A Compilation of Energy Levels and Wavelengths for the Spectrum of Neutral Beryllium (Be I)

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In this compilation we have used data from some 20 references, only two of which were available to C. E. Moore for her 1949 *Atomic Energy Levels* tables. The new compilation thus includes significant revisions, extensions, and improvements of the earlier data for configurations of the types $1s^2 2snl$ and $1s^2 2pnl$ and also extends the energy range to higher configurations, including those involving $1s$ electron excitation. The observed wavelengths for some 200 lines are given with their energy-level classifications. The wavelength measurements, which extend from 89 to 31 780 Å, were obtained from emission spectra of hollow-cathode and arc discharges, beam-foil spectra, and far-ultraviolet photoabsorption spectra. In addition to the energy levels derived from these spectra, we include levels obtained from multiphoton resonance-ionization mass spectrometry and projectile-Auger spectroscopy. We have evaluated a number of levels by using series formulas and/or theoretical results; these levels are more accurate than values derived from available wavelength measurements. Wavelengths calculated from energy-level differences are given for all lines; these "Ritz" wavelengths are more accurate than the observed values wherever the differences are significant. [S0047-2689(97)00405-9]

Key words: atomic energy levels; atomic spectra; atomic wavelengths; atomic wavenumbers; autoionization; beryllium; energy-level classifications; electron configurations; forbidden lines; infrared wavelengths; infrared wavenumbers; ionization potential; photoionization resonances; ultraviolet absorption; ultraviolet wavelengths.

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1. Introduction

The Atomic Energy Levels Data Center of the National Institute of Standards and Technology (NIST) evaluates and compiles data on atomic energy levels and spectral wavelengths. References for published compilations of such data for many spectra are given, for example, in a recent compilation of energy levels for the spectra of zinc [Sugar and Musgrove 1995], and extensive data from the compilations are interactively accessible at the NIST Physics Laboratory Web site [Fuhr *et al.* 1996]. This compilation for Be I results from an ongoing extension of the NIST atomic spectroscopic data program to include contributions from the Institute for Spectroscopy in Troitsk.

Johansson [1962] gave a good description of earlier research on Be I, which will not be repeated here. In preparing new wavelength and energy level tables for this spectrum, we have used data from some 20 references, only two of which were available to Moore when she compiled the Be I energy levels in 1949. Thus the data given here not only include significant revisions, extensions, and improvements of the earlier data for configurations of the types $1s^2 2snl$ and $2pnl$, but also extend the energy range to higher configurations including those involving $1s$ electron excitation.

2. Presentation of the Data in Tables 1 and 2

We have quoted under "Observed" in Table 1 what appears to be the most accurate available experimental wavelength for each line. The references for the wavelengths are indicated in the last column, the corresponding full refer-

TABLE 1. Wavelength and energy-level classifications for Be I

Relative intensity	Vacuum wavelength (Å)		Levels (cm^{-1})	Classification	Ref.
	Observed	Ritz	Lower – Upper		
A,B	89.16	89.16?	0.000–1 121 600?	$1s^22s^2\ ^1S_0-1s2s(^1S)3s4p(^1P^\circ)?\ ^1P^\circ_1?$	M74
A,B	90.24	90.24?	0.000–1 108 200?	$1s^22s^2\ ^1S_0-1s2s(^1S)3s3p(^1P^\circ)?\ ^1P^\circ_1?$	J87
A,B	90.67	90.67?	0.000–1 102 900?	$1s^22s^2\ ^1S_0-1s2s(^3S)3s4p(^3P^\circ)?\ ^1P^\circ_1?$	M74
A,B	92.20	92.20?	0.000–1 084 600?	$1s^22s^2\ ^1S_0-1s2s(^3S)3s3p(^3P^\circ)?\ ^1P^\circ_1?$	J87
A,B	96.29	96.29	0.000–1 038 500*a*	$1s^22s^2\ ^1S_0-1s(^2S)2s2p(^1P^\circ)4s\ ^1P^\circ_1$	M74
A,B	97.24	97.24?	0.000–1 028 400?*a*	$1s^22s^2\ ^1S_0-1s(^2S)2s2p(^1P^\circ)3d?\ ^1P^\circ_1?$	M74
3*A,B*	97.44	97.44	0.000–1 026 300*a*	$1s^22s^2\ ^1S_0-1s(^2S)2s2p(^1P^\circ)3s\ ^1P^\circ_1$	M74
5*A,B*	97.86	97.86?	0.000–1 021 900?*a*	$1s^22s^2\ ^1S_0-1s(^2S)2s2p(^3P^\circ)4s?\ ^1P^\circ_1?$	M74
A,B	97.97	97.97?	0.000–1 020 700?	$1s^22s^2\ ^1S_0-1s(^2S)2s2p(^3P^\circ)4d?\ ^1P^\circ_1?$	M74
A,B	98.66	98.66?	0.000–1 013 600?	$1s^22s^2\ ^1S_0-1s(^2S)2s2p(^3P^\circ)3d?\ ^1P^\circ_1?$	M74
5*A,B*	99.07	99.07	0.000–1 009 400*a*	$1s^22s^2\ ^1S_0-1s(^2S)2s2p(^3P^\circ)3s\ ^1P^\circ_1$	M74
5*A,B,bl*	100.86	100.86	0.000–991 500*a*	$1s^22s^2\ ^1S_0-1s2s^25p?\ ^1P^\circ_1?$	M74
6*A,B*	101.20	101.20	0.000–988 140*a*	$1s^22s^2\ ^1S_0-1s2s^24p?\ ^1P^\circ_1?$	M74
10*A,B*	102.13	102.13	0.000–979 140*a*	$1s^22s^2\ ^1S_0-1s2s^23p\ ^1P^\circ_1$	M74
A,B	104.67	104.67	21 978.28–977 360*a*	$1s^22s2p\ ^3P^\circ_0-1s(^2S)2s2p^2(^2P)\ ^3P$	M74
		104.67	21 978.925–977 360*a*	$1s^22s2p\ ^3P^\circ_1-1s(^2S)2s2p^2(^2P)\ ^3P$	M74
		104.67	21 981.27–977 360*a*	$1s^22s2p\ ^3P^\circ_2-1s(^2S)2s2p^2(^2P)\ ^3P$	M74
A,B	105.80	105.80	21 978.28–967 160*a*	$1s^22s2p\ ^3P^\circ_0-1s(^2S)2s2p^2(^2S)\ ^3S_1$	M74
		105.80	21 978.925–967 160*a*	$1s^22s2p\ ^3P^\circ_1-1s(^2S)2s2p^2(^2S)\ ^3S_1$	M74
		105.80	21 981.27–967 160*a*	$1s^22s2p\ ^3P^\circ_2-1s(^2S)2s2p^2(^2S)\ ^3S_1$	M74
10*A,B*	107.26	107.26	21 978.28–954 300*a*	$1s^22s2p\ ^3P^\circ_0-1s(^2S)2s2p^2(^2D)\ ^3D$	M74
		107.26	21 978.925–954 300*a*	$1s^22s2p\ ^3P^\circ_1-1s(^2S)2s2p^2(^2D)\ ^3D$	M74
		107.26	21 981.27–954 300*a*	$1s^22s2p\ ^3P^\circ_2-1s(^2S)2s2p^2(^2D)\ ^3D$	M74
10*A,B*	107.38	107.38	0.000–931 300*a*	$1s^22s^2\ ^1S_0-1s2s^22p\ ^1P^\circ_1$	M74
A,B	618.5	618.5	0.000–161 680*a*	$2s^2\ ^1S_0-3s10p?\ ^1P^\circ_1?$	E72
A,B	620.1	620.1	0.000–161 260*a*	$2s^2\ ^1S_0-3s9p?\ ^1P^\circ_1?$	E72
A,B	622.6	622.6	0.000–160 620*a*	$2s^2\ ^1S_0-3s8p?\ ^1P^\circ_1?$	E72
A,B	626.3	626.3	0.000–159 670*a*	$2s^2\ ^1S_0-3s7p?\ ^1P^\circ_1?$	E72
A,B	658.3	658.3	0.000–151 910*a*	$2s^2\ ^1S_0-3s4p\ ^1P^\circ_1$	E72
A,B	701.1	701.1	0.000–142 630*a*	$2s^2\ ^1S_0-3s3p\ ^1P^\circ_1$	E72
A	940.1	940.1	0.000–106 370	$2s^2\ ^1S_0-2p13s\ ^1P^\circ_1$	E72
A	941.4	941.4	0.000–106 230	$2s^2\ ^1S_0-2p12s\ ^1P^\circ_1$	E72
A	942.7	942.7	0.000–106 080	$2s^2\ ^1S_0-2p11s\ ^1P^\circ_1$	E72
A,B	944.9	944.9	0.000–105 830*a*	$2s^2\ ^1S_0-2p10s\ ^1P^\circ_1$	E72
A,B	947.7	947.7	0.000–105 520*a*	$2s^2\ ^1S_0-2p9s\ ^1P^\circ_1$	E72
A,B	951.6	951.6	0.000–105 090*a*	$2s^2\ ^1S_0-2p8s\ ^1P^\circ_1$	E72
A,B	957.8	957.8	0.000–104 410*a*	$2s^2\ ^1S_0-2p7s\ ^1P^\circ_1$	E72
A,B	959.7	959.87	0.000–104 181*a*	$2s^2\ ^1S_0-2p6d\ ^1P^\circ_1$	M69
A,B	967.8	967.8	0.000–103 330*a*	$2s^2\ ^1S_0-2p6s\ ^1P^\circ_1$	E72
A,B	971.9	971.90	0.000–102 891*a*	$2s^2\ ^1S_0-2p5d\ ^1P^\circ_1$	M69
A,B	986.2	986.2	0.000–101 400*a*	$2s^2\ ^1S_0-2p5s\ ^1P^\circ_1$	E72
A,B	994.6	994.35	0.000–[100 568]*a*	$2s^2\ ^1S_0-2p4d\ ^1P^\circ_1$	M69
A,B	1025	1025	0.000–97 600*a*	$2s^2\ ^1S_0-2p4s\ ^1P^\circ_1$	E72
A,B	1045.8	1045.54	0.000–95 644*a*	$2s^2\ ^1S_0-2p3d\ ^1P^\circ_1$	E72
A,B	1134	1134	0.000–88 200*a*	$2s^2\ ^1S_0-2p3s\ ^1P^\circ_1$	E72
A	1342.2	1342.208	0.000–[74 504.1]	$2s^2\ ^1S_0-2s13p\ ^1P^\circ_1$	E72
A	1344.7	1344.435	0.000–[74 380.7]	$2s^2\ ^1S_0-2s12p\ ^1P^\circ_1$	E72
A	1347.4	1347.326	0.000–[74 221.1]	$2s^2\ ^1S_0-2s11p\ ^1P^\circ_1$	E72
A	1351.3	1351.183	0.000–[74 009.2]	$2s^2\ ^1S_0-2s10p\ ^1P^\circ_1$	E72
A	1356.5	1356.679	0.000–[73 709.4]	$2s^2\ ^1S_0-2s9p\ ^1P^\circ_1$	E72
A	1364.3	1364.076	0.000–[73 309.7]	$2s^2\ ^1S_0-2s8p\ ^1P^\circ_1$	E72
A	1375.6	1375.482	0.000–[72 701.8]	$2s^2\ ^1S_0-2s7p\ ^1P^\circ_1$	E72
A	1393.9	1393.804	0.000–71 746.09	$2s^2\ ^1S_0-2s6p\ ^1P^\circ_1$	E72
4	1426.117	1426.117	0.000–70 120.49	$2s^2\ ^1S_0-2s5p\ ^1P^\circ_1$	J62
8	1491.762	1491.765	0.000–67 034.70	$2s^2\ ^1S_0-2s4p\ ^1P^\circ_1$	J62
30	1661.478	1661.479	0.000–60 187.34	$2s^2\ ^1S_0-2s3p\ ^1P^\circ_1$	J62
2	1907.12	1907.05	21 978.28–74 415.3	$2s2p\ ^3P^\circ_0-2s12d\ ^3D$	P31
		1907.07	21 978.925–74 415.3	$2s2p\ ^3P^\circ_1-2s12d\ ^3D$	P31
		1907.16	21 981.27–74 415.3	$2s2p\ ^3P^\circ_2-2s12d\ ^3D$	P31

