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Spectral investigation of doubly ionized rubidium (Rb III) from relativistic Hartree-Fock calculations

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Abstract. Radiative decay parameters (oscillator strengths, transition probabilities) for spectral lines in doubly ionized rubidium (Rb III) are reported for the first time. They have been obtained using a pseudo-relativistic Hartree-Fock (HFR) model including a large amount of intravalence correlation as well as core-polarization effects. The spectroscopic data listed in the present paper cover a wide range of wavelengths from extreme ultraviolet to near infrared.

1 Introduction

Notably because of their great interest in stellar nucleosynthesis, the atomic structures characterizing the first three spectra of the fifth row elements, from rubidium ($Z = 37$) to xenon ($Z = 54$), have been the subject of many experimental and theoretical investigations over the past few years. However, there still remains some ions for which no radiative data have been published so far. If we consider the doubly ionized species for example, according to the National Institute of Standards and Technology (NIST) bibliographic database [1], it appears that transition rates are completely missing in the literature for six ions, i.e. Rb III, Sr III, Mo III, Tc III, I III and Xe III. In order to partly fill in this gap, the present paper focuses on the particular case of Rb III for which we report transition probabilities and oscillator strengths calculated using a pseudo-relativistic Hartree-Fock (HFR) model including a large amount of electron correlation as well as core-polarization effects.

Doubly ionized rubidium (Rb III) is the third member of the bromine (Br I) isoelectronic sequence with the ground configuration $4s^24p^5$ consisting in the fundamental level $^2\mathrm{P}^\circ_{3/2}$ and the first excited level $^2\mathrm{P}^\circ_{1/2}$. The excited configurations are of the type $4s4p^6$ and $4s^24p^4nl$ ($nl = 4d, 5s, 5p, 6s, 5d, \ldots$). Reliable radiative data in this ion are particularly needed for stellar spectra observations, the astrophysical importance of rubidium having been underlined in many previous papers, such as those recently published in the context of spectroscopic observations of interstellar medium [2], intermediate-mass asymptotic giant branch stars [3] or globular clusters [4].

The present work can be seen as an extension of our recent investigations of the fifth row elements Y II, Y III [5], Zr II [6], Nb I [7], Nb II, Nb III [8], Mo II [9–11], Tc II [12], Ru I [13], Ru II, Ru III [14], Rh II [15,16], Rh III [17], Pd I [18], Pd III [17], Ag II [19,20], Ag III [17], Sn I [21–23], Sb I [24], Te II and Te III [25].

2 The Rb III spectrum

In 2006, Sansonetti [26] published a comprehensive compilation of wavelengths, energy levels and transition probabilities for the spectra of rubidium atom and ions from Rb I to Rb XXXVII. For this compilation, the literature for each ionization stage of rubidium has been reviewed, and lists of the most accurate wavelengths and energy levels have been assembled. In the case of Rb III, 232 observed spectral lines were reported between 465 and 4677 Å while 91 experimental energy levels belonging to the $4s^24p^5$, $4s4p^6$, $4s^24p^44d$, $4s^24p^45s$, $4s^24p^45p$, $4s^24p^46s$ and $4s^24p^45d$ configurations were listed. These data were based on previous works due to Tomboulian [27], Reader and Epstein [28], Hansen et al. [29] and Reader [30]. More precisely, the Rb III spectrum was first observed by Tomboulian [27] who measured the wavelengths between 250 and 2500 Å, found the $4p^5$ $^2\mathrm{P}^\circ$ interval, and identified 15 excited levels. More than thirty years later, the region 400–820 Å was investigated by Reader and Epstein [28] who identified transitions from the $4s4p^6$, $4s^24p^44d$ and $4s^24p^45s$ configurations to the $4s^24p^5$ $^2\mathrm{P}^\circ$ ground term and transitions from the $4s^24p^45p$ levels to the $4s^24p^44d$ and $4s^24p^45s$ configurations. Using a sliding spark, Hansen et al. [29] recorded spectra of Rb III between 370 and 3500 Å and published most of the levels belonging to the $4s^24p^45d$ and $4s^24p^46s$ configurations as well as those observed by Reader and Epstein [28]. These observations were then extended by Reader [30] to include a few more lines in the 1480–2660 and 4400–4700 Å

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Table 1. Radial parameters (in cm^{-1}) adopted for odd-parity configurations in Rb III.

