	23 757.049	2	
	$^{3}\mathrm{D}^{\circ}$	1	24 192.033	2	0.54
	$^{3}\mathrm{D}^{\circ}$	2	24 531.513	2	1.16
	$^{3}\mathrm{D}^{\circ}$	3	24 979.834	2	1.32
	$^{3}\mathrm{P}^{\circ}$	0	25 642.126	2	
	$^{3}\mathrm{P}^{\circ}$	1	25 704.110	2	1.52
	$^{3}\mathrm{P}^{\circ}$	2	25 956.519	2	1.52
	$^{1}\mathrm{F}^{\circ}$	3	26 816.266	2	1.09
	$^{1}\mathrm{P}^{\circ}$	1	28 554.221	2	1.02
$6s7s$	$^{3}\mathrm{S}$	1	26 160.293	2	
	$^{1}\mathrm{S}$	0	28 230.231	2	
$6s6d$	$^{1}\mathrm{D}$	2	30 236.826	2	
	$^{3}\mathrm{D}$	1	30 695.617	2	
	$^{3}\mathrm{D}$	2	30 750.672	2	1.11
	$^{3}\mathrm{D}$	3	30 818.115	2	1.32
$6s7p$	$^{3}\mathrm{P}^{\circ}$	0	30 743.490	2	
	$^{3}\mathrm{P}^{\circ}$	1	30 815.512	2	
	$^{3}\mathrm{P}^{\circ}$	2	30 987.240	2	
	$^{1}\mathrm{P}^{\circ}$	1	32 547.033	2	1.07
$5d7s$	$^{3}\mathrm{D}$	1	32 805.169	2	
	$^{3}\mathrm{D}$	2	32 943.774	2	
	$^{3}\mathrm{D}$	3	33 526.601	2	
	$^{1}\mathrm{D}$	2	33 796.011	2	
$6s8s$	$^{3}\mathrm{S}$	1	33 905.358	2	
	$^{1}\mathrm{S}$	0	34 371.002	2	
$6p^2$	$^{3}\mathrm{P}$	0	34 493.904	2	
	$^{3}\mathrm{P}$	1	34 823.406	2	1.53
	$^{3}\mathrm{P}$	2	35 344.413	2	1.56
	$^{1}\mathrm{D}$	2	38 556.227	2	
$6s4f$	$^{3}\mathrm{F}^{\circ}$	2	34 602.765	2	0.69
	$^{3}\mathrm{F}^{\circ}$	3	34 616.643	2	1.09
	$^{3}\mathrm{F}^{\circ}$	4	34 630.779	2	1.48
	$^{1}\mathrm{F}^{\circ}$	3	34 736.373	2	0.99
$6s7d$	$^{3}\mathrm{D}$	2	35 616.949	2	
	$^{3}\mathrm{D}$	1	35 709.289	2	
	$^{1}\mathrm{D}$	2	35 762.187	2	

TABLE 1. Energy levels of neutral Ba—Continued

Configuration	Term	J	Level/cm^{-1}	Reference(s)	Obs g^{a}
	$^{3}\mathrm{D}$	3	35 785.273	2	
$6s8p$	$^{3}\mathrm{P}^{\circ}$	0	35 648.5	12	
	$^{3}\mathrm{P}^{\circ}$	1	35 669.00	6	
	$^{3}\mathrm{P}^{\circ}$	2	35 757	12	
	$^{1}\mathrm{P}^{\circ}$	1	35 892.465	2	
$5d6d$	$^{3}\mathrm{G}$	3	35 894.395	2	
	$^{3}\mathrm{D}$	1	35 933.806	2	
	$^{1}\mathrm{F}$	3	36 165.312	2	1.50
	$^{3}\mathrm{D}$	2	36 200.412	2	
	$^{3}\mathrm{G}$	4	36 349.161	2	
	$^{1}\mathrm{P}$	1	36 446.570	2	
	$^{3}\mathrm{D}$	3	36 629.053	2	
	$^{3}\mathrm{G}$	5	36 837.670	2	
	$^{3}\mathrm{F}$	2	37 088.794	2	
	$^{3}\mathrm{S}$	1	37 095.486	2	
	$^{3}\mathrm{F}$	3	37 503.887	2	
	$^{3}\mathrm{P}$	0	37 675.8	8	
	$^{3}\mathrm{F}$	4	37 732.127	2	
	$^{1}\mathrm{D}$	2	37 837.305	2	
	$^{3}\mathrm{P}$	1	38 023.059	2	
	$^{1}\mathrm{G}$	4	38 176.994	2	
	$^{3}\mathrm{P}$	2	38 267.616	2	
	$^{1}\mathrm{S}$	0	38 924.0	8	
$5d7p$	$^{3}\mathrm{D}^{\circ}$	1	36 495.732	2	
	$^{3}\mathrm{F}^{\circ}$	3	36 511.207	2	
	$^{3}\mathrm{P}^{\circ}$	0	36 908.280	2	
	$^{3}\mathrm{P}^{\circ}$	1	36 989.981	2	
	$^{3}\mathrm{D}^{\circ}$	2	37 063.452	2	
	$^{3}\mathrm{P}^{\circ}$	2	37 077.477	2	
	$^{3}\mathrm{F}^{\circ}$	4	37 132.036	2	
	$^{1}\mathrm{F}^{\circ}$	3	37 282.124	2	
	$^{3}\mathrm{D}^{\circ}$	3	37 540.184	2	
	$^{1}\mathrm{P}^{\circ}$	1	38 499.860	2	
$6s9s$	$^{3}\mathrm{S}$	1	36 902.670	2	
	$^{1}\mathrm{S}$	0	37 234.20	4	
$6s5f$	$^{3}\mathrm{F}^{\circ}$	2	37 394.868	2	
	$^{3}\mathrm{F}^{\circ}$	3	37 418.920	2	
	$^{3}\mathrm{F}^{\circ}$	4	37 524.148	2	
	$^{1}\mathrm{F}^{\circ}$	3	37 739.734	2	
$6s8d$	$^{1}\mathrm{D}$	2	37 435.176	2	
	$^{3}\mathrm{D}$	1	37 961.908	2	
	$^{3}\mathrm{D}$	2	37 974.186	2	
	$^{3}\mathrm{D}$	3	37 988.434	2	
$6s9p$	$^{1}\mathrm{P}^{\circ}$	1	37 775.28	6	
	$^{3}\mathrm{P}^{\circ}$	1	37 936.87	6	
$6s6f$	$^{3}\mathrm{F}^{\circ}$	2	38 815.700	2	
	$^{3}\mathrm{F}^{\circ}$	3	38 819.378	2	
	$^{3}\mathrm{F}^{\circ}$	4	38 825.242	2	
	$^{1}\mathrm{F}^{\circ}$	3	38 883.903	2	
$6s10s$	$^{1}\mathrm{S}$	0	38 663.8	8	
$6s10p$	$^{3}\mathrm{P}^{\circ}$	1	39 160.21	6	
	$^{1}\mathrm{P}^{\circ}$	1	39 311.95	6	
$6s9d$	$^{3}\mathrm{D}$	3	39 185.700	2	
	$^{1}\mathrm{D}$	2	39 335.003	2	
$5d8s$	$^{3}\mathrm{D}$	1	39 382.81	5	
	$^{3}\mathrm{D}$	2	39 464.98	4	

TABLE 1. Energy levels of neutral Ba—Continued

Configuration	Term	J	Level/cm^{-1}	Reference(s)	Obs *g*[a]
	^{3}D	3	40 146.64	5	
	^{1}D	2	40 223.75	4	
6*s*11*s*	^{1}S	0	39 671.85	4	
6*s*7*f*	^{3}F$^\circ$	2	39 678.176	2	
	^{3}F$^\circ$	3	39 680.727	2	
	^{3}F$^\circ$	4	39 683.126	2	
	^{1}F$^\circ$	3	39 705.106	2	
5*d*4*f*	[3/2,5/2]	1	39 893.48	6	
	[5/2,7/2]	1	40 662.86	6	
	[5/2,5/2]	1	40 736.81	6	
6*s*11*p*	^{3}P$^\circ$	1	39 916.35	6	
	^{3}P$^\circ$	2	39 930.79	6	
	^{1}P$^\circ$	1	39 982.14	6	
6*s*10*d*	^{3}D	2	39 922.17	4	
	^{1}D	2	39 998.35	4	
6*s*12*s*	^{1}S	0	40 233.75	4	
6*s*8*g*	^{3}G	3	40 300.03[b]	5	
	^{3}G	4	40 300.03[b]	5	
	^{3}G	5	40 300.03[b]	5	
	^{1}G	4	40 300.03[b]	5	
6*s*12*p*	^{3}P$^\circ$	1	40 395.60	6	
	^{3}P$^\circ$	2	40 406.67	6	
	^{1}P$^\circ$	1	40 428.68	6	
6*s*11*d*	^{3}D	1	40 407.41	5	
	^{3}D	2	40 413.61	4	
	^{3}D	3	40 423.41	5	
	^{1}D	2	40 483.59	4	
6*s*13*s*	^{3}S	1	40 569.01	5	
	^{1}S	0	40 618.20	4	
6*s*9*f*	^{3}F$^\circ$	2	40 613.87	6	
6*s*9*g*	^{3}G	3	40 663.95	5	
	^{3}G	4	40 665.56[b]	5	
	^{3}G	5	40 665.56[b]	5	
	^{1}G	4	40 665.56[b]	5	
5*d*7*d*	^{3}D	1	40 684.41	5	
	^{3}G	3	40 698.60	5	
	^{1}F	3	40 867.31	5	
	^{3}D	2	40 905.72	5	
	^{3}G	4	40 974.30	5	
	^{3}S	1	41 019.57	5	
	^{3}F	2	41 204.74	4	
	^{3}P	0	41 441.22	7	
	^{3}D	3	41 459.38	5	
	^{3}G	5	41 550.29	5	
	^{1}P	1	41 570.37	5	
	^{3}F	3	41 726.63	5	
	^{1}D	2	41 841.51	4	
	^{3}F	4	41 845.63	5	
	^{3}P	1	41 930.91	5	
6*s*13*p*	^{3}P$^\circ$	1	40 732.01	6	
	^{3}P$^\circ$	2	40 741.76	6	
	^{1}P$^\circ$	1	40 765.23	6	
6*s*12*d*	^{3}D	1	40 742.6	5	
	^{3}D	2	40 748.01	4	

TABLE 1. Energy levels of neutral Ba—Continued

Configuration	Term	J	Level/cm^{-1}	Reference(s)	Obs g[a]
	^{3}D	3	40 748.20	5	
	^{1}D	2	40 781.43	4	
6s14s	^{3}S	1	40 869.7	5	
	^{1}S	0	40 891.57	4	
5d8p	^{3}D$^{\circ}$	1	40 893.76	6	
	^{3}P$^{\circ}$	0	41 083.92	6	
	^{3}P$^{\circ}$	1	41 097.20	6	
	^{3}P$^{\circ}$	2	41 759.93	6	
6s10f	^{3}F$^{\circ}$	2	40 895.14	6	
6s10g	^{3}G	3	40 926.77[b]	5	
	^{3}G	4	40 925.41	5	
	^{3}G	5	40 926.77[b]	5	
	^{1}G	4	40 926.77[b]	5	
6s14p	^{3}P$^{\circ}$	1	40 973.65	6	
	^{3}P$^{\circ}$	2	40 982.86	6	
	^{1}P$^{\circ}$	1	40 991.23	6	
6s13d	^{3}D	1	40 982.38	5	
	^{3}D	3	40 987.22	5	
	^{3}D	2	40 987.27	4	
	^{1}D	2	41 007.72	4	
6s15s	^{3}S	1	41 082.25	5	
	^{1}S	0	41 093.00	4	
6s16s	^{3}S	1	41 235.85	5	
	^{1}S	0	41 245.20	4	
6s17s	^{3}S	1	41 356.24	5	
	^{1}S	0	41 362.31	4	
6s18s	^{3}S	1	41 451.26	5	
	^{1}S	0	41 467.80	7	
6s19s	^{3}S	1	41 527.15	5	
	^{1}S	0	41 535.25	4	
6s20s	^{3}S	1	41 592.71	5	
	^{1}S	0	41 595.80	4	
6s21s	^{3}S	1	41 642.79	5	
	^{1}S	0	41 646.28	4	
6s22s	^{3}S	1	41 685.69	5	
	^{1}S	0	41 688.61	4	
6s23s	^{3}S	1	41 721.96	5	
	^{1}S	0	41 724.40	4	
6s24s	^{3}S	1	41 752.81	5	
	^{1}S	0	41 754.92	4	
6s25s	^{3}S	1	41 779.37	5	
	^{1}S	0	41 781.18	4	
6s15p	^{3}P$^{\circ}$	1	41 159.83	6	
	^{3}P$^{\circ}$	2	41 162.15	6	
	^{1}P$^{\circ}$	1	41 183.60	6	
6s16p	^{3}P$^{\circ}$	0	41 295.93	6	
	^{3}P$^{\circ}$	1	41 296.96	6	
	^{3}P$^{\circ}$	2	41 299.33	6	
	^{1}P$^{\circ}$	1	41 307.88	6	
6s17p	^{3}P$^{\circ}$	1	41 404.40	6	
	^{3}P$^{\circ}$	2	41 406.53	6	