Table 1. Wavelength and energy-level classifications for Be I—Continued

Relative intensity	Vacuum wavelength (Å) Observed	Ritz	Levels (cm^{-1}) Lower–Upper	Classification	Ref.
	1908.9	1908.9	931 800+x–984 186+x	$1s(^2S)2s2p^2(^4P)\ ^5P-1s(^2S)2p^3(^4S^\circ)^5S^\circ_2$	M81
3	1912.49	1912.42	21 978.28–74 268.1	$2s2p\ ^3P^\circ_0-2s11d\ ^3D$	P31
		1912.44	21 978.925–74 268.1	$2s2p\ ^3P^\circ_1-2s11d\ ^3D$	P31
		1912.53	21 981.27–74 268.1	$2s2p\ ^3P^\circ_2-2s11d\ ^3D$	P31
5	1919.76	1919.69	21 978.28–74 070.0	$2s2p\ ^3P^\circ_0-2s10d\ ^3D$	P31
		1919.71	21 978.925–74 070.0	$2s2p\ ^3P^\circ_1-2s10d\ ^3D$	P31
		1919.80	21 981.27–74 070.0	$2s2p\ ^3P^\circ_2-2s10d\ ^3D$	P31
7	1929.67	1929.60	21 978.28–73 802.6	$2s2p\ ^3P^\circ_0-2s9d\ ^3D$	P31
		1929.62	21 978.925–73 802.6	$2s2p\ ^3P^\circ_1-2s9d\ ^3D$	P31
		1929.71	21 981.27–73 802.6	$2s2p\ ^3P^\circ_2-2s9d\ ^3D$	P31
11	1943.68	1943.595	21 978.28–73 429.33	$2s2p\ ^3P^\circ_0-2s8d\ ^3D$	P31
		1943.619	21 978.925–73 429.33	$2s2p\ ^3P^\circ_1-2s8d\ ^3D$	P31
		1943.708	21 981.27–73 429.33	$2s2p\ ^3P^\circ_2-2s8d\ ^3D$	P31
2	1956.63	1956.56	21 978.28–73 088.5	$2s2p\ ^3P^\circ_0-2s8s\ ^3S_1$	P31
		1956.58	21 978.925–73 088.5	$2s2p\ ^3P^\circ_1-2s8s\ ^3S_1$	P31
		1956.67	21 981.27–73 088.5	$2s2p\ ^3P^\circ_2-2s8s\ ^3S_1$	P31
19	1964.59	1964.535	21 978.28–72 880.90	$2s2p\ ^3P^\circ_0-2s7d\ ^3D$	P31
		1964.560	21 978.925–72 880.90	$2s2p\ ^3P^\circ_1-2s7d\ ^3D$	P31
		1964.651	21 981.27–72 880.90	$2s2p\ ^3P^\circ_2-2s7d\ ^3D$	P31
7	1985.13	1985.06	21 978.28–72 354.7	$2s2p\ ^3P^\circ_0-2s7s\ ^3S_1$	P31
		1985.08	21 978.925–72 354.7	$2s2p\ ^3P^\circ_1-2s7s\ ^3S_1$	P31
		1985.17	21 981.27–72 354.7	$2s2p\ ^3P^\circ_2-2s7s\ ^3S_1$	P31
20	1998.01	1997.953	21 978.28–72 029.50	$2s2p\ ^3P^\circ_0-2s6d\ ^3D$	P31
		1997.979	21 978.925–72 029.50	$2s2p\ ^3P^\circ_1-2s6d\ ^3D$	P31
		1998.073	21 981.27–72 029.50	$2s2p\ ^3P^\circ_2-2s6d\ ^3D$	P31