Config.	Parameter	HFR	Fitted	Unc.	Ratio
$4p^5$	E_{av}	14 062	14 238	1	
	ζ_{4p}	4687	4997	1	1.07
$4p^4 5p$	E_{av}	221 972	212 763	7	
	$F^2(4p,4p)$	66 618	54 570	27	0.82
	α		–28	3	
	ζ_{4p}	5107	5278	3	1.03
	ζ_{5p}	693	847	3	1.22
	$F^2(4p,5p)$	14 551	11 894	24	0.82
	$G^0(4p,5p)$	3161	2543	3	0.80
	$G^2(4p,5p)$	4070	3293	12	0.81
$4p^5$–$4p^4 5p$	$R^0(4p,4p;4p,5p)$	1764	1588	fixed	0.90
	$R^2(4p,4p;4p,5p)$	8476	7628	fixed	0.90

regions. He located the missing levels of the $4s^2 4p^4 4d$ and $4s^2 4p^4 5p$ configurations and the $4s^2 4p^4(^1D)5d\ ^2G_{9/2}$ level and gave improved values for 13 previously identified levels.

In summary, in the seven lowest configurations of Rb III, i.e. $4s^2 4p^5$, $4s4p^6$, $4s^2 4p^4 4d$, $4s^2 4p^4 5s$, $4s^2 4p^4 5p$, $4s^2 4p^4 6s$ and $4s^2 4p^4 5d$, all the energy levels have been experimentally determined up to now if we except $4p^4(^3P)5d\ ^4F_{7/2}$, $4p^4(^3P)5d\ ^4F_{9/2}$, $4p^4(^1S)5d\ ^2D_{3/2}$, $4p^4(^1S)5d\ ^2D_{5/2}$ and $4p^4(^1S)6s\ ^2S_{1/2}$.

3 Atomic structure calculations

The computational procedure that we have used for calculating the atomic structure and radiative parameters in Rb III is the pseudo-relativistic Hartree-Fock (HFR) method originally described by Cowan [31] and modified to take core-polarization effects (CPOL) into account giving rise to the HFR + CPOL approach (see e.g. Refs. [32,33]). In this technique, intravalence correlation effects are considered by means of explicit introduction of interacting configurations in the physical model while core-valence contributions are estimated by using a core-polarization potential and a correction to the dipole operator depending on two parameters, i.e. the dipole polarizability of the ionic core, α_d, and the cut-off radius, r_c, which can be seen as a measure of the size of the ionic core.

In our calculations, configuration interaction was explicitly retained among the following 15 odd-parity and 13 even-parity configurations:

$$4s^2 4p^5 + 4s^2 4p^4 5p + 4s^2 4p^4 6p + 4s^2 4p^4 4f + 4s^2 4p^4 5f + 4s^2 4p^4 6f + 4s^2 4p^3 4d^2 + 4s^2 4p^3 4f^2 + 4s^2 4p^3 5s^2 + 4s^2 4p^3 5p^2 + 4s^2 4p^3 4d5s + 4s^2 4p^3 4f5p + 4s4p^5 4d + 4s4p^5 5d + 4s4p^5 5s$$

and

$$4s4p^6 + 4s^2 4p^4 4d + 4s^2 4p^4 5d + 4s^2 4p^4 6d + 4s^2 4p^4 5s + 4s^2 4p^4 6s + 4s^2 4p^3 4d5p + 4s^2 4p^3 5s5p + 4s^2 4p^3 4d4f + 4s^2 4p^3 4f5s + 4s4p^5 5p + 4s4p^5 4f + 4s4p^5 5f.$$

For the dipole polarizability, α_d, we used the value of 0.1576 a.u. corresponding to the $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10}$ Ni (Cu^+)-like Rb X ionic core. This value was taken from the work of Johnson et al. [34] who published theoretical values of electric-dipole, electric-quadrupole and magnetic-dipole susceptibilities (polarizabilities) calculated in the relativistic random-phase approximation (RRPA) for closed shell ions of He, Ne, Ar, Ni (Cu^+), Kr, Pb and Xe isoelectronic sequences. The cut-off radius, r_c, was chosen equal to 0.52 a.u. which corresponds to the HFR average value $\langle r \rangle$ for the outermost $3d$ core orbital.