TABLE 1. Energy levels of neutral Ba—Continued

Configuration	Term	J	Level/cm^{-1}	Reference(s)	Obs g[a]
	$^{1}P^{\circ}$	1	41 411.04	6	
$6s18p$	$^{3}P^{\circ}$	1	41 490.09	6	
	$^{3}P^{\circ}$	2	41 491.80	6	
	$^{1}P^{\circ}$	1	41 494.39	6	
$6s19p$	$^{3}P^{\circ}$	1	41 559.45	6	
	$^{3}P^{\circ}$	2	41 560.83	6	
	$^{1}P^{\circ}$	1	41 562.24	6	
$6s20p$	$^{3}P^{\circ}$	1	41 616.32	6	
	$^{3}P^{\circ}$	2	41 617.51	6	
	$^{1}P^{\circ}$	1	41 618.12	6	
$6s21p$	$^{3}P^{\circ}$	1	41 663.55	6	
	$^{1}P^{\circ}$	1	41 664.66	6	
$6s22p$	$^{3}P^{\circ}$	1	41 703.25	6	
	$^{1}P^{\circ}$	1	41 703.84	6	
$6s23p$	$^{1}P^{\circ}$	1	41 736.80	6	
	$^{3}P^{\circ}$	2	41 737.39	6	
$6s24p$	$^{1}P^{\circ}$	1	41 765.35	6	
	$^{3}P^{\circ}$	2	41 767.32	6	
$6s25p$	$^{1}P^{\circ}$	1	41 789.99	6	
	$^{3}P^{\circ}$	2	41 791.29	6	
$6s14d$	^{1}D	2	41 162.43	4	
	^{3}D	1	41 163.02	5	
	^{3}D	2	41 164.61	4	
	^{3}D	3	41 164.72	5	
$6s15d$	^{3}D	1	41 299.58	5	
	^{3}D	2	41 300.40	4	
	^{3}D	3	41 300.82	5	
	^{1}D	2	41 315.49	4	
$6s16d$	^{3}D	1	41 406.52	5	
	^{3}D	3	41 405.97	5	
	^{3}D	2	41 407.13	4	
	^{1}D	2	41 417.58	4	
$6s17d$	^{3}D	1	41 491.56	5	
	^{3}D	2	41 492.22	4	
	^{3}D	3	41 495.62	5	
	^{1}D	2	41 500.00	4	
$6s18d$	^{3}D	1	41 559.01	5	
	^{3}D	2	41 561.13	4	
	^{3}D	3	41 562.57	5	
	^{1}D	2	41 567.09	4	
$6s19d$	^{3}D	2	41 617.74	4	
	^{3}D	1	41 617.80	5	
	^{3}D	3	41 618.46	5	
	^{1}D	2	41 622.38	4	
$6s20d$	^{3}D	1	41 664.68	5	
	^{3}D	2	41 664.68	4	
	^{3}D	3	41 665.31	5	
	^{1}D	2	41 668.46	4	
$6s21d$	^{3}D	1	41 704.20	5	
	^{3}D	3	41 704.48	5	
	^{3}D	2	41 704.14	4	
	^{1}D	2	41 707.16	4	
$6s22d$	^{3}D	2	41 737.59	4	

TABLE 1. Energy levels of neutral Ba—Continued

Configuration	Term	J	Level/cm^{-1}	Reference(s)	Obs *g*[a]
	^{3}D	1	41 737.75	5	
	^{3}D	3	41 739.13	5	
	^{1}D	2	41 740.06	4	
6*s*23*d*	^{3}D	2	41 766.17	4	
	^{3}D	1	41 766.33	5	
	^{3}D	3	41 767.18	5	
	^{1}D	2	41 768.20	4	
6*s*24*d*	^{3}D	2	41 790.74	4	
	^{3}D	1	41 791.11	5	
	^{3}D	3	41 791.74	5	
	^{1}D	2	41 792.52	4	
6*s*25*d*	^{3}D	2	41 811.83	4	
	^{3}D	1	41 812.43	5	
	^{1}D	2	41 813.54	4	
6*s*11*f*	^{3}F$^{\circ}$	2	41 100.7	6	
6*s*12*f*	^{3}F$^{\circ}$	2	41 251.2	6	
6*s*17*f*	^{3}F$^{\circ}$	2	41 647.85	6	
6*s*18*f*	^{3}F$^{\circ}$	2	41 689.80	6	
6*s*19*f*	^{3}F$^{\circ}$	2	41 725.39	6	
6*s*20*f*	^{3}F$^{\circ}$	2	41 755.48	6	
6*s*21*f*	^{3}F$^{\circ}$	2	41 782.02	6	
6*s*22*f*	^{3}F$^{\circ}$	2	41 804.59	6	
6*s*23*f*	^{3}F$^{\circ}$	2	41 824.30	6	
6*s*24*f*	^{3}F$^{\circ}$	2	41 841.63	6	
6*s*25*f*	^{3}F$^{\circ}$	2	41 856.85	6	
6*s*11*g*	^{3}G	3	41 119.22[b]	5	
	^{3}G	4	41 119.99	5	
	^{3}G	5	41 119.22[b]	5	
	^{1}G	4	41 119.22[b]	5	
6*s*12*g*	^{3}G	3	41 266.46[b]	5	
	^{3}G	4	41 266.46[b]	5	
	^{3}G	5	41 266.46[b]	5	
	^{1}G	4	41 266.46[b]	5	
6*s*13*g*	^{3}G	3	41 379.96	5	
	^{3}G	4	41 380.36[b]	5	
	^{3}G	5	41 380.36[b]	5	
	^{1}G	4	41 380.36[b]	5	
6*s*14*g*	^{3}G	3	41 470.96	5	
	^{3}G	4	41 470.59[b]	5	
	^{3}G	5	41 470.59[b]	5	
	^{1}G	4	41 470.59[b]	5	
6*s*15*g*	^{3}G	3	41 543.76[b]	5	
	^{3}G	4	41 543.76[b]	5	
	^{3}G	5	41 539.69	5	
	^{1}G	4	41 543.76[b]	5	
6*s*16*g*	^{3}G	3	41 603.48[b]	5	
	^{3}G	4	41 603.48[b]	5	
	^{3}G	5	41 603.89	5	
	^{1}G	4	41 603.48[b]	5	
6*s*17*g*	^{3}G	3	41 652.79[b]	5	

TABLE 1. Energy levels of neutral Ba—Continued

Configuration	Term	J	Level/cm^{-1}	Reference(s)	Obs g[a]
	^{3}G	4	41 652.79[b]	5	
	^{3}G	5	41 653.07	5	
	^{1}G	4	41 652.79[b]	5	
6s18g	^{3}G	3	41 693.91	5	
	^{3}G	4	41 694.33[b]	5	
	^{3}G	5	41 694.33[b]	5	
	^{1}G	4	41 694.33[b]	5	
6s19g	^{3}G	3	41 729.48[b]	5	
	^{3}G	4	41 729.48[b]	5	
	^{3}G	5	41 729.48[b]	5	
	^{1}G	4	41 729.48[b]	5	
6s20g	^{3}G	3	41 759.09[b]	5	
	^{3}G	4	41 759.09[b]	5	
	^{3}G	5	41 759.09[b]	5	
	^{1}G	4	41 759.09[b]	5	
6s21g	^{3}G	3	41 784.81[b]	5	
	^{3}G	4	41 784.81[b]	5	
	^{3}G	5	41 784.81[b]	5	
	^{1}G	4	41 784.81[b]	5	
6s22g	^{3}G	3	41 807.16[b]	5	
	^{3}G	4	41 807.16[b]	5	
	^{3}G	5	41 807.16[b]	5	
	^{1}G	4	41 807.16[b]	5	
6s23g	^{3}G	3	41 826.32[b]	5	
	^{3}G	4	41 826.32[b]	5	
	^{3}G	5	41 826.32[b]	5	
	^{1}G	4	41 826.32[b]	5	
6s24g	^{3}G	3	41 843.92[b]	5	
	^{3}G	4	41 842.24	5	
	^{3}G	5	41 843.92[b]	5	
	^{1}G	4	41 843.92[b]	5	
6s25g	^{3}G	3	41 858.72[b]	5	
	^{3}G	4	41 858.91	5	
	^{3}G	5	41 858.72[b]	5	
	^{1}G	4	41 858.72[b]	5	

[a] Values derived by Moore[1] from published data.

[b] Part of an unresolved multiplet.

TABLE 2. Wavelengths, wave numbers, classifications, and transition probabilities for observed emission lines of neutral barium, Ba I