Relative intensity	Air wavelength (Å) Observed	Ritz	Vacuum wavelength (Å)	Levels (cm^{-1}) Lower–Upper	Classification	Ref.
9	2032.65	2032.600	2033.254	21 978.28–71 160.52	$2s2p\ ^3P^\circ_0-2s6s\ ^3S_1$	P31
		2032.627	2033.281	21 978.925–71 160.52	$2s2p\ ^3P^\circ_1-2s6s\ ^3S_1$	P31
		2032.724	2033.378	21 981.27–71 160.52	$2s2p\ ^3P^\circ_2-2s6s\ ^3S_1$	P31
11	2055.902	2055.877	2056.535	21 978.28–70 603.76	$2s2p\ ^3P^\circ_0-2s5d\ ^3D$	J62
		2055.904	2056.562	21 978.925–70 603.76	$2s2p\ ^3P^\circ_1-2s5d\ ^3D$	J62
13	2056.012	2056.003	2056.661	21 981.27–70 603.76	$2s2p\ ^3P^\circ_2-2s5d\ ^3D$	J62
3	2125.568	2125.544	2126.216	21 978.28–69 010.20	$2s2p\ ^3P^\circ_0-2s5s\ ^3S_1$	J62
		2125.573	2126.245	21 978.925–69 010.20	$2s2p\ ^3P^\circ_1-2s5s\ ^3S_1$	J62
5	2125.685	2125.679	2126.351	21 981.27–69 010.20	$2s2p\ ^3P^\circ_2-2s5s\ ^3S_1$	J62
1*w*	2147.35	2147.287	2147.963	42 565.35–89 121.08	$2s2p\ ^1P^\circ_1-2p3p\ ^1P_1$	J74
13	2174.986	2174.963	2175.645	21 978.28–67 941.66	$2s2p\ ^3P^\circ_0-2s4d\ ^3D$	J62
		2174.994	2175.676	21 978.925–67 941.66	$2s2p\ ^3P^\circ_1-2s4d\ ^3D$	J62
15	2175.103	2175.105	2175.787	21 981.27–67 941.66	$2s2p\ ^3P^\circ_2-2s4d\ ^3D$	J62
2	2194.249	2194.248	2194.933	56 882.43–102 441.9	$2p^2\ ^1D_2-2p5d\ ^1D^\circ_2$	J74
	2273.0	2273.0	2273.7	991 620+y–1 035 601+y	$1s(^2S)2s2p(^3P^\circ)3p\ ^5P-1s(^2S)2p^2(^3P)3p\ ^5S^\circ_2$	M89
	2306	2306.0	2306.7	1 000 700+z–1 044 052+z	$1s(^2S)2s2p(^3P^\circ)4p\ ^5P-1s(^2S)2p^2(^3P)4p\ ^5S^\circ_2$	A83
2	2330.23	2330.10	2330.81	59 693.65–102 597.1	$2p^2\ ^3P_0-2p5d\ ^3D^\circ$	J74
		2330.18	2330.89	59 695.07–102 597.1	$2p^2\ ^3P_1-2p5d\ ^3D^\circ$	J74
		2330.29	2331.00	59 697.08–102 597.1	$2p^2\ ^3P_2-2p5d\ ^3D^\circ$	J74
3*bl*	2336.50	2336.50	2337.22	56 882.43–99 668.3	$2p^2\ ^1D_2-2p4d\ ^1D^\circ_2$	J74
40	2348.610	2348.610	2349.329	0.000–42 565.35	$2s^2\ ^1S_0-2s2p\ ^1P^\circ_1$	J62
7	2350.661	2350.663	2351.383	21 978.28–64 506.45	$2s2p\ ^3P^\circ_0-2s4s\ ^3S_1$	J62
11	2350.703	2350.699	2351.418	21 978.925–64 506.45	$2s2p\ ^3P^\circ_1-2s4s\ ^3S_1$	J62
15	2350.829	2350.828	2351.548	21 981.27–64 506.45	$2s2p\ ^3P^\circ_2-2s4s\ ^3S_1$	J62
9*bl*	2481.319	2481.269	2482.018	59 693.65–99 983.45	$2p^2\ ^3P_0-2p4d\ ^3D^\circ_1$	J74
		2481.323	2482.073	59 695.07–99 983.98	$2p^2\ ^3P_1-2p4d\ ^3D^\circ_2$	J74
		2481.373	2482.122	59 697.08–99 985.19	$2p^2\ ^3P_2-2p4d\ ^3D^\circ_3$	J74
13	2494.543	2494.542	2495.294	21 978.28–62 053.72	$2s2p\ ^3P^\circ_0-2s3d\ ^3D$	J62

Table 1. Wavelength and energy-level classifications for Be I—Continued

Relative intensity	Air wavelength (Å) Observed	Air wavelength (Å) Ritz	Vacuum wavelength (Å)	Levels (cm⁻¹) Lower–Upper	Classification	Ref.
17	2494.583	2494.582	2495.334	21 978.925–62 053.72	$2s2p\ ^3P^\circ_1-2s3d\ ^3D$	J62
20	2494.728	2494.728	2495.480	21 981.27–62 053.72	$2s2p\ ^3P^\circ_2-2s3d\ ^3D$	J62
12	2650.454	2650.454	2651.243	21 978.925–59 697.08	$2s2p\ ^3P^\circ_1-2p^2\ ^3P_2$	J62
11	2650.550	2650.550	2651.339	21 978.28–59 695.07	$2s2p\ ^3P^\circ_0-2p^2\ ^3P_1$	J62
12	2650.613	2650.595	2651.384	21 978.925–59 695.07	$2s2p\ ^3P^\circ_1-2p^2\ ^3P_1$	P31
15	2650.619	2650.619	2651.408	21 981.27–59 697.08	$2s2p\ ^3P^\circ_2-2p^2\ ^3P_2$	J62
11	2650.694	2650.695	2651.484	21 978.925–59 693.65	$2s2p\ ^3P^\circ_1-2p^2\ ^3P_0$	J62
13	2650.760	2650.760	2651.549	21 981.27–59 695.07	$2s2p\ ^3P^\circ_2-2p^2\ ^3P_1$	J62
9	2738.050	2738.049	2738.859	56 882.43–93 393.98	$2p^2\ ^1D_2-2p3d\ ^1D^\circ_2$	J62
5	2898.127	2898.128	2898.978	59 693.65–94 188.57	$2p^2\ ^3P_0-2p3d\ ^3D^\circ_1$	J62
3	2898.188	2898.190	2899.039	59 695.07–94 189.26	$2p^2\ ^3P_1-2p3d\ ^3D^\circ_2$	J62
7	2898.254	{2898.248	2899.097	59 695.07–94 188.57	$2p^2\ ^3P_1-2p3d\ ^3D^\circ_1$	J62
		{2898.267	2899.116	59 697.08–94 190.35	$2p^2\ ^3P_2-2p3d\ ^3D^\circ_3$	J62
m		{2898.358	2899.208	59 697.08–94 189.26	$2p^2\ ^3P_2-2p3d\ ^3D^\circ_2$	J62