In order to minimize the discrepancies between experimental and computed energy levels, the radial parameters were adjusted using a well established least-squares optimization program [31]. The data required for the fitting procedure were taken from the compilation of Sansonetti [26]. More precisely, in the odd parity, the 23 known experimental energy level values were used to adjust all the radial parameters (average energies, E_{av}, Slater integrals, F^k, G^k, spin-orbit parameters, ζ_{nl} and effective interaction parameter, α, corresponding to the $4p^5$ and $4p^4 5p$ configurations. In the case of even parity, all the 68 level values listed in Sansonetti's compilation were considered to optimize the radial parameters describing the $4s4p^6$, $4p^4 4d$, $4p^4 5d$, $4p^4 5s$ and $4p^4 6s$ configurations, including the generalized Slater integrals (R^k) corresponding to interactions between those configurations.

The numerical values of the parameters adopted in the present calculations are reported in Tables 1 and 2 for odd and even parities, respectively. Note that all the F^k, G^k and R^k integrals, not optimized in our fitting process, were scaled down by a factor of 0.90 as suggested by Cowan [31]. The computed energies, Landé g-factors and the main eigenvector components are reported in Tables 3 and 4 for each level belonging to $4p^5$, $4p^4 5p$ odd-parity and $4s4p^6$, $4p^4 4d$, $4p^4 5d$, $4p^4 5s$, $4p^4 6s$ even-parity configurations, respectively. When comparing our results to the available experimental energy levels (also listed in Tabs. 3 and 4), the mean deviations were found to be 25 cm^{-1}, for the odd parity, and 111 cm^{-1}, for the even parity.

LS-coupling compositions were chosen for all the configurations considered in our work, the average purities obtained using this particular coupling scheme being found

Table 2. Radial parameters (in cm^{-1}) adopted for even-parity configurations in Rb III.

Config.	Parameter	HFR	Fitted	Unc.	Ratio
$4s4p^6$	E_{av}	178 671	161 301	178	
$4p^44d$	E_{av}	188 900	179 030	47	
	$F^2(4p,4p)$	652 57	525 35	71	0.81
	α		22	4	
	ζ_{4p}	4911	5264	14	1.07
	ζ_{4d}	191	253	7	1.32
	$F^2(4p,4d)$	434 93	373 59	118	0.86
	$G^1(4p,4d)$	509 29	397 70	363	0.78
	$G^3(4p,4d)$	308 93	246 82	260	0.80
$4p^45d$	E_{av}	264 341	253 622	221	
	$F^2(4p,4p)$	666 34	535 86	2196	0.80
	α		13	122	
	ζ_{4p}	5100	5301	65	1.04
	ζ_{5d}	51	60	3	1.18
	$F^2(4p,5d)$	9942	7798	33	0.78
	$G^1(4p,5d)$	8261	4720	816	0.57
	$G^3(4p,5d)$	5411	4035	135	0.75
$4p^45s$	E_{av}	190 907	182 143	17	
	$F^2(4p,4p)$	661 64	523 11	116	0.79
	α		82	4	
	ζ_{4p}	5055	5162	92	1.02
	$G^1(4p,5s)$	5727	4893	53	0.85
$4p^46s$	E_{av}	262 567	251 539	175	
	$F^2(4p,4p)$	666 91	505 66	3535	0.76
	α		183	188	
	ζ_{4p}	5115	5362	104	1.05
	$G^1(4p,6s)$	1619	1302	118	0.80
$4s4p^6$–$4p^44d$	$R^1(4p,4p;4s,4d)$	640 53	498 12	181	0.78
$4s4p^6$–$4p^45d$	$R^1(4p,4p;4s,5d)$	260 63	209 31	1136	0.80
$4s4p^6$–$4p^45s$	$R^1(4p,4p;4s,5s)$	1231	1108	fixed	0.90
$4s4p^6$–$4p^46s$	$R^1(4p,4p;4s,6s)$	256	231	fixed	0.90
$4p^44d$–$4p^45d$	$R^0(4p,4d;4p,5d)$	1858	1453	44	0.78 r1
	$R^2(4p,4d;4p,5d)$	141 60	110 76	338	0.78 r1
	$R^1(4p,4d;4p,5d)$	197 44	154 43	471	0.78 r1
	$R^3(4p,4d;4p,5d)$	123 98	9697	296	0.78 r1
$4p^44d$–$4p^45s$	$R^2(4p,4d;4p,5s)$	–107 87	–8903	139	0.83 r2
	$R^1(4p,4d;4p,5s)$	–3187	–2631	41	0.83 r2
$4p^44d$–$4p^46s$	$R^2(4p,4d;4p,6s)$	–5004	–4131	65	0.83 r2
	$R^1(4p,4d;4p,6s)$	–1997	–1649	26	0.83 r2
$4p^45d$–$4p^45s$	$R^2(4p,5d;4p,5s)$	3239	2621	665	0.81 r3
	$R^1(4p,5d;4p,5s)$	378	306	78	0.81 r3
$4p^45d$–$4p^46s$	$R^2(4p,5d;4p,6s)$	–2043	–1653	419	0.81 r3
	$R^1(4p,5d;4p,6s)$	–49	–40	10	0.81 r3