Intensity	λ_{air}/Å[a]	σ/cm^{-1}	Lower level	Upper level	A_{ul}/s^{-1}	Accuracy[b]	Reference(s)[c]
120	2 596.6357	38 499.860	$6s^2\,^1S_0$	$5d7p\,^1P^\circ_1$			
78	2 702.6331	36 989.981	$6s^2\,^1S_0$	$5d7p\,^3P^\circ_1$			
39	2 739.2363	36 495.727	$6s^2\,^1S_0$	$5d7p\,^3D^\circ_1$			
95	2 785.2784	35 892.465	$6s^2\,^1S_0$	$6s8p\,^1P^\circ_1$			
168	3 071.5841	32 547.034	$6s^2\,^1S_0$	$6s7p\,^1P^\circ_1$	4.2×10^7	C	27
2	3 262.3186	30 644.210	$6s5d\,^3D_1$	$6s7f\,^3F^\circ_2$			
3	3 281.4854	30 465.226	$6s5d\,^3D_2$	$6s7f\,^3F^\circ_3$			
5	3 322.7835	30 086.593	$6s5d\,^3D_3$	$6s7f\,^3F^\circ_4$			
8	3 356.7980	29 781.735	$6s5d\,^3D_1$	$6s6f\,^3F^\circ_2$			
13	3 376.9661	29 603.877	$6s5d\,^3D_2$	$6s6f\,^3F^\circ_3$			
2	3 377.3867	29 600.190	$6s5d\,^3D_2$	$6s6f\,^3F^\circ_2$			
19	3 420.3129	29 228.709	$6s5d\,^3D_3$	$6s6f\,^3F^\circ_4$			
1	3 421.0004	29 222.835	$6s5d\,^3D_3$	$6s6f\,^3F^\circ_3$			
860	3 501.1075	28 554.221	$6s^2\,^1S_0$	$5d6p\,^1P^\circ_1$	3.50×10^7	B	28, 29
47	3 524.9732	28 360.902	$6s5d\,^3D_1$	$6s5f\,^3F^\circ_2$			
6	3 529.4810	28 324.681	$6s5d\,^3D_2$	$5d7p\,^3D^\circ_3$			
5	3 531.3418	28 309.756	$6s5d\,^1D_2$	$6s7f\,^1F^\circ_3$			
74	3 544.6566	28 203.419	$6s5d\,^3D_2$	$6s5f\,^3F^\circ_3$			
9	3 547.6822	28 179.366	$6s5d\,^3D_2$	$6s5f\,^3F^\circ_2$			
6	3 561.9336	28 066.623	$6s5d\,^3D_2$	$5d7p\,^1F^\circ_3$			
6	3 566.6533	28 029.484	$6s5d\,^3D_1$	$5d7p\,^3D^\circ_2$			
6	3 576.0270	27 956.014	$6s5d\,^3D_1$	$5d7p\,^3P^\circ_1$			
18	3 577.6089	27 943.652	$6s5d\,^3D_3$	$5d7p\,^3D^\circ_3$			
87	3 579.6635	27 927.615	$6s5d\,^3D_3$	$6s5f\,^3F^\circ_4$			
10	3 586.5087	27 874.314	$6s5d\,^3D_1$	$5d7p\,^3P^\circ_0$			
11	3 588.0969	27 861.976	$6s5d\,^3D_2$	$5d7p\,^3P^\circ_2$			
2	3 589.9041	27 847.950	$6s5d\,^3D_2$	$5d7p\,^3D^\circ_2$			
12	3 593.2024	27 822.388	$6s5d\,^3D_3$	$6s5f\,^3F^\circ_3$			
16	3 599.4005	27 774.480	$6s5d\,^3D_2$	$5d7p\,^3P^\circ_1$			
11	3 610.9572	27 685.592	$6s5d\,^3D_3$	$5d7p\,^1F^\circ_3$			
57	3 630.6401	27 535.503	$6s5d\,^3D_3$	$5d7p\,^3F^\circ_4$			
19	3 636.8413	27 488.553	$6s5d\,^1D_2$	$6s6f\,^1F^\circ_3$			
1	3 639.7064	27 466.915	$6s5d\,^3D_3$	$5d7p\,^3D^\circ_2$			
114	3 640.3888	27 461.767	$6s5d\,^3D_1$	$5d7p\,^3D^\circ_1$			
13	3 662.5367	27 295.706	$6s5d\,^3D_2$	$5d7p\,^3F^\circ_3$			
13	3 688.3730	27 104.510	$6s5d\,^3D_2$	$5d7p\,^1P^\circ_1$			
33	3 794.7979	26 344.384	$6s5d\,^1D_2$	$6s5f\,^1F^\circ_3$			
53	3 861.8816	25 886.774	$6s5d\,^1D_2$	$5d7p\,^1F^\circ_3$			
3	3 881.3342	25 757.037	$6s6p\,^3P^\circ_0$	$5d6d\,^3P_1$			
165	3 889.3263	25 704.110	$6s^2\,^1S_0$	$5d6p\,^3P^\circ_1$	1.1×10^6	C$^+$	30
9	3 890.5714	25 695.884	$6s6p\,^3P^\circ_0$	$6s8d\,^3D_1$			
82	3 892.6555	25 682.127	$6s5d\,^1D_2$	$5d7p\,^3P^\circ_2$			
4	3 894.3494	25 670.956	$6s6p\,^3P^\circ_2$	$6s9d\,^3D_3$			
1	3 894.7817	25 668.108	$6s5d\,^1D_2$	$5d7p\,^3D^\circ_2$			
5	3 905.9632	25 594.630	$6s5d\,^1D_2$	$5d7p\,^3P^\circ_1$			
272	3 909.9092	25 568.799	$6s5d\,^3D_1$	$6s4f\,^3F^\circ_2$			
4	3 917.2520	25 520.872	$6s5d\,^3D_2$	$6s4f\,^1F^\circ_3$			
423	3 935.7167	25 401.142	$6s5d\,^3D_2$	$6s4f\,^3F^\circ_3$			
59	3 937.8681	25 387.265	$6s5d\,^3D_2$	$6s4f\,^3F^\circ_2$			
21	3 945.5928	25 337.562	$6s6p\,^3P^\circ_1$	$6s8d\,^3D_2$			
9	3 947.5057	25 325.284	$6s6p\,^3P^\circ_1$	$6s8d\,^3D_1$			
530	3 993.3989	25 034.246	$6s5d\,^3D_3$	$6s4f\,^3F^\circ_4$			
61	3 995.6551	25 020.111	$6s5d\,^3D_3$	$6s4f\,^3F^\circ_3$			
1	3 997.8728	25 006.231	$6s5d\,^3D_3$	$6s4f\,^3F^\circ_2$			
13	4 080.9615	24 497.113	$6s5d\,^1D_2$	$6s8p\,^1P^\circ_1$			
43	4 084.8673	24 473.690	$6s6p\,^3P^\circ_2$	$6s8d\,^3D_3$			
8	4 087.2467	24 459.444	$6s6p\,^3P^\circ_2$	$6s8d\,^3D_2$			
9	4 087.3435	24 458.864	$6s6p\,^3P^\circ_1$	$5d6d\,^3S_1$			
309	4 132.4266	24 192.033	$6s^2\,^1S_0$	$5d6p\,^3D^\circ_1$	1.50×10^6	B	28, 29, 30
14	4 179.3487	23 920.431	$6s6p\,^3P^\circ_2$	$6s8d\,^1D_2$			

TABLE 2. Wavelengths, wave numbers, classifications, and transition probabilities for observed emission lines of neutral barium, Ba I—Continued

Intensity	$\lambda_{\mathrm{air}}/\text{Å}$[a]	σ/cm^{-1}	Lower level	Upper level	$A_{\mathrm{ul}}/\mathrm{s}^{-1}$	Accuracy[b]	Reference(s)[c]
34	4 223.9634	23 667.782	$6s6p\ ^3\mathrm{P}^\circ_0$	$5d6d\ ^3\mathrm{D}_1$			
25	4 239.5552	23 580.741	$6s6p\ ^3\mathrm{P}^\circ_2$	$5d6d\ ^3\mathrm{S}_1$			
17	4 242.6050	23 563.790	$6s6p\ ^3\mathrm{P}^\circ_1$	$5d6d\ ^3\mathrm{D}_2$			
42	4 264.4174	23 443.264	$6s6p\ ^3\mathrm{P}^\circ_0$	$6s7d\ ^3\mathrm{D}_1$			
530	4 283.0973	23 341.023	$6s5d\ ^1\mathrm{D}_2$	$6s4f\ ^1\mathrm{F}^\circ_3$			
26	4 291.1571	23 297.183	$6s6p\ ^3\mathrm{P}^\circ_1$	$5d6d\ ^3\mathrm{D}_1$			
6	4 305.1815	23 221.292	$6s5d\ ^1\mathrm{D}_2$	$6s4f\ ^3\mathrm{F}^\circ_3$			
61	4 323.0031	23 125.564	$6s6p\ ^3\mathrm{P}^\circ_1$	$6s7d\ ^1\mathrm{D}_2$	8.8×10^{6}	C$^+$	30
18	4 325.1085	23 114.308	$6s6p\ ^3\mathrm{P}^\circ_2$	$5d6d\ ^3\mathrm{D}_3$			
39	4 332.9146	23 072.666	$6s6p\ ^3\mathrm{P}^\circ_1$	$6s7d\ ^3\mathrm{D}_1$			
271	4 350.3255	22 980.326	$6s6p\ ^3\mathrm{P}^\circ_1$	$6s7d\ ^3\mathrm{D}_2$			
9	4 359.5269	22 931.824	$6s6p\ ^3\mathrm{P}^\circ_2$	$5d6d\ ^1\mathrm{P}_1$			
273	4 402.5386	22 707.790	$6s6p\ ^3\mathrm{P}^\circ_1$	$6p^2\ ^3\mathrm{P}_2$	2.7×10^{7}	C	31
29	4 406.8319	22 685.667	$6s6p\ ^3\mathrm{P}^\circ_2$	$5d6d\ ^3\mathrm{D}_2$			
13	4 413.6612	22 650.566	$6s6p\ ^3\mathrm{P}^\circ_2$	$5d6d\ ^1\mathrm{F}_3$			
374	4 431.8943	22 557.382	$6s6p\ ^3\mathrm{P}^\circ_0$	$6p^2\ ^3\mathrm{P}_1$			
30	4 467.0914	22 379.650	$6s6p\ ^3\mathrm{P}^\circ_2$	$5d6d\ ^3\mathrm{G}_3$			
234	4 488.980	22 270.528	$6s6p\ ^3\mathrm{P}^\circ_2$	$6s7d\ ^3\mathrm{D}_3$	2.8×10^{7}	C$^+$	30
137	4 493.638	22 247.442	$6s6p\ ^3\mathrm{P}^\circ_2$	$6s7d\ ^1\mathrm{D}_2$	2.0×10^{7}	C$^+$	30
5	4 504.348	22 194.547	$6s6p\ ^3\mathrm{P}^\circ_2$	$6s7d\ ^3\mathrm{D}_1$			
209	4 505.924	22 186.782	$6s6p\ ^3\mathrm{P}^\circ_1$	$6p^2\ ^3\mathrm{P}_1$			
327	4 523.167	22 102.205	$6s6p\ ^3\mathrm{P}^\circ_2$	$6s7d\ ^3\mathrm{D}_2$			
230	4 573.853	21 857.281	$6s6p\ ^3\mathrm{P}^\circ_1$	$6p^2\ ^3\mathrm{P}_0$	1.21×10^{8}	B	31
580	4 579.638	21 829.668	$6s6p\ ^3\mathrm{P}^\circ_2$	$6p^2\ ^3\mathrm{P}_2$	7.0×10^{7}	C$^+$	31
22	4 589.756	21 781.546	$6s5d\ ^3\mathrm{D}_1$	$6s7p\ ^3\mathrm{P}^\circ_1$			
28	4 591.824	21 771.737	$6s5d\ ^3\mathrm{D}_2$	$6s7p\ ^3\mathrm{P}^\circ_2$			
108	4 599.717	21 734.379	$6s6p\ ^3\mathrm{P}^\circ_1$	$6s8s\ ^1\mathrm{S}_0$	4.07×10^{7}	B$^+$	31
28	4 604.983	21 709.523	$6s5d\ ^3\mathrm{D}_1$	$6s7p\ ^3\mathrm{P}^\circ_0$			
40	4 619.920	21 639.333	$6s6p\ ^3\mathrm{P}^\circ_0$	$6s8s\ ^3\mathrm{S}_1$	2.7×10^{6}	C$^+$	30
63	4 628.331	21 600.011	$6s5d\ ^3\mathrm{D}_2$	$6s7p\ ^3\mathrm{P}^\circ_1$			
133	4 673.619	21 390.707	$6s5d\ ^3\mathrm{D}_3$	$6s7p\ ^3\mathrm{P}^\circ_2$			
306	4 691.614	21 308.661	$6s6p\ ^3\mathrm{P}^\circ_2$	$6p^2\ ^3\mathrm{P}_1$			
24	4 699.095	21 274.742	$6s6p\ ^1\mathrm{P}^\circ_1$	$6s9d\ ^1\mathrm{D}_2$			
80	4 700.422	21 268.735	$6s6p\ ^3\mathrm{P}^\circ_1$	$6s8s\ ^3\mathrm{S}_1$	6.1×10^{6}	C$^+$	30
8	4 724.713	21 159.388	$6s6p\ ^3\mathrm{P}^\circ_1$	$5d7s\ ^1\mathrm{D}_2$			
371	4 726.434	21 151.683	$6s5d\ ^1\mathrm{D}_2$	$6s7p\ ^1\mathrm{P}^\circ_1$	3.3×10^{7}	C	28, 29
66	4 877.647	20 495.966	$6s6p\ ^1\mathrm{P}^\circ_1$	$6p^2\ ^1\mathrm{D}_2$			
63	4 902.848	20 390.614	$6s6p\ ^3\mathrm{P}^\circ_2$	$6s8s\ ^3\mathrm{S}_1$	5.4×10^{6}	C$^+$	30
25	4 947.312	20 207.355	$6s6p\ ^1\mathrm{P}^\circ_1$	$5d6d\ ^3\mathrm{P}_2$			
5	4 995.644	20 011.856	$6s6p\ ^3\mathrm{P}^\circ_2$	$5d7s\ ^3\mathrm{D}_3$			
19	5 054.958	19 777.044	$6s6p\ ^1\mathrm{P}^\circ_1$	$5d6d\ ^1\mathrm{D}_2$			
80	5 159.876	19 374.915	$6s6p\ ^1\mathrm{P}^\circ_1$	$6s8d\ ^1\mathrm{D}_2$			
5	5 253.804	19 028.531	$6s6p\ ^1\mathrm{P}^\circ_1$	$5d6d\ ^3\mathrm{F}_2$			
6	5 305.701	18 842.408	$6s6p\ ^1\mathrm{P}^\circ_1$	$6s9s\ ^3\mathrm{S}_1$			
199	5 424.548	18 429.593	$6s6p\ ^3\mathrm{P}^\circ_0$	$6s6d\ ^3\mathrm{D}_1$			
5	5 437.318	18 386.311	$6s6p\ ^1\mathrm{P}^\circ_1$	$5d6d\ ^1\mathrm{P}_1$			
280	5 519.044	18 114.049	$6s6p\ ^3\mathrm{P}^\circ_1$	$6s6d\ ^3\mathrm{D}_2$	5.7×10^{7}	C$^+$	30
1 830	5 535.481	18 060.261	$6s^2\ ^1\mathrm{S}_0$	$6s6p\ ^1\mathrm{P}^\circ_1$	1.19×10^{8}	A$^+$	32
112	5 535.869	18 058.994	$6s6p\ ^3\mathrm{P}^\circ_1$	$6s6d\ ^3\mathrm{D}_1$			
5	5 593.308	17 873.546	$6s6p\ ^1\mathrm{P}^\circ_1$	$5d6d\ ^3\mathrm{D}_1$			
21	5 679.995	17 600.765	$6s5d\ ^3\mathrm{D}_2$	$5d6p\ ^1\mathrm{F}^\circ_3$			
41	5 680.176	17 600.203	$6s6p\ ^3\mathrm{P}^\circ_1$	$6s6d\ ^1\mathrm{D}_2$			
740	5 777.618	17 303.371	$6s6p\ ^3\mathrm{P}^\circ_2$	$6s6d\ ^3\mathrm{D}_3$	8.0×10^{7}	C$^+$	30
5	5 784.042	17 284.153	$6s6p\ ^1\mathrm{P}^\circ_1$	$6p^2\ ^3\mathrm{P}_2$	2.1×10^{7}	C	31
203	5 800.226	17 235.928	$6s6p\ ^3\mathrm{P}^\circ_2$	$6s6d\ ^3\mathrm{D}_2$	2.4×10^{7}	C$^+$	30
419	5 805.681	17 219.733	$6s5d\ ^3\mathrm{D}_3$	$5d6p\ ^1\mathrm{F}^\circ_3$			
14	5 818.812	17 180.874	$6s6p\ ^3\mathrm{P}^\circ_2$	$6s6d\ ^3\mathrm{D}_1$			
610	5 826.274	17 158.872	$6s5d\ ^1\mathrm{D}_2$	$5d6p\ ^1\mathrm{P}^\circ_1$	4.50×10^{7}	B	28, 29
94	5 907.636	16 922.554	$6s5d\ ^3\mathrm{D}_1$	$5d6p\ ^3\mathrm{P}^\circ_2$			
700	5 971.698	16 741.018	$6s5d\ ^3\mathrm{D}_2$	$5d6p\ ^3\mathrm{P}^\circ_2$	1.6×10^{7}	C$^+$	30
8	5 978.461	16 722.081	$6s6p\ ^3\mathrm{P}^\circ_2$	$6s6d\ ^1\mathrm{D}_2$			