11	2986.062	2986.061	2986.932	52 080.94–85 560.11	$2s3s\ ^3S_1-2p3s\ ^3P^\circ_2$	J62
10	2986.418	2986.418	2987.289	52 080.94–85 556.11	$2s3s\ ^3S_1-2p3s\ ^3P^\circ_1$	J62
7	2986.62	2986.597	2987.468	52 080.94–85 554.1	$2s3s\ ^3S_1-2p3s\ ^3P^\circ_0$	P31
12	3019.333	3019.333	3020.213	58 907.83–92 018.08	$2s3p\ ^3P^\circ_2-2p3p\ ^3P_2$	J62
9	3019.492	3019.491	3020.371	58 907.45–92 015.97	$2s3p\ ^3P^\circ_{0,1}-2p3p\ ^3P_1$	J62
9	3019.526	3019.526	3020.405	58 907.83–92 015.97	$2s3p\ ^3P^\circ_2-2p3p\ ^3P_1$	J62
7	3019.599	3019.599	3020.478	58 907.45–92 014.79	$2s3p\ ^3P^\circ_{0,1}-2p3p\ ^3P_0$	J62
3	3089.826	3089.826	3090.723	66 811.88–99 166.77	$2s4p\ ^3P^\circ-2p4p\ ^3P_2$	J74
5	3090.023	3090.023	3090.920	66 811.88–99 164.71	$2s4p\ ^3P^\circ-2p4p\ ^3P_1$	J74
5	3090.130	3090.130	3091.027	66 811.88–99 163.59	$2s4p\ ^3P^\circ-2p4p\ ^3P_0$	J74
5	3110.814	3110.812	3111.714	62 053.72–94 190.35	$2s3d\ ^3D-2p3d\ ^3D^\circ_3$	J62
5	3110.918	3110.917	3111.819	62 053.72–94 189.26	$2s3d\ ^3D-2p3d\ ^3D^\circ_2$	J62
7	3110.986	3110.984	3111.886	62 053.72–94 188.57	$2s3d\ ^3D-2p3d\ ^3D^\circ_1$	J62
2*bl*	3111.068	3111.068	3111.971	[70 065.40]–102 199.38	$2s5p\ ^3P^\circ-2p5p\ ^3P_2$	J74
2*bl*	3111.235	3111.235	3112.137	[70 065.40]–102 197.66	$2s5p\ ^3P^\circ-2p5p\ ^3P_1$	J74
3	3111.420	3111.420	3112.322	[70 065.40]–102 195.75	$2s5p\ ^3P^\circ-2p5p\ ^3P_0$	J74
2	3119.850	3119.850	3120.755	67 941.66–99 985.19	$2s4d\ ^3D-2p4d\ ^3D^\circ_3$	J74
2*bl*	3119.968	3119.968	3120.873	67 941.66–99 983.98	$2s4d\ ^3D-2p4d\ ^3D^\circ_2$	J74
3	3120.020	3120.020	3120.924	67 941.66–99 983.45	$2s4d\ ^3D-2p4d\ ^3D^\circ_1$	J74
3*bl*	3124.993	3124.993?	3125.899?	68 241.02–100 231.82?	$2s4f\ ^3F^\circ-2p4f\ ^3F_4$	J74
3*bl*	3125.119	3125.119?	3126.025?	68 241.02–100 230.53?	$2s4f\ ^3F^\circ-2p4f\ ^3F_3$	J74
5*bl*	3134.763	3134.763?	3135.671?	70 749.90–102 641.00?	$2s5f\ ^1F^\circ_3-2p5f\ ^1F_3$	J74
3	3136.06	3136.06	3136.96	42 565.35–74 443.3	$2s2p\ ^1P^\circ_1-2s12d\ ^1D_2$	P32
7	3138.685	3138.685?	3139.594?	68 241.18–100 092.43?	$2s4f\ ^1F^\circ_3-2p4f\ ^1F_3$	J74
5	3145.425	3145.424	3146.335	71 746.09–103 529.1	$2s6p\ ^1P^\circ_1-2p6p\ ^1P_1$	J74
4	3150.08	3150.08	3150.99	42 565.35–74 301.4	$2s2p\ ^1P^\circ_1-2s11d\ ^1D_2$	P32
9	3160.768	3160.768	3161.683	70 120.49–101 749.21	$2s5p\ ^1P^\circ_1-2p5p\ ^1P_1$	J74
1	3163.84	3163.84	3164.75	42 565.35–74 163.4	$2s2p\ ^1P^\circ_1-2s11s\ ^1S_0$	P32
6	3168.602	3168.602	3169.519	42 565.35–74 115.88	$2s2p\ ^1P^\circ_1-2s10d\ ^1D_2$	J74
3	3187.34	3187.34	3188.26	42 565.35–73 930.4	$2s2p\ ^1P^\circ_1-2s10s\ ^1S_0$	P32
8	3193.830	3193.830	3194.753	42 565.35–73 866.67	$2s2p\ ^1P^\circ_1-2s9d\ ^1D_2$	J74
11	3208.600	3208.600	3209.527	67 034.70–98 191.94	$2s4p\ ^1P^\circ_1-2p4p\ ^1P_1$	H72
4	3220.39	3220.39	3221.32	42 565.35–73 608.5	$2s2p\ ^1P^\circ_1-2s9s\ ^1S_0$	P32
9	3229.620	3229.620	3230.552	42 565.35–73 519.81	$2s2p\ ^1P^\circ_1-2s8d\ ^1D_2$	J62
6	3269.038	3269.038	3269.981	42 565.35–73 146.57	$2s2p\ ^1P^\circ_1-2s8s\ ^1S_0$	J74
10	3282.905	3282.903	3283.849	42 565.35–73 017.42	$2s2p\ ^1P^\circ_1-2s7d\ ^1D_2$	J62
35	3321.011	3321.010	3321.966	21 978.28–52 080.94	$2s2p\ ^3P^\circ_0-2s3s\ ^3S_1$	J62
40	3321.079	3321.081	3322.037	21 978.925–52 080.94	$2s2p\ ^3P^\circ_1-2s3s\ ^3S_1$	J62
45	3321.340	3321.340	3322.296	21 981.27–52 080.94	$2s2p\ ^3P^\circ_2-2s3s\ ^3S_1$	J62
8*bl*	3345.430	3345.430	3346.392	42 565.35–72 448.28	$2s2p\ ^1P^\circ_1-2s7s\ ^1S_0$	J74
11	3367.633	3367.633	3368.600	42 565.35–72 251.27	$2s2p\ ^1P^\circ_1-2s6d\ ^1D_2$	J62
1	3451.372	3451.374	3452.363	64 428.31–93 393.98	$2s3d\ ^1D_2-2p3d\ ^1D^\circ_2$	J62
17	3455.183	3455.183	3456.173	60 187.34–89 121.08	$2s3p\ ^1P^\circ_1-2p3p\ ^1P_1$	J62
11	3476.564	3476.564	3477.559	42 565.35–71 321.15	$2s2p\ ^1P^\circ_1-2s6s\ ^1S_0$	J62
17	3515.539	3515.541	3516.547	42 565.35–71 002.34	$2s2p\ ^1P^\circ_1-2s5d\ ^1D_2$	J62
5	3561.310	3561.321	3562.338	70 120.9–98 191.94	$2s5p\ ^1P^\circ_1-2p4p\ ^1P_1$	J74