r1, r2, r3: ratios of these parameters have been fixed in the fitting process.

to be equal to 97% for $4p^5$, 72% for $4p^45p$, 67% for $4s4p^6$, 63% for $4p^44d$, 67% for $4p^45s$, 62% for $4p^45d$ and 76% for $4p^46s$. Energy levels were also classified using LS-coupling designations in Sansonetti's compilation [26] except for members of the $4p^45s$ and $4p^45p$ configurations which were given in J_1j coupling and pair-coupling, respectively. It is interesting to note here that these latter couplings do not appear substantially better than the LS-coupling, the average purities being found to be equal to 65% in J_1j coupling for $4p^45s$ and 76% in pair-coupling for $4p^45p$, which is similar to the average LS purities obtained in our work for the same configurations, i.e. 67% and 72%, respectively.

4 Computed oscillator strengths and transition probabilities

The theoretical weighted oscillator strengths in the logarithmic scale, $\log gf$, and weighted transition

Table 3. Experimental and calculated odd-parity energy levels in Rb III. Energies are given in cm^{-1}.

E_{exp}^{a}	E_{calc}	ΔE	g-factor	J	Leading components (in %) in LS coupling[b]
0.0	0	0	1.334	1.5	97% $4p^5\ ^2$P
7374.5	7374	0	0.666	0.5	97% $4p^5\ ^2$P
198 108.00	198 066	43	1.553	2.5	81% $4p^4(^3P)5p\ ^4$P + 16% $4p^4(^3P)5p\ ^4$D
198 339.83	198 348	–8	1.653	1.5	70% $4p^4(^3P)5p\ ^4$P + 8% $4p^4(^3P)5p\ ^4$S + 7% $4p^4(^3P)5p\ ^4$D
200 471.55	200 534	–63	1.959	0.5	58% $4p^4(^3P)5p\ ^4$P + 18% $4p^4(^3P)5p\ ^2$P + 11% $4p^4(^1D)5p\ ^2$P
200 904.85	200 888	16	1.414	3.5	94% $4p^4(^3P)5p\ ^4$D + 5% $4p^4(^1D)5p\ ^2$F
201 148.86	201 140	9	1.242	2.5	65% $4p^4(^3P)5p\ ^2$D + 23% $4p^4(^3P)5p\ ^4$D + 6% $4p^4(^1D)5p\ ^2$F
204 656.66	204 625	32	1.242	1.5	29% $4p^4(^3P)5p\ ^4$D + 26% $4p^4(^3P)5p\ ^2$D + 25% $4p^4(^3P)5p\ ^2$P
204 931.05	204 970	–39	1.604	0.5	37% $4p^4(^3P)5p\ ^4$P + 30% $4p^4(^3P)5p\ ^2$P + 15% $4p^4(^3P)5p\ ^2$S
206 380.68	206 338	42	0.159	0.5	90% $4p^4(^3P)5p\ ^4$D
206 465.50	206 463	2	1.255	1.5	56% $4p^4(^3P)5p\ ^4$D + 33% $4p^4(^3P)5p\ ^2$P + 6% $4p^4(^1D)5p\ ^2$P
206 877.52	206 822	55	1.347	2.5	59% $4p^4(^3P)5p\ ^4$D + 29% $4p^4(^3P)5p\ ^2$D + 11% $4p^4(^3P)5p\ ^4$P
209 115.86	209 114	2	1.240	1.5	43% $4p^4(^3P)5p\ ^2$D + 15% $4p^4(^3P)5p\ ^4$S + 15% $4p^4(^3P)5p\ ^2$P
209 327.25	209 332	–4	1.626	1.5	62% $4p^4(^3P)5p\ ^4$S + 27% $4p^4(^3P)5p\ ^2$D + 7% $4p^4(^3P)5p\ ^4$P
209 717.04	209 825	–108	1.603	0.5	71% $4p^4(^3P)5p\ ^2$S + 20% $4p^4(^3P)5p\ ^2$P
216 235.44	216 246	–10	0.887	2.5	91% $4p^4(^1D)5p\ ^2$F
217 262.38	217 254	8	1.159	3.5	94% $4p^4(^1D)5p\ ^2$F + 5% $4p^4(^3P)5p\ ^4$D
218 711.04	218 749	–38	1.313	1.5	72% $4p^4(^1D)5p\ ^2$P + 10% $4p^4(^3P)5p\ ^2$P + 9% $4p^4(^1D)5p\ ^2$D
220 856.92	220 818	39	0.875	1.5	86% $4p^4(^1D)5p\ ^2$D + 8% $4p^4(^3P)5p\ ^2$P
221 044.60	221 050	–5	1.203	2.5	94% $4p^4(^1D)5p\ ^2$D
222 301.41	222 278	23	0.676	0.5	69% $4p^4(^1D)5p\ ^2$P + 28% $4p^4(^3P)5p\ ^2$P
238 894.2	238 883	11	0.668	0.5	90% $4p^4(^1S)5p\ ^2$P
239 587.7	239 596	–8	1.334	1.5	91% $4p^4(^1S)5p\ ^2$P