TABLE 2. Wavelengths, wave numbers, classifications, and transition probabilities for observed emission lines of neutral barium, Ba I—Continued

Intensity	$\lambda_{\mathrm{air}}/\text{Å}$[a]	σ/cm^{-1}	Lower level	Upper level	$A_{\mathrm{ul}}/\mathrm{s}^{-1}$	Accuracy[b]	Reference(s)[c]
620	5 997.087	16 670.145	$6s5d\ ^3D_1$	$5d6p\ ^3P^\circ_1$	2.8×10^7	C^+	30
610	6 019.470	16 608.160	$6s5d\ ^3D_1$	$5d6p\ ^3P^\circ_0$	8.1×10^7	C	30
840	6 063.114	16 488.609	$6s5d\ ^3D_2$	$5d6p\ ^3P^\circ_1$	5.6×10^7	C^+	30
5	6 083.394	16 433.644	$6s6p\ ^1P^\circ_1$	$6p^2\ ^3P_0$	1.1×10^7	D^+	31
880	6 110.783	16 359.986	$6s5d\ ^3D_3$	$5d6p\ ^3P^\circ_2$			
5	6 129.233	16 310.740	$6s6p\ ^1P^\circ_1$	$6s8s\ ^1S_0$	6.0×10^6	C	31
900	6 341.680	15 764.333	$6s5d\ ^3D_2$	$5d6p\ ^3D^\circ_3$	1.2×10^7	C^+	30
3	6 411.112	15 593.608	$6s6p\ ^3P^\circ_1$	$6s7s\ ^1S_0$			
580	6 450.851	15 497.548	$6s5d\ ^3D_1$	$5d6p\ ^3D^\circ_2$	1.10×10^7	B	28–30
1 770	6 482.908	15 420.916	$6s5d\ ^1D_2$	$5d6p\ ^1F^\circ_3$			
1 060	6 498.760	15 383.301	$6s5d\ ^3D_3$	$5d6p\ ^3D^\circ_3$	5.4×10^7	C^+	30
890	6 527.311	15 316.012	$6s5d\ ^3D_2$	$5d6p\ ^3D^\circ_2$	3.30×10^7	B	28–30
740	6 595.325	15 158.068	$6s5d\ ^3D_1$	$5d6p\ ^3D^\circ_1$	3.80×10^7	B^+	28–30
9	6 654.114	15 024.149	$5d6p\ ^3F^\circ_2$	$5d6d\ ^3F_2$			
462	6 675.270	14 976.532	$6s5d\ ^3D_2$	$5d6p\ ^3D^\circ_1$	1.89×10^7	B^+	28–30
454	6 693.842	14 934.980	$6s5d\ ^3D_3$	$5d6p\ ^3D^\circ_2$	1.46×10^7	B	28–30
4	6 771.858	14 762.920	$5d6p\ ^1D^\circ_2$	$5d6d\ ^1D_2$			
62	6 865.686	14 561.170	$6s5d\ ^1D_2$	$5d6p\ ^3P^\circ_2$			
8	6 867.905	14 556.464	$5d6p\ ^3F^\circ_3$	$5d6d\ ^3F_3$			
1	6 961.482	14 360.795	$5d6p\ ^1D^\circ_2$	$6s8d\ ^1D_2$			
770	7 059.943	14 160.516	$6s5d\ ^3D_3$	$5d6p\ ^3F^\circ_4$	5.0×10^7	C	30
6	7 089.908	14 100.668	$5d6p\ ^3F^\circ_2$	$5d6d\ ^1F_3$			
530	7 120.331	14 040.421	$6s5d\ ^3D_1$	$5d6p\ ^1D^\circ_2$	1.1×10^7	C	28, 29
5	7 153.624	13 975.076	$5d6p\ ^3F^\circ_4$	$5d6d\ ^3F_4$			
53	7 195.230	13 894.266	$6s6p\ ^3P^\circ_0$	$6s7s\ ^3S_1$	5.6×10^6	C^+	30
25	7 228.796	13 829.751	$5d6p\ ^3F^\circ_2$	$5d6d\ ^3G_3$			
1	7 229.568	13 828.275	$5d6p\ ^1D^\circ_2$	$6s9s\ ^3S_1$			
1 280	7 280.296	13 731.922	$6s5d\ ^3D_2$	$5d6p\ ^3F^\circ_3$	3.2×10^7	C^+	28–30
2	7 359.308	13 584.492	$6s5d\ ^1D_2$	$5d6p\ ^3D^\circ_3$			
3	7 375.502	13 554.665	$5d6p\ ^1D^\circ_2$	$5d6d\ ^3D_3$			
143	7 392.405	13 523.671	$6s6p\ ^3P^\circ_1$	$6s7s\ ^3S_1$	1.8×10^7	C^+	30
1	7 410.009	13 491.543	$5d6p\ ^3D^\circ_2$	$5d6d\ ^3P_1$			
30	7 417.536	13 477.854	$6s5d\ ^3D_3$	$5d6p\ ^1D^\circ_2$	7.7×10^5	C	28, 29
29	7 459.664	13 401.738	$5d6p\ ^3F^\circ_3$	$5d6d\ ^3G_4$			
253	7 488.075	13 350.891	$6s5d\ ^3D_3$	$5d6p\ ^3F^\circ_3$	7.3×10^6	C^+	28–30
2	7 513.455	13 305.791	$5d6p\ ^3D^\circ_2$	$5d6d\ ^1D_2$			
1	7 523.642	13 287.776	$5d6p\ ^3D^\circ_3$	$5d6d\ ^3P_2$			
22	7 610.477	13 136.164	$6s5d\ ^1D_2$	$5d6p\ ^3D^\circ_2$	1.1×10^6	C	28, 29
14	7 636.777	13 090.926	$5d6p\ ^1D^\circ_2$	$5d6d\ ^1F_3$			
23	7 642.793	13 080.621	$5d6p\ ^3F^\circ_4$	$5d6d\ ^3G_5$			
560	7 672.085	13 030.680	$6s5d\ ^3D_1$	$5d6p\ ^3F^\circ_2$	1.5×10^7	C	28, 29
3	7 706.567	12 972.376	$5d6p\ ^3D^\circ_2$	$5d6d\ ^3F_3$			
3	7 751.753	12 896.759	$5d6p\ ^3D^\circ_1$	$5d6d\ ^3F_2$			
299	7 780.478	12 849.145	$6s5d\ ^3D_2$	$5d6p\ ^3F^\circ_2$	7.6×10^6	C	28, 29
5	7 839.569	12 752.294	$5d6p\ ^3D^\circ_3$	$5d6d\ ^3F_4$			
2	7 877.801	12 690.407	$6s6p\ ^1P^\circ_1$	$6s6d\ ^3D_2$	1.6×10^6	C^+	30
150	7 905.747	12 645.548	$6s6p\ ^3P^\circ_2$	$6s7s\ ^3S_1$	2.7×10^7	C^+	30
160	7 911.329	12 636.625	$6s^2\ ^1S_0$	$6s6p\ ^3P^\circ_1$			
1	7 982.440	12 524.054	$5d6p\ ^3D^\circ_3$	$5d6d\ ^3F_3$			
2	8 120.517	12 311.102	$5d6p\ ^3P^\circ_2$	$5d6d\ ^3P_2$			
70	8 210.239	12 176.565	$6s6p\ ^1P^\circ_1$	$6s6d\ ^1D_2$			
2	8 514.260	11 741.776	$5d6p\ ^3D^\circ_1$	$5d6d\ ^3D_1$			
700	8 559.998	11 679.037	$6s5d\ ^1D_2$	$5d6p\ ^1D^\circ_2$	2.0×10^7	C^+	28, 29
5	8 567.435	11 668.899	$5d6p\ ^3D^\circ_2$	$5d6d\ ^3D_2$			
4	8 581.908	11 649.220	$5d6p\ ^3D^\circ_3$	$5d6d\ ^3D_3$			
13	8 654.078	11 552.072	$6s5d\ ^1D_2$	$5d6p\ ^3F^\circ_3$	3.1×10^5	D^+	28, 29
2	8 793.184	11 369.322	$5d6p\ ^3D^\circ_3$	$5d6d\ ^3G_4$			
5	8 799.836	11 360.728	$5d6p\ ^1F^\circ_3$	$5d6d\ ^1G_4$			
43	8 861.014	11 282.292	$6s6p\ ^3P^\circ_1$	$5d^2\ ^3P_2$			
80	8 915.013	11 213.954	$6s6p\ ^3P^\circ_0$	$5d^2\ ^3P_1$			
2	8 937.707	11 185.481	$5d6p\ ^3D^\circ_3$	$5d6d\ ^1F_3$			

TABLE 2. Wavelengths, wave numbers, classifications, and transition probabilities for observed emission lines of neutral barium, Ba I—Continued