Table 1. Wavelength and energy-level classifications for Be I—Continued

Relative intensity	Air wavelength (Å) Observed	Ritz	Vacuum wavelength (Å)	Levels (cm^{-1}) Lower–Upper	Classification	Ref.
13	3736.298	3736.298	3737.361	42 565.35–69 322.20	$2s2p\ ^1P^\circ_1-2s5s\ ^1S_0$	J62
22	3813.454	3813.453	3814.536	42 565.35–68 780.86	$2s2p\ ^1P^\circ_1-2s4d\ ^1D_2$	J62
3	3865.130	3865.127	3866.223	59 695.07–85 560.11	$2p^2\ ^3P_1-2p3s\ ^3P^\circ_2$	H69
5	3865.423	3865.427	3866.523	59 697.08–85 560.11	$2p^2\ ^3P_2-2p3s\ ^3P^\circ_2$	H69
1	3865.513	3865.512	3866.608	59 693.65–85 556.11	$2p^2\ ^3P_0-2p3s\ ^3P^\circ_1$	H69
2	3865.722	3865.725	3866.821	59 695.07–85 556.11	$2p^2\ ^3P_1-2p3s\ ^3P^\circ_1$	H69
3	3866.025	{3866.025	3867.121	59 697.08–85 556.11	$2p^2\ ^3P_2-2p3s\ ^3P^\circ_1$	H69
		{3866.025	3867.121	59 695.07–85 554.1	$2p^2\ ^3P_1-2p3s\ ^3P^\circ_0$	H69
6	4253.05	4252.965	4254.162	62 053.72–85 560.11	$2s3d\ ^3D-2p3s\ ^3P^\circ_2$	P31
5	4253.76	4253.689	4254.886	62 053.72–85 556.11	$2s3d\ ^3D-2p3s\ ^3P^\circ_1$	P31
2	4254.12	4254.05	4255.25	62 053.72 85 554.1	$2s3d\ ^3D-2p3s\ ^3P^\circ_0$	P31
19	4407.935	4407.937	4409.175	42 565.35–65 245.33	$2s2p\ ^1P^\circ_1-2s4s\ ^1S_0$	J62
7	4526.409	4526.408	4527.677	67 034.70–89 121.08	$2s4p\ ^1P^\circ_1-2p3p\ ^1P_1$	J74
	4548.538	4548.538	4549.813	0.000–21 978.925	$1s^22s^2\ ^1S_0-2s2p\ ^3P^\circ_1$	B53
30	4572.664	4572.665	4573.946	42 565.35–64 428.31	$2s2p\ ^1P^\circ_1-2s3d\ ^1D_2$	J62
2	4709.37	4709.395	4710.713	52 080.94–73 309.15	$2s3s\ ^3S_1-2s8p\ ^3P^\circ$	H69
3	4849.16	4849.157	4850.512	52 080.94–72 697.32	$2s3s\ ^3S_1-2s7p\ ^3P^\circ$	H69
5	5087.75	5087.723	5089.141	52 080.94–71 730.62	$2s3s\ ^3S_1-2s6p\ ^3P^\circ$	H69
5	5261.525	5261.530	5262.994	70 120.49–89 121.08	$2s5p\ ^1P^\circ_1-2p3p\ ^1P_1$	J74
	5557.8	5558.81	5560.36	52 080.94–[70 065.40]	$2s3s\ ^3S_1-2s5p\ ^3P^\circ$	H72
3	5857.01	5857.009	5858.632	54 677.26–71 746.09	$2s3s\ ^1S_0-2s6p\ ^1P^\circ_1$	H69
3	6229.110	6229.109	6230.832	56 882.43–72 931.65	$2p^2\ ^1D_2-2s7f\ ^1F^\circ_3$	J62
7	6473.539	6473.540	6475.329	54 677.26–70 120.49	$2s3s\ ^1S_0-2s5p\ ^1P^\circ_1$	J62
9	6564.521	6564.524	6566.337	56 882.43–72 111.62	$2p^2\ ^1D_2-2s6f\ ^1F^\circ_3$	J62
2*bl*	6726.0	6725.96	6727.82	56 882.43–71 746.09	$2p^2\ ^1D_2-2s6p\ ^1P^\circ_1$	H69
9*w*	6786.559	6786.560	6788.433	52 080.94–66 811.88	$2s3s\ ^3S_1-2s4p\ ^3P^\circ$	J62
1*w*	6884.22	6884.26	6886.16	58 907.45–73 429.33	$2s3p\ ^3P^\circ_{0,1}-2s8d\ ^3D$	H69
2*w*	6884.44	6884.44	6886.34	58 907.83–73 429.3	$2s3p\ ^3P^\circ_2-2s8d\ ^3D$	H69
13	6982.749	6982.739	6984.664	42 565.35–56 882.43	$2s2p\ ^1P^\circ_1-2p^2\ ^1D_2$	J62
2*w*	7154.40	7154.46	7156.43	58 907.45–72 880.90	$2s3p\ ^3P^\circ_{0,1}-2s7d\ ^3D$	H69
3*w*	7154.65	7154.65	7156.62	58 907.83–72 880.90	$2s3p\ ^3P^\circ_2-2s7d\ ^3D$	H69
13	7209.134	7209.134	7211.121	56 882.43–70 749.90	$2p^2\ ^1D_2-2s5f\ ^1F^\circ_3$	J62
1*w*	7308.17	7308.29	7310.30	60 187.34–73 866.67	$2s3p\ ^1P^\circ_1-2s9d\ ^1D_2$	H69
2*w,bl*	7498.3	7498.42	7500.49	60 187.34–73 519.81	$2s3p\ ^1P^\circ_1-2s8d\ ^1D_2$	H69
3	7551.898	7551.898	7553.977	56 882.43–70 120.49	$2p^2\ ^1D_2-2s5p\ ^1P^\circ_1$	J62
3*w*	7618.680	7618.663	7620.760	58 907.45–72 029.50	$2s3p\ ^3P^\circ_{0,1}-2s6d\ ^3D$	J62
5*w*	7618.881	7618.884	7620.981	58 907.83–72 029.50	$2s3p\ ^3P^\circ_2-2s6d\ ^3D$	J62
2*w*	7792.00	7792.04	7794.18	60 187.34–73 017.42	$2s3p\ ^1P^\circ_1-2s7d\ ^1D_2$	H69
11	8090.061	8090.066	8092.291	4 677.26–67 034.70	$2s3s\ ^1S_0-2s4p\ ^1P^\circ_1$	J62
1*w*	8158.993	8158.977	8161.220	58 907.45–71 160.52	$2s3p\ ^3P^\circ_{0,1}-2s6s\ ^3S_1$	J62
3*w*	8159.243	8159.230	8161.473	58 907.83–71 160.52	$2s3p\ ^3P^\circ_2-2s6s\ ^3S_1$	J62
20	8254.070	8254.067	8256.336	42 565.35–54 677.26	$2s2p\ ^1P^\circ_1-2s3s\ ^1S_0$	J62
3*w,bl*	8287.07	8286.89	8289.17	60 187.34–72 251.27	$2s3p\ ^1P^\circ_1-2s6d\ ^1D_2$	J62
9	8547.366	8547.357	8549.705	58 907.45–70 603.76	$2s3p\ ^3P^\circ_{0,1}-2s5d\ ^3D$	J62
11	8547.659	8547.634	8549.983	58 907.83–70 603.76	$2s3p\ ^3P^\circ_2-2s5d\ ^3D$	J62
17	8801.370	8801.369	8803.786	56 882.43–68 241.18	$2p^2\ ^1D_2-2s4f\ ^1F^\circ_3$	J62
2	8882.18	8882.162	8884.601	62 053.72–73 309.15	$2s3d\ ^3D-2s8p\ ^3P^\circ$	H69
3	9190.45	9190.45	9192.97	62 053.72–72 931.60	$2s3d\ ^3D-2s7f\ ^3F^\circ$	H69
5*w*	9243.916	9243.880	9246.417	60 187.34–71 002.34	$2s3p\ ^1P^\circ_1-2s5d\ ^1D_2$	J62
3	9392.74	9392.740	9395.317	62 053.72–72 697.32	$2s3d\ ^3D-2s7p\ ^3P^\circ$	H69
7	9847.32	9847.31	9850.01	56 882.43–67 034.70	$2p^2\ ^1D_2-2s4p\ ^1P^\circ_1$	J62
3*w*	9895.63	9895.58	9898.30	58 907.45–69 010.20	$2s3p\ ^3P^\circ_{0,1}-2s5s\ ^3S_1$	J62
5*w*	9895.96	9895.95	9898.67	58 907.83–69 010.20	$2s3p\ ^3P^\circ_2-2s5s\ ^3S_1$	J62
5	9939.78	9939.78	9942.50	62 053.72–72 111.55	$2s3d\ ^3D-2s6f\ ^3F^\circ$	H69
5	10331.03	10331.057	10333.888	62 053.72–71 730.62	$2s3d\ ^3D-2s6p\ ^3P^\circ$	H69
7	11066.06	11066.01	11069.04	58 907.45–67 941.66	$2s3p\ ^3P^\circ_{0,1}-2s4d\ ^3D$	J62
9	11066.46	11066.47	11069.50	58 907.83–67 941.66	$2s3p\ ^3P^\circ_2-2s4d\ ^3D$	J62
7	11496.39	11496.39	11499.54	62 053.72–70 749.72	$2s3d\ ^3D-2s5f\ ^3F^\circ$	H69
13	14643.92	14643.96	14647.96	52 080.94–58 907.83	$2s3s\ ^3S_1-2s3p\ ^3P^\circ_2$	J62
11	14644.75	14644.77	14648.77	52 080.94–58 907.45	$2s3s\ ^3S_1-2s3p\ ^3P^\circ_{0,1}$	J62

Table 1. Wavelength and energy-level classifications for Be I—Continued

Relative intensity	Air wavelength (Å) Observed	Air wavelength (Å) Ritz	Vacuum wavelength (Å)	Levels (cm^{-1}) Lower–Upper	Classification	Ref.
11	16157.72	16157.72	16162.14	62 053.72–68 241.02	$2s3d\ ^3D-2s4f\ ^3F^\circ$	H69
5	17855.38	17855.456	17860.332	58 907.45–64 506.45	$2s3p\ ^3P^\circ_{0,1}-2s4s\ ^3S_1$	H69
7	17856.63	17856.668	17861.544	58 907.83–64 506.45	$2s3p\ ^3P^\circ_2-2s4s\ ^3S_1$	H69
13	18143.54	18143.60	18148.56	54 677.26–60 187.34	$2s3s\ ^1S_0-2s3p\ ^1P^\circ_1$	J62
9	19765.29	19765.303	19770.699	60 187.34–65 245.33	$2s3p\ ^1P^\circ_1-2s4s\ ^1S_0$	H69
9	30249.89	30249.76	30258.01	56 882.43–60 187.34	$2p^2\ ^1D_2-2s3p\ ^1P^\circ_1$	H69
9	31775.05	31775.00	31783.67	58 907.45–62 053.72	$2s3p\ ^3P^\circ_{0,1}-2s3d\ ^3D$	H69
11	31778.70	31778.84	31787.51	58 907.83–62 053.72	$2s3p\ ^3P^\circ_2-2s3d\ ^3D$	H69

ences being given in Sec. 6. The references for the wavelengths are not necessarily the appropriate citations for the original classifications of the lines. The Ritz wavelengths in Table 1 are discussed in Section 5.

The intensities are based on values in the references but have been adjusted to avoid the "0" and "00" intensities in Refs. [J62], [H69], and [J74]. The intensities in these references were given on a logarithmic scale, with values for lines below 11 400 Å being derived from photographic plate blackening. This scale has been expanded somewhat here, but is still very compressed as compared to a linear scale of relative intensities. We have also adjusted intensities from different references to a more uniform scale for lines of particular multiplets, lines belonging to series, etc. The following symbols are used to characterize the lines:

- *A* observed in absorption
- *bl* blended with another line that may affect the wavelength and intensity
- *B* line or feature having large width due to autoionization broadening
- *m* masked by another line (no wavelength measurement)
- *w* wide, diffuse, hazy, etc.