[a]From [26]. [b]Only the first three components larger than 5% are given.

probabilities, gA, computed in the present work are reported in Table 5 for 538 Rb III lines alongside the numerical values of the lower and upper energy levels of the transitions and the corresponding wavelengths in Å. Only transitions for which $\log gf$-values are greater than –2 are listed in the table. It was indeed found that most of transitions with $\log gf < -2$ were affected by cancellation effects. As a reminder, in order to calculate gA or gf for a transition between the atomic states γJ and $\gamma' J'$, we have to compute the value of the line strength

$$S = \left|\langle \gamma J \|\, P^{(1)}\, \| \gamma' J' \rangle\right|^2 \tag{1}$$

or that of its square root

$$S^{1/2} = \langle \gamma J \|\, P^{(1)}\, \| \gamma' J' \rangle \tag{2}$$

where $P^{(1)}$ is the electric dipole operator. Because of intermediate coupling and configuration interaction mixing, the wavefunctions are expanded in terms of basis functions:

$$|\gamma J\rangle = \sum_{\beta} y^{\gamma}_{\beta J} |\beta J\rangle, \tag{3}$$

$$|\gamma' J'\rangle = \sum_{\beta'} y^{\gamma'}_{\beta' J'} |\beta' J'\rangle. \tag{4}$$

We may then write (2) in the form

$$S^{1/2} = \sum_{\beta} \sum_{\beta'} y^{\gamma}_{\beta J} \left\langle \beta J || P^{(1)} || \beta' J' \right\rangle y^{\gamma'}_{\beta' J'}. \tag{5}$$

This sum thus represents a mixing of amplitudes rather than line strengths themselves with the consequence that the effect of mixing is not necessarily a tendency to average out the various line strengths. There are frequently destructive interference effects that cause a weak line to become still weaker. In this context, the cancellation factor is given by:

$$CF = \left[\frac{\left| \sum_{\beta} \sum_{\beta'} y^{\gamma}_{\beta J} \langle \beta J |\, |P^{(1)}|\, | \beta' J' \rangle\, y^{\gamma'}_{\beta' J'} \right|}{\sum_{\beta} \sum_{\beta'} \left| y^{\gamma}_{\beta J} \langle \beta J |\, |P^{(1)}|\, | \beta' J' \rangle\, y^{\gamma'}_{\beta' J'} \right|} \right]^2. \tag{6}$$

According to Cowan [31], very small values of this factor (typically when CF is smaller than about 0.05) indicate that the corresponding transition rates may be expected to show large percentage errors. In Figure 1, CF-factors are plotted as a function of $\log gf$ for all Rb III transitions. As seen from this figure, it is clear that most of lines with $\log gf$ smaller than –2 are affected by very small values of CF indicating that the corresponding decay rates could be unreliable. On the contrary, most of the transitions listed in Table 5, in particular those with $\log gf > -1$, do not appear to be affected by cancellation effects.