Intensity	$\lambda_{\mathrm{air}}/\mathrm{Å}$[a]	σ/cm^{-1}	Lower level	Upper level	$A_{\mathrm{ul}}/\mathrm{s}^{-1}$	Accuracy[b]	Reference(s)[c]
2	9 133.129	10 946.146	$5d6p\,^3P^\circ_2$	$6s9s\,^3S_1$			
12	9 189.391	10 879.128	$5d6p\,^3F^\circ_2$	$5d7s\,^3D_2$			
4	9 215.263	10 848.585	$5d6p\,^3F^\circ_3$	$5d7s\,^1D_2$			
56	9 219.709	10 843.353	$6s6p\,^3P^\circ_1$	$5d^2\,^3P_1$			
3	9 252.910	10 804.446	$5d6p\,^3P^\circ_0$	$5d6d\,^1P_1$			
18	9 307.978	10 740.525	$5d6p\,^3F^\circ_2$	$5d7s\,^3D_1$			
18	9 324.387	10 721.623	$5d6p\,^1D^\circ_2$	$5d7s\,^1D_2$			
9	9 367.277	10 672.533	$5d6p\,^3P^\circ_2$	$5d6d\,^3D_3$			
510	9 370.119	10 669.295	$6s5d\,^1D_2$	$5d6p\,^3F^\circ_2$	7.6×10^6	C	28, 29
3	9 398.465	10 637.117	$5d6p\,^3D^\circ_3$	$6s7d\,^3D_2$			
3	9 403.541	10 631.375	$5d6p\,^3D^\circ_1$	$6p^2\,^3P_1$			
2	9 414.584	10 618.905	$5d6p\,^1F^\circ_3$	$6s8d\,^1D_2$			
7	9 449.937	10 579.179	$5d6p\,^3F^\circ_3$	$5d7s\,^3D_3$			
89	9 455.973	10 572.425	$6s6p\,^3P^\circ_1$	$5d^2\,^3P_0$			
8	9 524.551	10 496.304	$5d6p\,^3P^\circ_1$	$5d6d\,^3D_2$			
36	9 589.303	10 425.427	$6s6p\,^3P^\circ_1$	$5d^2\,^1D_2$			
184	9 608.894	10 404.171	$6s6p\,^3P^\circ_2$	$5d^2\,^3P_2$			
9	9 645.600	10 364.579	$5d6p\,^3D^\circ_3$	$6p^2\,^3P_2$	1.1×10^7	C	31
4	9 704.309	10 301.875	$5d6p\,^3D^\circ_1$	$6p^2\,^3P_0$	1.6×10^7	C	31
11	9 713.719	10 291.895	$5d6p\,^3D^\circ_2$	$6p^2\,^3P_1$			
83	9 830.175	10 169.970	$6s6p\,^1P^\circ_1$	$6s7s\,^1S_0$			
116	10 000.908	9 996.351	$5d6p\,^3F^\circ_3$	$5d7s\,^3D_2$			
760	10 032.139	9 965.232	$6s6p\,^3P^\circ_2$	$5d^2\,^3P_1$			
10	10 129.566	9 869.386	$5d6p\,^1D^\circ_2$	$5d7s\,^3D_2$			
12	10 187.992	9 812.787	$5d6p\,^1F^\circ_3$	$5d6d\,^3D_3$			
169	10 233.079	9 769.552	$5d6p\,^3F^\circ_4$	$5d7s\,^3D_3$			
32	10 273.849	9 730.783	$5d6p\,^1D^\circ_2$	$5d7s\,^3D_1$			
6	10 348.668	9 660.432	$5d6p\,^3P^\circ_2$	$6s7d\,^3D_2$			
4	10 370.281	9 640.298	$5d6p\,^3P^\circ_1$	$6p^2\,^3P_2$	1.3×10^6	C	31
354	10 471.290	9 547.306	$6s6p\,^3P^\circ_2$	$5d^2\,^1D_2$			
5	10 540.086	9 484.989	$5d^2\,^1D_2$	$6s7p\,^1P^\circ_1$	1.8×10^6	D	28, 29
6	10 649.102	9 387.891	$5d6p\,^3P^\circ_2$	$6p^2\,^3P_2$	2.7×10^6	C	31
6	10 693.349	9 349.046	$5d6p\,^1F^\circ_3$	$5d6d\,^1F_3$			
14	10 790.936	9 264.499	$5d6p\,^3D^\circ_2$	$5d7s\,^1D_2$			
12	11 012.472	9 078.127	$5d6p\,^1F^\circ_3$	$5d6d\,^3G_3$			
6	11 075.702	9 026.301	$6s5d\,^3D_1$	$6s6p\,^1P^\circ_1$	3.1×10^3	D$^+$	33
24	11 114.134	8 995.089	$5d6p\,^3D^\circ_2$	$5d7s\,^3D_3$			
4	11 256.967	8 880.955	$5d6p\,^1P^\circ_1$	$6s8d\,^1D_2$			
235	11 303.035	8 844.760	$6s5d\,^3D_2$	$6s6p\,^1P^\circ_1$	1.1×10^5	C	33
19	11 423.170	8 751.741	$5d6p\,^3D^\circ_1$	$5d7s\,^3D_2$			
4	11 583.013	8 630.969	$5d6p\,^3F^\circ_2$	$6s6d\,^3D_1$			
48	11 606.996	8 613.136	$5d6p\,^3D^\circ_1$	$5d7s\,^3D_1$			
111	11 697.128	8 546.767	$5d6p\,^3D^\circ_3$	$5d7s\,^3D_3$			
51	11 884.158	8 412.260	$5d6p\,^3D^\circ_2$	$5d7s\,^3D_2$			
5	11 974.995	8 348.450	$5d6p\,^1P^\circ_1$	$6s9s\,^3S_1$			
7	12 048.660	8 297.407	$6s6p\,^3P^\circ_1$	$5d^2\,^3F_2$			
18	12 083.250	8 273.655	$5d6p\,^3D^\circ_2$	$5d7s\,^3D_1$			
5	12 233.285	8 172.183	$5d6p\,^3F^\circ_2$	$6s6d\,^1D_2$			
5	12 342.254	8 100.032	$6s6p\,^1P^\circ_1$	$6s7s\,^3S_1$	9.0×10^4	D	30
24	12 553.166	7 963.939	$5d6p\,^3D^\circ_3$	$5d7s\,^3D_2$			
5	12 667.033	7 892.349	$5d6p\,^1P^\circ_1$	$5d6d\,^1P_1$			
10	12 752.436	7 839.494	$5d6p\,^3P^\circ_2$	$5d7s\,^1D_2$			
8	12 811.668	7 803.250	$5d6p\,^3F^\circ_3$	$6s6d\,^3D_2$			
54	13 206.285	7 570.082	$5d6p\,^3P^\circ_2$	$5d7s\,^3D_3$			
6	13 324.518	7 502.910	$6s6d\,^1D_2$	$6s5f\,^1F^\circ_3$			
32	13 809.019	7 239.664	$5d6p\,^3P^\circ_1$	$5d7s\,^3D_2$			
19	13 956.732	7 163.043	$5d6p\,^3P^\circ_0$	$5d7s\,^3D_1$			
7	13 957.905	7 162.441	$5d6p\,^1D^\circ_2$	$6s6d\,^1D_2$			
22	14 078.557	7 101.059	$5d6p\,^3P^\circ_1$	$5d7s\,^3D_1$			
4	14 154.96	7 062.730	$5d6p\,^1P^\circ_1$	$6s7d\,^3D_2$			
11	14 158.30	7 061.067	$5d6p\,^3F^\circ_4$	$6s6d\,^3D_3$			

TABLE 2. Wavelengths, wave numbers, classifications, and transition probabilities for observed emission lines of neutral barium, Ba I—Continued

Intensity	λ_{air}/Å[a]	σ/cm^{-1}	Lower level	Upper level	A_{ul}/s^{-1}	Accuracy[b]	Reference(s)[c]
16	14 307.86	6 987.256	$5d6p\ ^3P^\circ_2$	$5d7s\ ^3D_2$			
73	14 323.26	6 979.745	$5d6p\ ^1F^\circ_3$	$5d7s\ ^1D_2$			
3	14 723.08	6 790.199	$5d6p\ ^1P^\circ_1$	$6p^2\ ^3P_2$	8.6×10^5	C	31
3	14 907.88	6 706.029	$6s6d\ ^3D_3$	$6s5f\ ^3F^\circ_4$			
1 300	14 999.85	6 664.911	$6s5d\ ^1D_2$	$6s6p\ ^1P^\circ_1$	2.50×10^5	B	33
9	15 371.93	6 503.587	$5d6p\ ^3D^\circ_1$	$6s6d\ ^3D_1$			
15	16 074.95	6 219.159	$5d6p\ ^3D^\circ_2$	$6s6d\ ^3D_2$			
3	16 218.51	6 164.111	$5d6p\ ^3D^\circ_2$	$6s6d\ ^3D_1$			
12	16 315.39	6 127.509	$5d6p\ ^1F^\circ_3$	$5d7s\ ^3D_2$			
3	16 995.71	5 882.232	$5d^2\ ^3F_2$	$5d6p\ ^1F^\circ_3$			
309	17 064.11	5 858.654	$6s6p\ ^1P^\circ_1$	$5d^2\ ^3P_2$			
15	17 123.66	5 838.280	$5d6p\ ^3D^\circ_3$	$6s6d\ ^3D_3$			
7	17 186.95	5 816.778	$5d6p\ ^1P^\circ_1$	$6s8s\ ^1S_0$	2.7×10^6	D$^+$	31
5	17 961.09	5 566.071	$5d^2\ ^3F_3$	$5d6p\ ^1F^\circ_3$			
75	18 202.77	5 492.169	$5d^2\ ^1D_2$	$5d6p\ ^1P^\circ_1$	1.2×10^6	C$^+$	28, 29
8	19 017.10	5 256.990	$5d6p\ ^3D^\circ_3$	$6s6d\ ^1D_2$			
51	19 072.24	5 241.790	$5d6p\ ^1P^\circ_1$	$5d7s\ ^1D_2$			
11	19 253.32	5 192.491	$5d^2\ ^3F_4$	$5d6p\ ^1F^\circ_3$			
4	19 416.74	5 148.790	$6s6p\ ^1P^\circ_1$	$5d^2\ ^3P_0$			
5	19 810.05	5 046.564	$5d6p\ ^3P^\circ_1$	$6s6d\ ^3D_2$			
730	19 987.39	5 001.790	$6s6p\ ^1P^\circ_1$	$5d^2\ ^1D_2$			
5	20 132.23	4 965.804	$6s7p\ ^3P^\circ_0$	$6s7d\ ^3D_1$			
10	20 210.09	4 946.673	$6s7p\ ^3P^\circ_1$	$6s7d\ ^1D_2$			
3	20 428.54	4 893.777	$6s7p\ ^3P^\circ_1$	$6s7d\ ^3D_1$			
8	20 563.76	4 861.598	$5d6p\ ^3P^\circ_2$	$6s6d\ ^3D_3$			
198	20 711.38	4 826.947	$6s7s\ ^3S_1$	$6s7p\ ^3P^\circ_2$			
22	20 836.18	4 798.035	$6s7p\ ^3P^\circ_2$	$6s7d\ ^3D_3$			
4	20 936.90	4 774.953	$6s7p\ ^3P^\circ_2$	$6s7d\ ^1D_2$			
4	21 242.24	4 706.317	$5d^2\ ^3F_3$	$5d6p\ ^3P^\circ_2$			
87	21 475.41	4 655.219	$6s7s\ ^3S_1$	$6s7p\ ^3P^\circ_1$			
12	21 567.67	4 635.305	$5d^2\ ^3P_2$	$5d6p\ ^1P^\circ_1$	2.6×10^5	D	28, 29
22	21 812.87	4 583.198	$6s7s\ ^3S_1$	$6s7p\ ^3P^\circ_0$			
28	22 218.39	4 499.548	$6s6d\ ^1D_2$	$6s4f\ ^1F^\circ_3$			
560	22 311.47	4 480.778	$6s5d\ ^3D_1$	$6s6p\ ^3P^\circ_2$			
28	23 158.98	4 316.802	$6s7s\ ^1S_0$	$6s7p\ ^1P^\circ_1$			
9 900	23 253.56	4 299.244	$6s5d\ ^3D_2$	$6s6p\ ^3P^\circ_2$			
3	24 707.77	4 046.205	$5d7s\ ^3D_2$	$5d7p\ ^3P^\circ_1$			
4	24 908.60	4 013.583	$5d7s\ ^3D_3$	$5d7p\ ^3D^\circ_3$			
4	25 008.53	3 997.544	$5d7s\ ^3D_3$	$6s5f\ ^3F^\circ_4$			
3	25 349.81	3 943.726	$5d7s\ ^1D_2$	$6s5f\ ^1F^\circ_3$			
10 000	25 514.88	3 918.212	$6s5d\ ^3D_3$	$6s6p\ ^3P^\circ_2$			
10	25 587.16	3 907.145	$6s6d\ ^3D_1$	$6s4f\ ^3F^\circ_2$			
13	25 859.67	3 865.970	$6s6d\ ^3D_2$	$6s4f\ ^3F^\circ_3$			
18	26 221.23	3 812.663	$6s6d\ ^3D_3$	$6s4f\ ^3F^\circ_4$			
213	29 222.21	3 421.122	$6s5d\ ^3D_2$	$6s6p\ ^3P^\circ_1$			
21	29 788.70	3 356.062	$5d^2\ ^3F_4$	$5d6p\ ^3D^\circ_3$			
11	30 467.24	3 281.319	$5d^2\ ^3F_3$	$5d6p\ ^3D^\circ_2$			
8	30 685.32	3 257.998	$5d^2\ ^3F_2$	$5d6p\ ^3D^\circ_1$	6.5×10^5	D$^-$	28, 29
402	30 931.59	3 232.059	$6s5d\ ^3D_1$	$6s6p\ ^3P^\circ_0$			

[a] Wavelengths and classifications are from Karlsson and Litzén.[2] The uncertainty in the observed wave numbers ranges from 0.001 cm^{-1} for strong, unblended lines to 0.010 cm^{-1} for weak or incompletely resolved lines.

[b] Accuracy code from Klose *et al.*[3] A—Uncertainty is 3%, B—uncertainty is 10%, C—uncertainty is 25%, D—uncertainty is 50%.

[c] Reference for transition probability.