The values of the two levels for each transition in Table 1 are given under "Levels." A question mark following the upper level indicates a tentative classification. The configuration and term notations for the two levels, as taken from Table 2, are given under "Classification." No *J* value is given for a level in Table 1 if the value under "Level" in Table 2 represents three unresolved (triplet or ^5P) levels.

The energy-level data are presented in Table 2 in the standard format used in our compilations. The odd-parity levels are given in italics. The values of levels derived from wider autoionization-broadened features are followed by the letter "*a*." The levels of many of the triplet (or quintet) terms have not been resolved; the *J* values of such levels represented by a single level value are given under "*J*." Level values given in brackets or with such notations as "$-x$" have been predicted by methods described below.

3. Energy Levels and Spectrum for $1s^22snl$, $1s^22pnl$, and $1s^23snp$ Configurations

Johansson measured the spectrum of a Be hollow-cathode discharge from 2050 to 31 780 Å and also measured the $2s^2\ ^1S-2s3p$, $4p$, $5p\ ^1P^\circ$ vacuum UV lines on an arc-spectrum plate supplied by Shenstone [Johansson, 1962, 1974, Holmström and Johansson, 1969]. Most of the $2snl$ levels in Table 2 are from the 1962 paper, and most of the $2pnl$ levels are from the 1974 paper. The estimated errors of most of the measured wavelengths from these references were given as:

[J62] 0.01 Å for $\lambda<5000$ Å, 0.02 Å for $\lambda>5000$ Å;
[H69] 0.01 Å for $\lambda<4600$ Å, 0.02 Å for $\lambda>4600$ Å;
[J74] 0.02 Å.

Below 95 000 cm^{-1}, the two-place levels should in most cases be accurate to about ±0.05 cm^{-1} and the one-place levels to about ±0.5 cm^{-1}. The two-place levels above 95 000 cm^{-1} have estimated errors up to about 0.2 cm^{-1}.

A number of the levels are based on, or most accurately determined by, a single observed transition. Small changes in the previous values for a few such levels have been made so as to obtain exact agreement of the Ritz-calculated wavelength with the observed wavelength (see Section 5).

The three-place value given for the $2s2p\ ^3P^\circ_1$ level should be accurate to about 0.010 cm^{-1} with respect to the ground level, based on an uncertainty of 0.002 Å in the measurement of the corresponding intersystem line at 4548 Å [Bozman *et al.*].

We have deviated from our usual practice in these compilations by including in Table 1 the wavelengths in air for the region longer than 10 000 Å, since the corresponding measurements [J62, H69] were in fact made by using "standard-air" wavelengths for calibration [Johansson, 1961]. Most of the energy-level separations based on these measurements appear to have Ritz-principle consistencies of about ±0.02 cm^{-1}, implying wavelength uncertainties of 0.02 Å at 10 000 Å to 0.2 Å at 31 800 Å.

All the $2snl$ series interact with $2pn'l'$ terms or series to

TABLE 2. Energy levels of Be I

Configuration	Term	J	Level (cm^{-1})
$2s^2$	^{1}S	0	0.000
$2s2p$	^{3}P°	0	*21 978.28*
		1	*21 978.925*
		2	*21 981.27*
$2s2p$	^{1}P°	1	*42 565.35*
$2s3s$	^{3}S	1	52 080.94
$2s3s$	^{1}S	0	54 677.26
$2p^2$	^{1}D	2	56 882.43
$2s3p$	^{3}P°	0,1	*58 907.45*
		2	*58 907.83*
$2p^2$	^{3}P	0	59 693.65
		1	59 695.07
		2	59 697.08
$2s3p$	^{1}P°	1	*60 187.34*
$2s3d$	^{3}D	1,2,3	62 053.72
$2s3d$	^{1}D	2	64 428.31
$2s4s$	^{3}S	1	64 506.45
$2s4s$	^{1}S	0	65 245.33
$2s4p$	^{3}P°	0,1,2	*66 811.88*
$2s4p$	^{1}P°	1	*67 034.70*
$2s4d$	^{3}D	1,2,3	67 941.66
$2s4f$	^{3}F°	2,3,4	*68 241.02*
$2s4f$	^{1}F°	3	*68 241.18*
$2s4d$	^{1}D	2	68 780.86
$2s5s$	^{3}S	1	69 010.20
$2s5s$	^{1}S	0	69 322.20
$2s5p$	^{3}P°	0,1,2	*[70 065.40]*
$2s5p$	^{1}P°	1	*70 120.49*
$2s5d$	^{3}D	1,2,3	70 603.76
$2s5f$	^{3}F°	2,3,4	*70 749.72*
$2s5f$	^{1}F°	3	*70 749.90*
$2s5d$	^{1}D	2	71 002.34
$2s6s$	^{3}S	1	71 160.52
$2s6s$	^{1}S	0	71 321.15
$2s6p$	^{3}P°	0,1,2	*71 730.62*
$2s6p$	^{1}P°	1	*71 746.09*
$2s6d$	^{3}D	1,2,3	72 029.50
$2s6f$	^{3}F°	2,3,4	*72 111.55*
$2s6f$	^{1}F°	3	*72 111.62*
$2s6d$	^{1}D	2	72 251.27
$2s7s$	^{3}S	1	72 354.7
$2s7s$	^{1}S	0	72 448.28
$2s7p$	^{3}P°	0,1,2	*72 697.32*
$2s7p$	^{1}P°	1	*[72 701.8]*
$2s7d$	^{3}D	1,2,3	72 880.90
$2s7f$	^{3}F°	2,3,4	*72 931.60*
$2s7f$	^{1}F°	3	*72 931.65*
$2s7d$	^{1}D	2	73 017.42
$2s8s$	^{3}S	1	73 088.5
$2s8s$	^{1}S	0	73 146.57
$2s8p$	^{3}P°	0,1,2	*73 309.15*
$2s8p$	^{1}P°	1	*[73 309.7]*
$2s8d$	^{3}D	1,2,3	73 429.33
$2s8d$	^{1}D	2	73 519.81
$2s9s$	^{1}S	0	73 608.5
$2s9p$	^{1}P°	1	*[73 709.4]*
$2s9d$	^{3}D	1,2,3	73 802.6
$2s9d$	^{1}D	2	73 866.67
$2s10s$	^{1}S	0	73 930.4
$2s10p$	^{1}P°	1	*[74 009.2]*
$2s10d$	^{3}D	1,2,3	74 070.0
$2s10d$	^{1}D	2	74 115.88
$2s11s$	^{1}S	0	74 163.4
$2s11p$	^{1}P°	1	*[74 221.1]*
$2s11d$	^{3}D	1,2,3	74 268.1
$2s11d$	^{1}D	2	74 301.4
$2s12p$	^{1}P°	1	*[74 380.7]*
$2s12d$	^{3}D	1,2,3	74 415.3
$2s12d$	^{1}D	2	74 443.3
$2s13p$	^{1}P°	1	*[74 504.1]*
Be II ($^2S_{1/2}$)	**Limit**		***75 192.64***
$2p^2$	^{1}S	0	76 190*a*
$2p3s$	^{3}P°	0	*85 554.1*
		1	*85 556.11*
		2	*85 560.11*
$2p3s$	^{1}P°	1	*88 200a*
$2p3p$	^{1}P	1	89 121.08
$2p3p$	^{3}P	0	92 014.79
		1	92 015.97
		2	92 018.08
$2p3d$	^{1}D°	2	*93 393.98*
$2p3d$	^{3}D°	1	*94 188.57*
		2	*94 189.26*
		3	*94 190.35*
$2p3d$	^{1}P°	1	*95 644a*
$2p4s$	^{1}P°	1	*97 600a*
$2p4p$	^{1}P	1	98 191.94
$2p4p$	^{3}P	0	99 163.59
		1	99 164.71
		2	99 166.77
$2p4d$	^{1}D°	2	*99 668.3*
$2p4d$	^{3}D°	1	*99 983.45*
		2	*99 983.98*
		3	*99 985.19*
$2p4f$	^{1}F	3	100 092.43 ?
$2p4f$	^{3}F	2	
		3	100 230.53 ?
		4	100 231.82 ?
$2p4d$	^{1}P°	1	*[100 568]a*
$2p5s$	^{1}P°	1	*101 400a*
$2p5p$	^{1}P	1	101 749.21
$2p5p$	^{3}P	0	102 195.75
		1	102 197.66
		2	102 199.38
$2p5d$	^{1}D°	2	*102 441.9*
$2p5d$	^{3}D°		*102 597.1*
$2p5f$	^{1}F	3	102 641.00 ?
$2p5d$	^{1}P°	1	*102 891a*
$2p6s$	^{1}P°	1	*103 330a*
$2p6p$	^{1}P	1	103 529.1
$2p6d$	^{1}P°	1	*104 181a*
$2p7s$	^{1}P°	1	*104 410a*
$2p7d$	^{1}P°	1	*104 959a*
$2p8s$	^{1}P°	1	*105 090a*
$2p8d$	^{1}P°	1	*105 468*
$2p9s$	^{1}P°	1	*105 520a*
$2p9d$	^{1}P°	1	*105 809*
$2p10s$	^{1}P°	1	*105 830a*