It was found that core-polarization effects considered in our physical model, by assuming a Rb X ionic core of 28 electrons occupying closed shells up to $3d$ surrounded by 7 valence electrons, have an influence of the order of a few percent (within 15%) on the final oscillator strengths. It was also verified that our computed transition rates are very little sensitive to small changes of core-polarization parameters used in the model potential. As an example,

Table 4. Experimental and calculated even-parity energy levels in Rb III. Energies are given in cm^{-1}.

E_{exp}[a]	E_{calc}	ΔE	g-factor	J	Leading components (in %) in LS coupling[b]
130 032.2	130 032	0	2.003	0.5	67% $4s4p^6\ ^2S$ + 31% $4p^4(^1D)4d\ ^2S$
154 721.27	154 808	–86	1.417	3.5	93% $4p^4(^3P)4d\ ^4D$
154 877.27	154 892	–15	1.362	2.5	91% $4p^4(^3P)4d\ ^4D$
155 564.24	155 590	–26	1.198	1.5	90% $4p^4(^3P)4d\ ^4D$
156 393.46	156 530	–136	0.087	0.5	91% $4p^4(^3P)4d\ ^4D$
162 918.68	162 708	210	1.320	4.5	93% $4p^4(^3P)4d\ ^4F$ + 6% $4p^4(^1D)4d\ ^2G$
165 541.48	165 285	257	1.211	3.5	79% $4p^4(^3P)4d\ ^4F$ + 12% $4p^4(^3P)4d\ ^2F$ + 6% $4p^4(^1D)4d\ ^2G$
166 088.20	166 864	–776	0.944	0.5	38% $4p^4(^1D)4d\ ^2P$ + 35% $4p^4(^3P)4d\ ^2P$ + 15% $4p^4(^3P)4d\ ^4P$
167 086.06	167 056	30	1.577	2.5	79% $4p^4(^3P)5s\ ^4P$ + 14% $4p^4(^3P)4d\ ^4P$
167 819.74	167 621	198	1.039	2.5	94% $4p^4(^3P)4d\ ^4F$
168 085.32	167 965	120	1.469	1.5	42% $4p^4(^3P)4d\ ^4P$ + 20% $4p^4(^3P)5s\ ^4P$ + 9% $4p^4(^3P)5s\ ^2P$
168 449.92	168 400	49	2.299	0.5	70% $4p^4(^3P)4d\ ^4P$ + 10% $4p^4(^3P)4d\ ^2P$ + 10% $4p^4(^3P)5s\ ^4P$
168 750.71	168 525	225	0.521	1.5	88% $4p^4(^3P)4d\ ^4F$ + 5% $4p^4(^3P)4d\ ^4P$
170 423.82	170 576	–152	0.938	1.5	36% $4p^4(^1D)4d\ ^2D$ + 28% $4p^4(^3P)4d\ ^2D$ + 13% $4p^4(^3P)4d\ ^2P$
171 159.30	171 264	–105	1.133	3.5	64% $4p^4(^3P)4d\ ^2F$ + 15% $4p^4(^3P)4d\ ^4F$ + 12% $4p^4(^1D)4d\ ^2G$
172 041.74	172 090	–48	1.424	1.5	35% $4p^4(^3P)5s\ ^2P$ + 35% $4p^4(^3P)4d\ ^4P$
172 525.74	172 685	–160	1.442	1.5	40% $4p^4(^3P)5s\ ^4P$ + 18% $4p^4(^1D)4d\ ^2P$ + 14% $4p^4(^3P)4d\ ^2P$