TABLE 3. Energy levels of singly ionized Ba

Configuration	Term	J	Level/cm^{-1}	Reference	Obs *g*[a]
6*s*	^{2}S	1/2	0.000	2	
5*d*	^{2}D	3/2	4 873.852	2	0.79
	^{2}D	5/2	5 674.807	2	1.12
6*p*	^{2}P$^\circ$	1/2	20 261.561	2	
	^{2}P$^\circ$	3/2	21 952.404	2	1.32
7*s*	^{2}S	1/2	42 355.175	2	1.98
6*d*	^{2}D	3/2	45 949.472	2	0.79
	^{2}D	5/2	46 154.847	2	1.18
4*f*	^{2}F$^\circ$	5/2	48 258.617	2	
	^{2}F$^\circ$	7/2	48 483.332	2	
7*p*	^{2}P$^\circ$	1/2	49 389.822	2	
	^{2}P$^\circ$	3/2	50 011.340	2	
5*f*	^{2}F$^\circ$	5/2	57 390.922	2	
	^{2}F$^\circ$	7/2	57 631.739	2	
8*s*	^{2}S	1/2	58 025.211	2	
7*d*	^{2}D	3/2	59 800.254	2	
	^{2}D	5/2	59 894.928	2	
8*p*	^{2}P$^\circ$	1/2	61 339.5	34	
	^{2}P$^\circ$	3/2	61 642.0	34	
5*g*	^{2}G	7/2	63 026.725[b]	2	
	^{2}G	9/2	63 026.725[b]	2	
6*f*	^{2}F$^\circ$	5/2	64 596.33	36	
	^{2}F$^\circ$	7/2	64 697.08	36	
9*s*	^{2}S	1/2	65 683.646	2	
8*d*	^{2}D	3/2	66 673.651	2	
	^{2}D	5/2	66 725.591	2	
9*p*	^{2}P$^\circ$	1/2	67 511.2	34	
	^{2}P$^\circ$	3/2	67 681.4	34	
6*g*	^{2}G	7/2	68 426.095[b]	2	
	^{2}G	9/2	68 426.095[b]	2	
7*f*	^{2}F$^\circ$	5/2	69 211.75	36	
	^{2}F$^\circ$	7/2	69 260.46	36	
10*s*	^{2}S	1/2	70 014.584	2	
9*d*	^{2}D	3/2	70 620.247	2	
	^{2}D	5/2	70 651.905	2	
10*p*	^{2}P$^\circ$	1/2	71 129.8	34	
	^{2}P$^\circ$	3/2	71 235.2	34	
7*g*	^{2}G	7/2	71 682.623	2	
	^{2}G	9/2	71 682.623[b]	2	
8*f*	^{2}F$^\circ$	5/2	72 142.77	36	
	^{2}F$^\circ$	7/2	72 170.19	36	
11*s*	^{2}S	1/2	72 705.28	36	
10*d*	^{2}D	3/2	73 101.58	36	
	^{2}D	5/2	73 122.35	36	
11*p*	^{2}P$^\circ$	1/2	73 436.0	34	
	^{2}P$^\circ$	3/2	73 506.7	34	

TABLE 3. Energy levels of singly ionized Ba—Continued

Configuration	Term	J	Level/cm^{-1}	Reference	Obs g[a]
8g	^{2}G	7/2	73 795.87[b]	36	
	^{2}G	9/2	73 795.87[b]	36	
9f	^{2}F°	5/2	74 091.05	36	
	^{2}F°	7/2	74 108.92	36	
12s	^{2}S	1/2	74 491.63	36	
11d	^{2}D	3/2	74 765.50	36	
	^{2}D	5/2	74 779.78	36	
12p	^{2}P°	1/2	74 997.4	34	
	^{2}P°	3/2	75 046.9	34	
9g	^{2}G	7/2	75 244.13[b]	36	
	^{2}G	9/2	75 244.13[b]	36	
10f	^{2}F°	5/2	75 447.5	34	
	^{2}F°	7/2	75 459.0	34	
12d	^{2}D	5/2	75 945.97	36	
10g	^{2}G	7/2	76 279.68[b]	36	
	^{2}G	9/2	76 279.68[b]	36	
11f	^{2}F°	5/2	76 425.6	34	
	^{2}F°	7/2	76 433.7	34	
12f	^{2}F°	5/2	77 154.3	34	
	^{2}F°	7/2	77 160.6	34	
13f	^{2}F°	5/2	77 710	34	
	^{2}F°	7/2	77 715	34	
14f	^{2}F°	5/2	78 163[b]	34	
	^{2}F°	7/2	78 163[b]	34	
20s	^{2}S	1/2	79 059.04	35	
21s	^{2}S	1/2	79 240.50	35	
22s	^{2}S	1/2	79 393.13	35	
23s	^{2}S	1/2	79 522.98	35	
24s	^{2}S	1/2	79 634.08	35	
25s	^{2}S	1/2	79 730.02	35	
26s	^{2}S	1/2	79 813.37	35	
27s	^{2}S	1/2	79 886.33	35	
28s	^{2}S	1/2	79 950.51	35	
29s	^{2}S	1/2	80 007.22	35	
30s	^{2}S	1/2	80 057.61	35	
31s	^{2}S	1/2	80 102.69	35	
32s	^{2}S	1/2	80 142.89	35	
33s	^{2}S	1/2	80 179.29	35	
34s	^{2}S	1/2	80 212.13	35	
35s	^{2}S	1/2	80 241.77	35	
36s	^{2}S	1/2	80 268.78	35	
37s	^{2}S	1/2	80 293.35	35	
38s	^{2}S	1/2	80 315.93	35	

TABLE 3. Energy levels of singly ionized Ba—Continued

Configuration	Term	J	Level/cm^{-1}	Reference	Obs g[a]
39*s*	^{2}S	1/2	80 336.50	35	
40*s*	^{2}S	1/2	80 355.35	35	
41*s*	^{2}S	1/2	80 372.80	35	
42*s*	^{2}S	1/2	80 388.86	35	
43*s*	^{2}S	1/2	80 403.73	35	
44*s*	^{2}S	1/2	80 417.53	35	
45*s*	^{2}S	1/2	80 430.41	35	
46*s*	^{2}S	1/2	80 442.31	35	
47*s*	^{2}S	1/2	80 453.47	35	
48*s*	^{2}S	1/2	80 463.86	35	
49*s*	^{2}S	1/2	80 473.48	35	
50*s*	^{2}S	1/2	80 482.60	35	
19*d*	^{2}D	3/2	79 096.95	35	
	^{2}D	5/2	79 098.85	35	
20*d*	^{2}D	3/2	79 272.22	35	
	^{2}D	5/2	79 273.91	35	
21*d*	^{2}D	3/2	79 420.04	35	
	^{2}D	5/2	79 421.43	35	
22*d*	^{2}D	3/2	79 545.81	35	
	^{2}D	5/2	79 546.54	35	
23*d*	^{2}D	3/2	79 653.97	35	
	^{2}D	5/2	79 654.96	35	
24*d*	^{2}D	3/2	79 747.22	35	
	^{2}D	5/2	79 748.14	35	
25*d*	^{2}D	3/2	79 828.32	35	
	^{2}D	5/2	79 829.11	35	
26*d*	^{2}D	3/2	79 899.47	35	
	^{2}D	5/2	79 900.23	35	
27*d*	^{2}D	3/2	79 962.10	35	
	^{2}D	5/2	79 962.71	35	
28*d*	^{2}D	3/2	80 017.50	35	
	^{2}D	5/2	80 018.02	35	
29*d*	^{2}D	3/2	80 066.83	35	
	^{2}D	5/2	80 067.24	35	
30*d*	^{2}D	3/2	80 111.09[b]	35	
	^{2}D	5/2	80 111.09[b]	35	
31*d*	^{2}D	3/2	80 150.56[b]	35	
	^{2}D	5/2	80 150.56[b]	35	
32*d*	^{2}D	3/2	80 186.13[b]	35	
	^{2}D	5/2	80 186.13[b]	35	
33*d*	^{2}D	3/2	80 218.25[b]	35	
	^{2}D	5/2	80 218.25[b]	35	
34*d*	^{2}D	3/2	80 247.37[b]	35	
	^{2}D	5/2	80 247.37[b]	35	
35*d*	^{2}D	3/2	80 273.88[b]	35	

TABLE 3. Energy levels of singly ionized Ba—Continued

Configuration	Term	J	Level/cm^{-1}	Reference	Obs g[a]
	^{2}D	5/2	80 273.88[b]	35	
36*d*	^{2}D	3/2	80 298.01[b]	35	
	^{2}D	5/2	80 298.01[b]	35	
37*d*	^{2}D	3/2	80 320.15[b]	35	
	^{2}D	5/2	80 320.15[b]	35	
38*d*	^{2}D	3/2	80 340.44[b]	35	
	^{2}D	5/2	80 340.44[b]	35	
39*d*	^{2}D	3/2	80 358.91[b]	35	
	^{2}D	5/2	80 358.91[b]	35	
40*d*	^{2}D	3/2	80 376.10[b]	35	
	^{2}D	5/2	80 376.10[b]	35	
41*d*	^{2}D	3/2	80 391.94[b]	35	
	^{2}D	5/2	80 391.94[b]	35	
42*d*	^{2}D	3/2	80 406.64[b]	35	
	^{2}D	5/2	80 406.64[b]	35	
43*d*	^{2}D	3/2	80 420.16[b]	35	
	^{2}D	5/2	80 420.16[b]	35	
44*d*	^{2}D	3/2	80 432.86[b]	35	
	^{2}D	5/2	80 432.86[b]	35	
45*d*	^{2}D	3/2	80 444.57[b]	35	
	^{2}D	5/2	80 444.57[b]	35	
46*d*	^{2}D	3/2	80 455.67[b]	35	
	^{2}D	5/2	80 455.67[b]	35	
47*d*	^{2}D	3/2	80 465.79[b]	35	
	^{2}D	5/2	80 465.79[b]	35	
48*d*	^{2}D	3/2	80 475.41[b]	35	
	^{2}D	5/2	80 475.41[b]	35	

[a] Values derived by Moore[1] from published and unpublished data.
[b] Part of an unresolved multiplet.

TABLE 4. Wavelengths, wave numbers, classifications, and transition probabilities for observed emission lines of singly ionized barium, Ba II