TABLE 2. Energy levels of Be I—Continued

Configuration	Term	J	Level (cm^{-1})
$2p10d$	$^1P^\circ$	1	*106 057*
$2p11s$	$^1P^\circ$	1	*106 080*
$2p12s$	$^1P^\circ$	1	*106 230*
$2p11d$	$^1P^\circ$	1	*106 246*
$2p13s$	$^1P^\circ$	1	*106 370*
$2p12d$	$^1P^\circ$	1	*106 384*
$2p13d$	$^1P^\circ$	1	*106 491*
$2p14d$	$^1P^\circ$	1	*106 578*
$2p15d$	$^1P^\circ$	1	*106 649*
$2p16d$	$^1P^\circ$	1	*106 708*
Be II ($^2P^\circ_{1/2}$)	*Limit*		*107 121.40*
Be II ($^2P^\circ_{3/2}$)	*Limit*		*107 127.98*
$3s3p$	$^1P^\circ$	1	*142 630a*
$3s4p$	$^1P^\circ$	1	*151 910a*
$3s7p$?	$^1P^\circ$?	1	*159 670a*
$3s8p$?	$^1P^\circ$?	1	*160 620a*
$3s9p$?	$^1P^\circ$?	1	*161 260a*
$3s10p$?	$^1P^\circ$?	1	*161 680a*
Be II $3s(^2S_{1/2})$	*Limit*		163 424.55
$1s2s^22p$	$^3P^\circ$	0,1,2	*921 900a*
$1s2s^22p$	$^1P^\circ$	1	*931 300a*
$1s(^2S)2s2p^2(^4P)$	^5P	1,2,3	931 800+x
$1s(^2S)2s2p^2(^4P)$	^3P	0,1,2	953 000a
$1s(^2S)2s2p^2(^2D)$	^3D	1,2,3	954 300a
$1s(^2S)2s2p^2(^2S)$	^3S	1	1 967 160a
$1s(^2S)2s2p^2(^2P)$	^3P	0,1,2	1 977 360a
$1s2s^23p$	$^1P^\circ$	1	*979 140a*
$1s(^2S)2p3(^4S^\circ)$	$^5S^\circ$	2	*984 186+x*
$1s(^2S)2s2p^2(^2P)$	^1P	1	985 900a
$1s2s^24p$?	$^1P^\circ$?	1	*988 140a*
$1s(^2S)2s2p(^3P^\circ)3p$	^5P	1,2,3	991 620+y
$1s2s^25p$?	$^1P^\circ$?	1	*991 500a*
Be II $1s2s^2(^2S_{1/2})$	*Limit*		994 900
$1s(^2S)2s2p(^3P^\circ)4p$	^5P	1,2,3	1 000 700+z
$1s(^2S)2s2p(^3P^\circ)3s$	$^1P^\circ$	1	*1 009 400a*
$1s(^2S)2s2p(^3P^\circ)3d$?	$^1P^\circ$?	1	*1 013 600?*
$1s(^2S)2s2p(^3P^\circ)4d$?	$^1P^\circ$?	1	*1 020 700?*
$1s(^2S)2s2p(^3P^\circ)4s$?	$^1P^\circ$?	1	*1 021 900?a*
$1s(^2S)2s2p(^1P^\circ)3s$	$^1P^\circ$	1	*1 026 300a*
$1s(^2S)2s2p(^1P^\circ)3d$?	$^1P^\circ$?	1	*1 028 400?a*
Be II $1s(^2S)2s2p(^3P^\circ)(^2P^\circ)$	*Limit*		*1 033 000*
$1s(^2S)2p^2(^3P)3p$	$^5S^\circ$	2	*1 035 601+y*
$1s(^2S)2s2p(^1P^\circ)4s$	$^1P^\circ$	1	*1 038 500a*
$1s(^2S)2p^2(^3P)4p$	$^5S^\circ$	2	*1 044 052+z*
Be II $1s(^2S)2s2p(^1P^\circ)(^2P^\circ)$	*Limit*		*1 050 900*
$1s2s(^3S)3s3p(^3P^\circ)$?	$^1P^\circ$?	1	*1 084 600?*
$1s2s(^3S)3s4p(^3P^\circ)$?	$^1P^\circ$?	1	*1 102 900?*
$1s2s(^1S)3s3p(^1P^\circ)$?	$^1P^\circ$?	1	*1 108 200?*
$1s2s(^1S)3s4p(^1P^\circ)$?	$^1P^\circ$?	1	*1 121 600?*

some extent. Seaton [1976] gives semiempirical formulas for small corrections to theoretical quantum defects that already include most of the perturbations for the $2snl$ series ($l=s, p, d, f$) [Norcross and Seaton 1976]. His method gave an optimal value of 75 192.5±0.1 cm^{-1} for the ionization energy, based on the experimental data for the $2sns$, nd and nf series. This agrees with the value adopted here (Table 2), which Beigang *et al.* [1983] derived from high $2sns$ ^1S and $2snd$ ^1D ($n \geqslant 15$) series members observed with laser spectroscopy. The adopted ionization energy is 0.57 cm^{-1} higher than Johansson's value [J62] because the latter was affected by perturbations of the $2snf\,^1F^\circ$ (and other) series members used in its derivation [Seaton 1976].

The most accurate calculations of the $2s^2$ ^1S, $2p^2$ ^1D, and $2s3d$ ^1D levels for which the resulting eigenvectors are available to us are those recently carried out by Weiss [1995] using the superposition-of-configurations method including both intershell and core-correlation corrections. He finds an 8.7% $2p^2$ ^1S contribution to the eigenvector for the $2s^2$ ^1S ground level, and a 15.4% $2p^2$ ^1D contribution to the nominal $2s3d$ ^1D eigenvector. The nominal $2p^2$ ^1D level has 60% $2p^2$ ^1D purity, with a calculated 39% total $2snd$ ^1D character. The position of the $2p^2$ ^1D level below the $2p^2$ ^3P term is of course due to the strong interaction with the $2snd$ ^1D series. Weiss's calculations and similar results obtained in earlier investigations [Fischer, 1984, Wen *et al.*, 1988] support Johansson's designations of the $2p^2$ ^1D and $2snd$ ^1D levels. We note that the resultant labeling of the high $2snd$ ^1D levels yields physically appropriate (small negative) quantum defects for this series.

The formulas and parameter values given by Norcross and Seaton [1976] and Seaton [1976] yield predicted values for all $2snl$ terms ($l=s, p, d, f$) through $n=10$, and values for higher levels can be obtained by interpolation between $n=10$ and $n=\infty$. Predicted values for the $2snd$ ^1D series members can also be obtained by use of the two-channel quantum-defect parameters given by Beigang *et al.* Seaton compared predicted and observed values for terms in the range $n \leqslant 10$ and noted the probability that his predicted values for several particular $2sns$, np, or nd terms were more accurate than the experimental values.

The experimental wavelength for the $2s3s$ ^3S–$2s5p$ $^3P^\circ$ line near 5558 Å is from Hontzeas *et al.*, this unresolved multiplet having been masked in Johansson's spectra. The predicted value for the $2s5p$ $^3P^\circ$ position in Table 2 is from Seaton's parameterization of the $2snp$ $^3P^\circ$ series. Seaton's discussion would indicate an uncertainty less than 0.1 cm^{-1} for the $2s5p$ $^3P^\circ$ value, which corresponds to an error smaller than 0.03 Å in the calculated wavelength for the above line. The adopted $2s5p$ $^3P^\circ$ position and, consequently, the $2p5p$ ^3P levels are 0.19 cm^{-1} lower than the previous values [H69, J74].