173 415.56	173 386	29	1.447	2.5	56% $4p^4(^3P)4d\ ^4P$ + 15% $4p^4(^3P)5s\ ^4P$ + 10% $4p^4(^3P)4d\ ^2F$
174 575.13	174 421	154	1.249	2.5	27% $4p^4(^1D)4d\ ^2D$ + 25% $4p^4(^3P)4d\ ^4P$ + 19% $4p^4(^3P)4d\ ^2D$
175 434.49	175 349	85	2.630	0.5	83% $4p^4(^3P)5s\ ^4P$ + 12% $4p^4(^3P)4d\ ^4P$
176 458.02	176 616	–158	1.510	1.5	38% $4p^4(^3P)5s\ ^2P$ + 36% $4p^4(^3P)5s\ ^4P$ + 11% $4p^4(^3P)4d\ ^4P$
177 062.82	177 246	–183	0.961	2.5	63% $4p^4(^3P)4d\ ^2F$ + 16% $4p^4(^1D)4d\ ^2D$ + 8% $4p^4(^3P)4d\ ^2D$
178 239.98	177 982	258	1.125	4.5	93% $4p^4(^1D)4d\ ^2G$ + 6% $4p^4(^3P)4d\ ^4F$
178 322.45	177 977	345	0.939	3.5	81% $4p^4(^1D)4d\ ^2G$ + 14% $4p^4(^3P)4d\ ^2F$
179 095.92	179 000	95	0.715	0.5	94% $4p^4(^3P)5s\ ^2P$
186 615.76	186 573	43	1.026	2.5	51% $4p^4(^1D)4d\ ^2F$ + 44% $4p^4(^1D)5s\ ^2D$
187 167.80	187 124	44	0.835	1.5	90% $4p^4(^1D)5s\ ^2D$ + 6% $4p^4(^3P)5s\ ^2P$
187 392.77	187 516	–123	1.065	2.5	47% $4p^4(^1D)5s\ ^2D$ + 39% $4p^4(^1D)4d\ ^2F$ + 7% $4p^4(^1D)4d\ ^2D$
188 488.28	188 583	–94	1.144	3.5	88% $4p^4(^1D)4d\ ^2F$ + 9% $4p^4(^3P)4d\ ^2F$
200 876.2	200 704	173	0.881	1.5	48% $4p^4(^1S)4d\ ^2D$ + 27% $4p^4(^1D)4d\ ^2D$ + 10% $4p^4(^1D)4d\ ^2P$
202 644.0	203 065	–421	1.196	2.5	38% $4p^4(^1D)4d\ ^2D$ + 28% $4p^4(^3P)4d\ ^2D$ + 25% $4p^4(^1S)4d\ ^2D$
204 096.3	204 144	–47	1.914	0.5	70% $4p^4(^1S)5s\ ^2S$ + 11% $4p^4(^1D)4d\ ^2S$ + 5% $4s4p^6\ ^2S$
204 223.5	204 316	–93	1.203	1.5	37% $4p^4(^3P)4d\ ^2P$ + 31% $4p^4(^1D)4d\ ^2P$ + 14% $4p^4(^1D)4d\ ^2D$
207 113.9	206 995	119	1.199	2.5	63% $4p^4(^1S)4d\ ^2D$ + 25% $4p^4(^3P)4d\ ^2D$ + 5% $4p^4(^3P)5d\ ^2D$
207 263.3	206 924	339	0.785	0.5	42% $4p^4(^1D)4d\ ^2P$ + 41% $4p^4(^3P)4d\ ^2P$ + 8% $4p^4(^1S)5s\ ^2S$
213 628.4	213 785	–157	0.848	1.5	37% $4p^4(^3P)4d\ ^2D$ + 36% $4p^4(^1S)4d\ ^2D$ + 8% $4p^4(^3P)5d\ ^2D$
214 660.2	214 651	9	1.968	0.5	55% $4p^4(^1D)4d\ ^2S$ + 21% $4s4p^6\ ^2S$ + 14% $4p^4(^1S)5s\ ^2S$
241 129	241 141	–12	1.572	2.5	90% $4p^4(^3P)6s\ ^4P$ + 5% $4p^4(^1D)6s\ ^2D$
241 489	241 559	–70	1.377	3.5	75% $4p^4(^3P)5d\ ^4D$ + 19% $4p^4(^3P)5d\ ^4F$