Intensity	λ/Å[a]	σ/cm^{-1}	Uncertainty/cm^{-1}	Lower level	Upper level	Reference[b]	A_{ul}/s^{-1}	Accuracy[c]	Reference(s)[d]
	1 433.15	69 776	2	$5d\ ^2\mathrm{D}_{5/2}$	$10f\ ^2\mathrm{F}^\circ_{5/2}$	37			
	1 444.85	69 211	2	$5d\ ^2\mathrm{D}_{3/2}$	$9f\ ^2\mathrm{F}^\circ_{5/2}$	37			
	1 504.01	66 489	2	$5d\ ^2\mathrm{D}_{5/2}$	$8f\ ^2\mathrm{F}^\circ_{7/2}$	37			
	1 554.38	64 335	2	$5d\ ^2\mathrm{D}_{3/2}$	$7f\ ^2\mathrm{F}^\circ_{5/2}$	37			
	1 572.73	63 584	2	$5d\ ^2\mathrm{D}_{5/2}$	$7f\ ^2\mathrm{F}^\circ_{7/2}$	37			
	1 573.92	63 536	2	$5d\ ^2\mathrm{D}_{5/2}$	$7f\ ^2\mathrm{F}^\circ_{5/2}$	37			
	1 630.40	61 334	2	$6s\ ^2\mathrm{S}_{1/2}$	$8p\ ^2\mathrm{P}^\circ_{1/2}$	37	2.4×10^{6}	C	3, 42
	1 674.51	59 719	2	$5d\ ^2\mathrm{D}_{3/2}$	$6f\ ^2\mathrm{F}^\circ_{5/2}$	37			
	1 694.37	59 019	2	$5d\ ^2\mathrm{D}_{5/2}$	$6f\ ^2\mathrm{F}^\circ_{7/2}$	37			
	1 697.16	58 922	2	$5d\ ^2\mathrm{D}_{5/2}$	$6f\ ^2\mathrm{F}^\circ_{5/2}$	37			
	1 771.03	56 464	2	$5d\ ^2\mathrm{D}_{3/2}$	$8p\ ^2\mathrm{P}^\circ_{1/2}$	37	1.0×10^{7}	D	3, 42
	1 892.65	52 836	2	$6p\ ^2\mathrm{P}^\circ_{1/2}$	$10d\ ^2\mathrm{D}_{3/2}$	37	1.3×10^{7}	D	3, 42
10	1 924.6712	51 956.927	0.010	$5d\ ^2\mathrm{D}_{5/2}$	$5f\ ^2\mathrm{F}^\circ_{7/2}$	2			
	1 954.21	51 172	2	$6p\ ^2\mathrm{P}^\circ_{3/2}$	$10d\ ^2\mathrm{D}_{5/2}$	37	1.4×10^{7}	D	3, 42
	1 970.19	50 757	2	$6p\ ^2\mathrm{P}^\circ_{3/2}$	$11s\ ^2\mathrm{S}_{1/2}$	37			
6	1 985.7548	50 358.686	0.010	$6p\ ^2\mathrm{P}^\circ_{1/2}$	$9d\ ^2\mathrm{D}_{3/2}$	2	2.0×10^{7}	D	3, 42
	1 999.52	50 012	2	$6s\ ^2\mathrm{S}_{1/2}$	$7p\ ^2\mathrm{P}^\circ_{3/2}$	37			
	2 009.20	49 755	2	$6p\ ^2\mathrm{P}^\circ_{1/2}$	$10s\ ^2\mathrm{S}_{1/2}$	37	6.5×10^{6}	C$^+$	3, 42
5	2 024.0561	49 389.828	0.010	$6s\ ^2\mathrm{S}_{1/2}$	$7p\ ^2\mathrm{P}^\circ_{1/2}$	2	6.9×10^{6}	C	3, 42
12	2 052.7516	48 699.501	0.010	$6p\ ^2\mathrm{P}^\circ_{3/2}$	$9d\ ^2\mathrm{D}_{5/2}$	2	2.2×10^{7}	D	3, 42
	2 053.91	48 672	2	$6p\ ^2\mathrm{P}^\circ_{3/2}$	$9d\ ^2\mathrm{D}_{3/2}$	37	3.7×10^{6}	D	3, 42
9	2 079.9753	48 062.181	0.010	$6p\ ^2\mathrm{P}^\circ_{3/2}$	$10s\ ^2\mathrm{S}_{1/2}$	2	1.2×10^{7}	C$^+$	3, 42
74	2 153.9336	46 412.091	0.010	$6p\ ^2\mathrm{P}^\circ_{1/2}$	$8d\ ^2\mathrm{D}_{3/2}$	2	3.4×10^{7}	C	3, 42
30	2 200.8853	45 422.082	0.010	$6p\ ^2\mathrm{P}^\circ_{1/2}$	$9s\ ^2\mathrm{S}_{1/2}$	2	1.1×10^{7}	C$^+$	3, 42
45	2 214.7634	45 137.488	0.010	$5d\ ^2\mathrm{D}_{3/2}$	$7p\ ^2\mathrm{P}^\circ_{3/2}$	2	1.6×10^{6}	D	3, 42
170	2 232.7858	44 773.189	0.010	$6p\ ^2\mathrm{P}^\circ_{3/2}$	$8d\ ^2\mathrm{D}_{5/2}$	2	3.7×10^{7}	C	3, 42
17	2 235.3795	44 721.243	0.010	$6p\ ^2\mathrm{P}^\circ_{3/2}$	$8d\ ^2\mathrm{D}_{3/2}$	2	6.1×10^{6}	C	3, 42
173	2 245.6883	44 515.970	0.010	$5d\ ^2\mathrm{D}_{3/2}$	$7p\ ^2\mathrm{P}^\circ_{1/2}$	2	1.6×10^{7}	D	3, 42
415	2 254.7779	44 336.532	0.010	$5d\ ^2\mathrm{D}_{5/2}$	$7p\ ^2\mathrm{P}^\circ_{3/2}$	2	1.4×10^{7}	D	3, 42
68	2 285.9894	43 731.243	0.010	$6p\ ^2\mathrm{P}^\circ_{3/2}$	$9s\ ^2\mathrm{S}_{1/2}$	2	2.0×10^{7}	C$^+$	3, 42
3 370	2 304.2473	43 384.765	0.010	$5d\ ^2\mathrm{D}_{3/2}$	$4f\ ^2\mathrm{F}^\circ_{5/2}$	2			
4 310	2 335.2672	42 808.525	0.010	$5d\ ^2\mathrm{D}_{5/2}$	$4f\ ^2\mathrm{F}^\circ_{7/2}$	2			
510	2 347.5915	42 583.810	0.010	$5d\ ^2\mathrm{D}_{5/2}$	$4f\ ^2\mathrm{F}^\circ_{5/2}$	2			
249	2 528.4078	39 538.693	0.010	$6p\ ^2\mathrm{P}^\circ_{1/2}$	$7d\ ^2\mathrm{D}_{3/2}$	2	6.9×10^{7}	C	3, 42
381	2 634.7799	37 942.525	0.010	$6p\ ^2\mathrm{P}^\circ_{3/2}$	$7d\ ^2\mathrm{D}_{5/2}$	2	7.3×10^{7}	C	3, 42
41	2 641.3710	37 847.851	0.010	$6p\ ^2\mathrm{P}^\circ_{3/2}$	$7d\ ^2\mathrm{D}_{3/2}$	2	1.2×10^{7}	C	3, 42
64	2 647.2608	37 763.649	0.010	$6p\ ^2\mathrm{P}^\circ_{1/2}$	$8s\ ^2\mathrm{S}_{1/2}$	2	2.26×10^{7}	B	3, 42
77	2 771.3528	36 072.810	0.010	$6p\ ^2\mathrm{P}^\circ_{3/2}$	$8s\ ^2\mathrm{S}_{1/2}$	2	3.95×10^{7}	B	3, 42
	3 552.45	28 141.6	0.5	$6d\ ^2\mathrm{D}_{3/2}$	$9f\ ^2\mathrm{F}^\circ_{5/2}$	36	3.9×10^{5}	C	3, 42
	3 567.73	28 021.1	0.5	$4f\ ^2\mathrm{F}^\circ_{5/2}$	$10g\ ^2\mathrm{G}_{7/2}$	36			
	3 576.28	27 954.1	0.5	$6d\ ^2\mathrm{D}_{5/2}$	$9f\ ^2\mathrm{F}^\circ_{7/2}$	36	4.1×10^{5}	C	3, 42
	3 596.57	27 796.4	0.5	$4f\ ^2\mathrm{F}^\circ_{7/2}$	$10g\ ^2\mathrm{G}_{7/2,9/2}$	36			
	3 735.75	26 760.8	0.5	$4f\ ^2\mathrm{F}^\circ_{7/2}$	$9g\ ^2\mathrm{G}_{7/2,9/2}$	36			
	3 816.69	26 193.3	0.5	$6d\ ^2\mathrm{D}_{3/2}$	$8f\ ^2\mathrm{F}^\circ_{5/2}$	36			
	3 842.80	26 015.3	0.5	$6d\ ^2\mathrm{D}_{5/2}$	$8f\ ^2\mathrm{F}^\circ_{7/2}$	36			
	3 854.76	25 934.6	0.5	$7p\ ^2\mathrm{P}^\circ_{3/2}$	$12d\ ^2\mathrm{D}_{5/2}$	36			
500	3 891.7790	25 687.911	0.010	$6p\ ^2\mathrm{P}^\circ_{1/2}$	$6d\ ^2\mathrm{D}_{3/2}$	2	2.17×10^{8}	B	3, 42
	3 914.73	25 537.3	0.5	$4f\ ^2\mathrm{F}^\circ_{5/2}$	$8g\ ^2\mathrm{G}_{7/2}$	36			
	3 939.67	25 375.7	0.5	$7p\ ^2\mathrm{P}^\circ_{1/2}$	$11d\ ^2\mathrm{D}_{3/2}$	36			
	3 949.51	25 312.5	0.5	$4f\ ^2\mathrm{F}^\circ_{7/2}$	$8g\ ^2\mathrm{G}_{7/2,9/2}$	36			
	4 036.26	24 768.4	0.5	$7p\ ^2\mathrm{P}^\circ_{3/2}$	$11d\ ^2\mathrm{D}_{5/2}$	36			
	4 083.77	24 480.3	0.5	$7p\ ^2\mathrm{P}^\circ_{3/2}$	$12s\ ^2\mathrm{S}_{1/2}$	36			
910	4 130.6491	24 202.443	0.010	$6p\ ^2\mathrm{P}^\circ_{3/2}$	$6d\ ^2\mathrm{D}_{5/2}$	2	2.18×10^{8}	B	3, 42
103	4 166.0014	23 997.068	0.010	$6p\ ^2\mathrm{P}^\circ_{3/2}$	$6d\ ^2\mathrm{D}_{3/2}$	2	3.54×10^{7}	B	3, 42
	4 216.04	23 712.3	0.5	$7p\ ^2\mathrm{P}^\circ_{1/2}$	$10d\ ^2\mathrm{D}_{3/2}$	36	5.09×10^{6}	B	3, 42
8	4 267.9199	23 424.025	0.010	$4f\ ^2\mathrm{F}^\circ_{5/2}$	$7g\ ^2\mathrm{G}_{7/2}$	2	3.1×10^{7}	D	3, 42
	4 287.80	23 315.4	0.5	$7p\ ^2\mathrm{P}^\circ_{1/2}$	$11s\ ^2\mathrm{S}_{1/2}$	36			
	4 297.60	23 262.3	0.5	$6d\ ^2\mathrm{D}_{3/2}$	$7f\ ^2\mathrm{F}^\circ_{5/2}$	36			
4	4 309.2662	23 199.282	0.010	$4f\ ^2\mathrm{F}^\circ_{7/2}$	$7g\ ^2\mathrm{G}_{7/2,9/2}$	2	3.1×10^{7}	D	3, 42
	4 325.73	23 111.0	0.5	$7p\ ^2\mathrm{P}^\circ_{3/2}$	$10d\ ^2\mathrm{D}_{5/2}$	36	5.65×10^{6}	B	3, 42
	4 326.74	23 105.6	0.5	$6d\ ^2\mathrm{D}_{5/2}$	$7f\ ^2\mathrm{F}^\circ_{7/2}$	36			

TABLE 4. Wavelengths, wave numbers, classifications, and transition probabilities for observed emission lines of singly ionized barium, Ba II—Continued