We give values of the $2snp$ $^1P^\circ$ levels for $7 \leqslant n \leqslant 13$ as predicted by Johansson's parameters for this series. The errors are probably of the order of 1 cm^{-1} or less, whereas the estimated uncertainty of the measurements of the corresponding resonance lines [E72] is ~16 cm^{-1}. Seaton's method should be more accurate than Johansson's formulae for other series, but a less accurate fit of the $^1P^\circ$ series was apparently obtained by Seaton; we used the simpler method of Johansson, since neither of these parameterizations can be assumed to have high accuracy for this series.

Johansson [1974] remarked that his classifications of four lines (3125−3139 Å) as transitions from $2p4f$ and $2p5f$ levels needed confirmation; we list these levels as tentative.

The value of the $2p^2\ ^1S$ autoionizing level is from the determination by Clark *et al.* of its position at 997±5 cm^{-1} above the Be II $2s\ ^2S$ ionization energy. Clark *et al.* also used multiphoton resonance-ionization mass spectrometry to observe three-photon $2pnd\ ^1P^\circ$ resonances (n=3–16); these $^1P^\circ$ levels here are from their data, the $2p4d\ ^1P^\circ$ position having been calculated by us using an interpolated value for the quantum defect. The uncertainties are 5–6 cm^{-1}, so that the Ritz wavelengths of the $2s^2\ ^1S-2pnd\ ^1P^\circ$ series in the 1000 Å region should be accurate to about 0.05 Å. These calculated wavelengths for n=3–6 agree with the "peak-absorption" wavelengths of the corresponding asymmetric photoabsorption features from Mehlman-Balloffet and Esteva [1969] within the ±0.5 Å uncertainties of the measurements, whereas the wavelengths of the $2p4d$, $5d$ and $6d\ ^1P^\circ$ features as determined by Esteva *et al.* [1972] are shorter than the Ritz wavelengths by more than 2 Å.

The $2pns\ ^1P^\circ$ levels (n=3–13) are from the measurements by Esteva *et al.* of the very asymmetric, autoionization-broadened $2s^2\ ^1S-2pns\ ^1P^\circ$ absorption features in the range 940−1134 Å. The estimated errors vary from several Å (equivalent to several hundred cm^{-1}) for n=3 and 4 down to perhaps 1 Å or less (~100 cm^{-1}) for the sharpest features.

We also took the $3snp\ ^1P^\circ$ levels from the corresponding absorption-series measurements [E72], but with the interpretation by Lendel *et al.* of the structures above n=4. According to their theoretical analysis, neither $3s5p\ ^1P^\circ$ nor $3s6p\ ^1P^\circ$ is an appropriate designation for any of the observed resonances. We give the $3snp\ ^1P^\circ$ designations for n>4 as tentative: in addition to the perturbation of this series by $3p4s\ ^1P^\circ$, discussed by Lendel *et al.*, more recent calculations indicate strong interactions with $3pnd\ ^1P^\circ$ terms [Kramida 1995].

4. *K*-Shell Excitation

Most of the *K*-shell excitation levels in Table 2 are derived from absorption features measured by Mehlman and Esteva [1974] in the region near 100 Å (1 000 000 cm^{-1}). Their estimated uncertainties varied from 0.02 to 0.05 Å (~200–500 cm^{-1}), depending on the line breadths. Pending more accurate calculations of the complex structure in this region, we give several of these levels involving an nd or higher np electron as tentative. Recent calculations including configuration interaction indicate that single-configuration designations are meaningless for some of these levels [Kramida 1995]. We took the positions of two levels in this region from Jannitti *et al.* The values for the three Be II *K*-excitation limit terms in Table 2 are from Mehlman and Esteva.

We evaluated the $1s2s^22p\ ^3P^\circ$, $1s(^2S)2s2p^2(^4P)\ ^3P$, and $1s(^2S)2s2p^2(^2P)\ ^1P$ positions using the ejected-electron energies measured by Rødbro *et al.* [1979], the identifications having been made or confirmed by Chung [1990]. The uncertainties are 1000–2000 cm^{-1}. On the basis of his calculations, Chung assigned nine features in the Auger spectra as arising from Be I *K*-excitation; some of the corresponding terms have been more accurately determined in photoabsorption spectra or by theoretical calculations (see below).

Three lines observed in Be beam-foil spectra have been reliably classified as transitions between Be I *K*-excitation quintet terms [Brooks *et al.* 1980, Agentoft *et al.* 1983]: $1s2s2p^2\ ^5P-1s2p^3\ ^5S^\circ$ (1908.5±0.6 Å), $1s2s2p3p\ ^5P-1s2p^23p\ ^5S^\circ$ (2273.0±0.2 Å), and $1s2s2p4p\ ^5P-1s2p^24p\ ^5S^\circ$ (2306 Å). These lines are the first three members of a $1s2s2pnp\ ^5P-1s2p^2np\ ^5S^\circ$ satellite series approaching the Be II $1s2s2p\ ^4P^\circ-1s2p^2\ ^4P$ line at 2324.6 Å. In Table 2 we give level values for these quintet terms based on theoretical calculations for the three ^5P terms combined with experimental wavenumbers of the three lines. The ^5P positions relative to the Be I ground level were obtained by combining theoretical total binding energies for the ^5P levels with the accurately known total binding energy for the ground level. The accurate nonrelativistic energies calculated for the $1s2s2p3p\ ^5P$ and $1s2s2p4p\ ^5P$ terms by Bunge and Rubio were decreased by a relativistic contribution of 440 cm^{-1} taken from the calculations of Agentoft *et al.* The $1s2s2p^2\ ^5P$ energy calculated by Agentoft *et al.* was, on the other hand, reduced by a correction of 990 cm^{-1}, based on comparisons of their values for the nonrelativistic $1s2s2p3p\ ^5P$ and $1s2s2p4p\ ^5P$ energies with the more accurate values of Bunge and Rubio.

The position of the $1s2s2p^2\ ^5P$ term in Table 2 should be accurate within an error of, at most, a few hundred cm^{-1}, and the errors of the $1s2s2p3p\ ^5P$ and $1s2s2p4p\ ^5P$ positions are probably less than 100 cm^{-1}. We have given the upper $^5S^\circ$ levels for the above three transitions to the nearest cm^{-1}, the experimental separations between these levels and the corresponding lower ^5P levels having estimated uncertainties of about 20 cm^{-1} for the $1s2p^3$ and $1s2p^24p\ ^5S^\circ$ levels, and 4 cm^{-1} for the $1s2p^23p\ ^5S^\circ$ level. The ^5P and corresponding $^5S^\circ$ level involved in each transition have "$+x$," "$+y$," or "$+z$" following their values to indicate an unknown correction for each of the three $^5P/^5S^\circ$ two-level systems with respect to the ground level. According to the above estimates, the uncertainties of these corrections are comparable with, or smaller than, the uncertainties of the other best-determined *K*-excitation levels in Table 2; the unknown corrections are nevertheless indicated explicitly because they may well be larger than the errors of any of the *L*-excitation levels also given to the nearest cm^{-1}.

5. Ritz Wavelengths Calculated from the Energy Levels

Wavelengths in vacuum calculated from energy-level differences (Ritz wavelengths) are given for all lines in Table 1. In addition, for the lines above 2000 Å we have included Ritz wavelengths in air under standard conditions as obtained from the five-parameter air-dispersion formula of Peck and Reeder [1972].

The Ritz wavelength should in general be more accurate than the observed value wherever the difference is more than one or two units in the last decimal place. In addition to the Ritz wavelengths predicted from bracketed level values derived from series formulas or other methods noted above, various other Ritz wavelengths are significantly more accurate than the corresponding observed values. The better accuracy of the Ritz wavelengths for the $2s^2\ ^1S-2pnd\ ^1P^{\circ}$ series was noted above, and we also can point to the relatively high accuracy of the Ritz wavelengths for the $2s^2\ ^1S-2snp\ ^1P^{\circ}$ lines (n=6–13) below 1400 Å. As another example, the estimated errors of most of the three-place Ritz wavelengths for the $2s2p\ ^3P^{\circ}-2sns\ ^3S$ and $2s2p\ ^3P^{\circ}-2snd\ ^3D$ series members in the 1907–2495 Å region are in the range 0.002–0.010 Å, and the errors of the two-place Ritz values are about 0.02 Å; whereas the measurements of the higher members of these series [Paschen and Kruger, 1931] have expected errors up to about 0.05 Å. Although the available measurements have not resolved the $2s2p\ ^3P^{\circ}$ fine structure for most lines of these series, the accurate triplet fine structures predicted by the Ritz wavelengths may be useful for future higher-resolution observations. The Ritz wavelengths also comprise relatively accurate values for a number of poorly measured (usually weak and/or blended) lines in various regions of the spectrum.

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