Intensity	λ/Å[a]	σ/cm^{-1}	Uncertainty/cm^{-1}	Lower level	Upper level	Reference[b]	A_{ul}/s^{-1}	Accuracy[c]	Reference(s)[d]
	4 329.62	23 090.2	0.5	$7p\ ^2\mathrm{P}^\circ_{3/2}$	$10d\ ^2\mathrm{D}_{3/2}$	36	9.39×10^{5}	B	3, 42
	4 405.23	22 693.9	0.5	$7p\ ^2\mathrm{P}^\circ_{3/2}$	$11s\ ^2\mathrm{S}_{1/2}$	36			
	4 509.63	22 168.6	0.5	$4f\ ^2\mathrm{F}^\circ_{7/2}$	$9d\ ^2\mathrm{D}_{5/2}$	36			
188	4 524.926	22 093.615	0.010	$6p\ ^2\mathrm{P}^\circ_{1/2}$	$7s\ ^2\mathrm{S}_{1/2}$	2	6.63×10^{7}	B	3, 42
9 300	4 554.033	21 952.404	0.010	$6s\ ^2\mathrm{S}_{1/2}$	$6p\ ^2\mathrm{P}^\circ_{3/2}$	2	1.11×10^{8}	B	41
	4 708.94	21 230.3	0.5	$7p\ ^2\mathrm{P}^\circ_{1/2}$	$9d\ ^2\mathrm{D}_{3/2}$	36	8.47×10^{6}	B	3, 42
	4 843.46	20 640.7	0.5	$7p\ ^2\mathrm{P}^\circ_{3/2}$	$9d\ ^2\mathrm{D}_{5/2}$	36	9.34×10^{6}	B	3, 42
	4 847.14	20 625.0	0.5	$7p\ ^2\mathrm{P}^\circ_{1/2}$	$10s\ ^2\mathrm{S}_{1/2}$	36	3.5×10^{6}	C^{+}	3, 42
	4 850.84	20 609.3	0.5	$7p\ ^2\mathrm{P}^\circ_{3/2}$	$9d\ ^2\mathrm{D}_{3/2}$	36	1.55×10^{6}	B	3, 42
273	4 899.927	20 402.772	0.010	$6p\ ^2\mathrm{P}^\circ_{3/2}$	$7s\ ^2\mathrm{S}_{1/2}$	2	1.04×10^{8}	B	3, 42
6 900	4 934.077	20 261.560	0.010	$6s\ ^2\mathrm{S}_{1/2}$	$6p\ ^2\mathrm{P}^\circ_{1/2}$	2	9.53×10^{7}	B	41
10	4 957.092	20 167.491	0.010	$4f\ ^2\mathrm{F}^\circ_{5/2}$	$6g\ ^2\mathrm{G}_{7/2}$	2	5.1×10^{7}	C	3, 42
	4 997.81	20 003.2	0.5	$7p\ ^2\mathrm{P}^\circ_{3/2}$	$10s\ ^2\mathrm{S}_{1/2}$	36	6.4×10^{6}	C^{+}	3, 42
5	5 012.954	19 942.754	0.010	$4f\ ^2\mathrm{F}^\circ_{7/2}$	$6g\ ^2\mathrm{G}_{7/2,9/2}$	2	5.2×10^{7}	C	3, 42
	5 361.35	18 646.9	0.5	$6d\ ^2\mathrm{D}_{3/2}$	$6f\ ^2\mathrm{F}^\circ_{5/2}$	36	4.0×10^{6}	C^{+}	3, 42
	5 391.60	18 542.2	0.5	$6d\ ^2\mathrm{D}_{5/2}$	$6f\ ^2\mathrm{F}^\circ_{7/2}$	36	4.2×10^{6}	C^{+}	3, 42
	5 421.05	18 441.5	0.5	$6d\ ^2\mathrm{D}_{5/2}$	$6f\ ^2\mathrm{F}^\circ_{5/2}$	36	2.8×10^{5}	C^{+}	3, 42
	5 428.79	18 415.2	0.5	$4f\ ^2\mathrm{F}^\circ_{5/2}$	$8d\ ^2\mathrm{D}_{3/2}$	36	1.9×10^{5}	C	3, 42
	5 480.30	18 242.1	0.5	$4f\ ^2\mathrm{F}^\circ_{7/2}$	$8d\ ^2\mathrm{D}_{5/2}$	36	1.8×10^{5}	C	3, 42
	5 784.18	17 283.8	0.5	$7p\ ^2\mathrm{P}^\circ_{1/2}$	$8d\ ^2\mathrm{D}_{3/2}$	36	1.59×10^{7}	B	3, 42
331	5 853.675	17 078.552	0.010	$5d\ ^2\mathrm{D}_{3/2}$	$6p\ ^2\mathrm{P}^\circ_{3/2}$	2	6.00×10^{6}	B	41
	5 981.25	16 714.3	0.5	$7p\ ^2\mathrm{P}^\circ_{3/2}$	$8d\ ^2\mathrm{D}_{5/2}$	36	1.73×10^{7}	B	3, 42
	5 999.85	16 662.5	0.5	$7p\ ^2\mathrm{P}^\circ_{3/2}$	$8d\ ^2\mathrm{D}_{3/2}$	36	2.86×10^{6}	B	3, 42
	6 135.83	16 293.2	0.5	$7p\ ^2\mathrm{P}^\circ_{1/2}$	$9s\ ^2\mathrm{S}_{1/2}$	36	6.64×10^{6}	B	3, 42
1 510	6 141.713	16 277.597	0.010	$5d\ ^2\mathrm{D}_{5/2}$	$6p\ ^2\mathrm{P}^\circ_{3/2}$	2	4.12×10^{7}	B	41
	6 378.9	15 672.3	0.5	$7p\ ^2\mathrm{P}^\circ_{3/2}$	$9s\ ^2\mathrm{S}_{1/2}$	36	1.18×10^{7}	B	3, 42
900	6 496.898	15 387.708	0.010	$5d\ ^2\mathrm{D}_{3/2}$	$6p\ ^2\mathrm{P}^\circ_{1/2}$	2	3.10×10^{7}	B	41
6	6 769.477	14 768.113	0.010	$4f\ ^2\mathrm{F}^\circ_{5/2}$	$5g\ ^2\mathrm{G}_{7/2}$	2	9.4×10^{7}	C	3, 42
7	6 874.079	14 543.390	0.010	$4f\ ^2\mathrm{F}^\circ_{7/2}$	$5g\ ^2\mathrm{G}_{7/2,9/2}$	2	9.3×10^{7}	C	3, 42
24	8 710.768	11 476.892	0.010	$6d\ ^2\mathrm{D}_{5/2}$	$5f\ ^2\mathrm{F}^\circ_{7/2}$	2	7.88×10^{7}	B	3, 42
18	8 737.751	11 441.450	0.010	$6d\ ^2\mathrm{D}_{3/2}$	$5f\ ^2\mathrm{F}^\circ_{5/2}$	2	7.29×10^{7}	B	3, 42
2	8 897.463	11 236.074	0.010	$6d\ ^2\mathrm{D}_{5/2}$	$5f\ ^2\mathrm{F}^\circ_{5/2}$	2	4.93×10^{6}	B	3, 42
9	9 603.111	10 410.437	0.010	$7p\ ^2\mathrm{P}^\circ_{1/2}$	$7d\ ^2\mathrm{D}_{3/2}$	2	4.16×10^{7}	B	3, 42
14	10 115.009	9 883.589	0.010	$7p\ ^2\mathrm{P}^\circ_{3/2}$	$7d\ ^2\mathrm{D}_{5/2}$	2	4.27×10^{7}	B	3, 42
2	10 212.839	9 788.914	0.010	$7p\ ^2\mathrm{P}^\circ_{3/2}$	$7d\ ^2\mathrm{D}_{3/2}$	2	6.92×10^{6}	B	3, 42
3	11 577.083	8 635.390	0.010	$7p\ ^2\mathrm{P}^\circ_{1/2}$	$8s\ ^2\mathrm{S}_{1/2}$	2	1.75×10^{7}	B	3, 42
5	12 474.957	8 013.867	0.010	$7p\ ^2\mathrm{P}^\circ_{3/2}$	$8s\ ^2\mathrm{S}_{1/2}$	2	2.80×10^{7}	B	3, 42
29	13 057.798	7 656.165	0.010	$7s\ ^2\mathrm{S}_{1/2}$	$7p\ ^2\mathrm{P}^\circ_{3/2}$	2	2.14×10^{7}	B	3, 42
13	14 211.47	7 034.649	0.010	$7s\ ^2\mathrm{S}_{1/2}$	$7p\ ^2\mathrm{P}^\circ_{1/2}$	2	1.66×10^{7}	B	3, 42
2	18 530.69	5 394.979	0.010	$5f\ ^2\mathrm{F}^\circ_{7/2}$	$5g\ ^2\mathrm{G}_{7/2,9/2}$	2	1.96×10^{7}	B	3, 42
2	25 923.24	3 856.490	0.010	$6d\ ^2\mathrm{D}_{5/2}$	$7p\ ^2\mathrm{P}^\circ_{3/2}$	2	3.66×10^{6}	B	3, 42
	29 059	3 440.3	2	$6d\ ^2\mathrm{D}_{3/2}$	$7p\ ^2\mathrm{P}^\circ_{1/2}$	11	2.89×10^{6}	B	3, 42

[a] λ_{air} above 2000; λ_{vac} below 2000.

[b] Reference for wavelength and classification.

[c] Accuracy code from Klose *et al.*[3] A—uncertainty is 3%; B—uncertainty is 10%; C—uncertainty is 25%; D—uncertainty is 50%.

[d] Reference for transition probability.

TABLE 5. Ionization energies

Ion	Limit	Energy[a]/cm^{-1}	Energy/eV[b]	Reference(s)
Ba	$6s\ ^2S_{1/2}$	42 034.910(10)	5.211 664 1(12)	2, 20
Ba$^+$	$5s^2 5p^6\ ^1S_0$	80 686.25(10)	10.003 82(12)	35

[a]The uncertainty in the last two digits is given in parentheses.

[b]1 cm^{-1} is equivalent to 1.239 841 857(49)$\times 10^{-4}$ eV (Mohr and Taylor[43]).

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5. References

[1] C. E. Moore, *Atomic Energy Levels*, *Natl. Bur. Std. Circ. No. 467* (U.S. Government Printing Office, Washington, DC, 1958), Vol. III.
[2] H. Karlsson and U. Litzén, Phys. Scr. **60**, 321 (1999).
[3] J. Z. Klose, J. R. Fuhr, and W. L. Wiese, J. Phys. Chem. Ref. Data **31**, 217 (2002).
[4] J. R. Rubbmark, S. A. Borgström, and K. Bockasten, J. Phys. B **10**, 421 (1977).
[5] P. Camus, M. Dieulin, and A. El Himdy, Phys. Rev. A **26**, 379 (1982).
[6] J. A. Armstrong, J. J. Wynne, and P. Esherick, J. Opt. Soc. Am. **69**, 211 (1979).
[7] M. Aymar, P. Camus, M. Dieulin, and C. Morillon, Phys. Rev. A **18**, 2173 (1978).
[8] J. Lu, C. J. Dai, C. Q. Li, X. H. Xu, Z. D. Liu, and J. C. Tang, J. Quant. Spectrosc. Radiat. Transf. **61**, 339 (1999).
[9] D. J. Bradley, P. Ewart, J. V. Nicholas, and J. R. D. Shaw, J. Phys. B **6**, 1594 (1973).
[10] H. P. Palenius, Phys. Lett. **56A**, 451 (1976).
[11] Ph. Cahuzac, Phys. Lett. **32A**, 150 (1970).
[12] C.-H. Li, S. M. Rochester, M. G. Kozlov, and D. Budker (unpublished).
[13] J. L. Carlsten, T. J. McIlrath, and W. H. Parkinson, J. Phys. B **8**, 38 (1975).
[14] J. F. Kelly, Phys. Rev. A **29**, 144 (1984).
[15] T. F. Gallagher, R. Kachru, and N. H. Tran, Phys. Rev. A **26**, 2611 (1982).
[16] E. A. J. M. Bente and W. Hogervorst, Z. Phys. D: At. Mol. Clusters **14**, 119 (1989).
[17] W. R. S. Garton and F. S. Tompkins, Ap. J. **158**, 1219 (1969).
[18] W. Vassen, E. Bente, and W. Hogervorst, J. Phys. B **20**, 2383 (1987).
[19] B. H. Post, W. Vassen, and W. Hogervorst, J. Phys. B **19**, 511 (1986).
[20] B. H. Post, W. Vassen, W. Hogervorst, M. Aymar, and O. Robaux, J. Phys. B **18**, 187 (1985).
[21] B. H. Post, W. Hogervorst, and W. Vassen, Phys. Rev. A **29**, 2989 (1984).
[22] M. A. Zaki Ewiss, W. Hogervorst, W. Vassen, and B. H. Post, Z. Phys. A **322**, 211 (1985).
[23] E. R. Eliel and W. Hogervorst, Phys. Rev. A **27**, 2995 (1983).
[24] E. R. Eliel and W. Hogervorst, J. Phys. B **16**, 1881 (1983).
[25] W. Hogervorst and E. R. Eliel, Z. Phys. A **310**, 19 (1983).
[26] H. Rinneberg and J. Neukammer, J. Phys. **44**, 177 (1983).
[27] L. Jahreiss and M. C. E. Huber, Phys. Rev. A **31**, 692 (1985).
[28] S. Niggli and M. C. E. Huber, Phys. Rev. A **35**, 2908 (1987).
[29] S. Niggli and M. C. E. Huber, Phys. Rev. A **37**, 2714 (1988).
[30] G. García and J. Campos, J. Quant. Spectrosc. Radiat. Transf. **42**, 567 (1989).
[31] S. Niggli and M. C. E. Huber, Phys. Rev. A **39**, 3924 (1989).
[32] F. M. Kelly and M. S. Mathur, Can. J. Phys. **55**, 83 (1977).
[33] A. Bizzarri and M. C. E. Huber, Phys. Rev. A **42**, 5422 (1990).
[34] R. A. Roig and G. Tondello, J. Opt. Soc. Am. **65**, 829 (1975).
[35] J. Boulmer, P. Camus, J.-M. Gagné, and P. Pillet, J. Phys. B **20**, L143 (1987).
[36] E. Rasmussen, Z. Phys. **83**, 404 (1933).
[37] F. A. Saunders, E. G. Schneider, and E. Buckingham, Proc. Natl. Acad. Sci. U.S.A. **20**, 291 (1934).
[38] T. B. Lucatorto, T. J. McIlrath, J. Sugar, and S. M. Younger, Phys. Rev. Lett. **47**, 1124 (1981).
[39] R. A. Roig, J. Opt. Soc. Am. **66**, 1400 (1976).
[40] A. A. Isaev, M. A. Kazaryan, S. V. Markova, and G. G. Petrash, Sov. J. Quantum Electron. **5**, 285 (1975).
[41] M. D. Davidson, L. C. Snoek, H. Volten, and A. Dönszelmann, Astron. Astrophys. **255**, 457 (1992).
[42] A. Lindgård and S. E. Nielsen, At. Data Nucl. Data Tables **19**, 533 (1977).
[43] P. J. Mohr and B. N. Taylor, Rev. Mod. Phys. **72**, 351 (2000).