241 669	241 724	–55	1.361	2.5	68% $4p^4(^3P)5d\ ^4D$ + 11% $4p^4(^3P)5d\ ^4P$ + 10% $4p^4(^3P)5d\ ^4F$
242 040	242 022	18	1.361	1.5	33% $4p^4(^3P)5d\ ^4D$ + 30% $4p^4(^3P)6s\ ^2P$ + 17% $4p^4(^3P)5d\ ^4P$
242 295	242 282	13	1.337	1.5	42% $4p^4(^3P)6s\ ^2P$ + 28% $4p^4(^3P)5d\ ^4D$ + 12% $4p^4(^3P)6s\ ^4P$
242 791	242 824	–33	1.112	0.5	45% $4p^4(^3P)5d\ ^4D$ + 37% $4p^4(^3P)5d\ ^4P$ + 10% $4p^4(^3P)5d\ ^2P$
	242 834		1.322	4.5	94% $4p^4(^3P)5d\ ^4F$ + 5% $4p^4(^1D)5d\ ^2G$
243 773	243 695	78	1.159	3.5	65% $4p^4(^3P)5d\ ^2F$ + 27% $4p^4(^3P)5d\ ^4F$ + 6% $4p^4(^1D)5d\ ^2G$
245 050	245 065	–15	1.711	0.5	53% $4p^4(^3P)5d\ ^4P$ + 23% $4p^4(^3P)5d\ ^2P$ + 15% $4p^4(^3P)5d\ ^4D$
246 316	246 279	37	1.371	1.5	50% $4p^4(^3P)5d\ ^4P$ + 14% $4p^4(^3P)5d\ ^2D$ + 10% $4p^4(^3P)5d\ ^2P$
246 471	246 444	27	1.125	2.5	29% $4p^4(^3P)5d\ ^4F$ + 28% $4p^4(^3P)5d\ ^2F$ + 20% $4p^4(^3P)5d\ ^4P$
247 709	247 725	–16	1.620	1.5	73% $4p^4(^3P)6s\ ^4P$ + 21% $4p^4(^3P)6s\ ^2P$
247 807	247 779	28	2.483	0.5	88% $4p^4(^3P)6s\ ^4P$ + 6% $4p^4(^3P)6s\ ^2P$
248 747	248 785	–38	0.737	0.5	45% $4p^4(^3P)6s\ ^2P$ + 20% $4p^4(^3P)5d\ ^4D$ + 19% $4p^4(^3P)5d\ ^2P$
	248 790		1.252	3.5	51% $4p^4(^3P)5d\ ^4F$ + 27% $4p^4(^3P)5d\ ^2F$ + 21% $4p^4(^3P)5d\ ^4D$
249 087	249 073	14	0.610	0.5	46% $4p^4(^3P)6s\ ^2P$ + 25% $4p^4(^3P)5d\ ^2P$ + 19% $4p^4(^3P)5d\ ^4D$
249 217	249 138	79	0.608	1.5	75% $4p^4(^3P)5d\ ^4F$ + 14% $4p^4(^3P)5d\ ^4D$ + 6% $4p^4(^3P)5d\ ^4P$

Table 4. Continued.

E_{exp}^{a}	E_{calc}	ΔE	g-factor	J	Leading components (in %) in LS coupling[b]
249 272	249 199	73	1.286	2.5	41% $4p^4(^3P)5d\ ^4F$ + 31% $4p^4(^3P)5d\ ^4P$ + 19% $4p^4(^3P)5d\ ^4D$
250 122	250 193	–71	1.075	1.5	26% $4p^4(^3P)5d\ ^2P$ + 24% $4p^4(^3P)5d\ ^2D$ + 16% $4p^4(^3P)5d\ ^4D$
250 165	250 022	143	1.133	2.5	47% $4p^4(^3P)5d\ ^2F$ + 30% $4p^4(^3P)5d\ ^4P$ + 17% $4p^4(^3P)5d\ ^4F$
252 829	252 862	–33	1.135	2.5	58% $4p^4(^3P)5d\ ^2D$ + 21% $4p^4(^3P)5d\ ^2F$
253 024	253 218	–194	1.126	1.5	49% $4p^4(^3P)5d\ ^2P$ + 28% $4p^4(^3P)5d\ ^2D$ + 9% $4p^4(^1D)5d\ ^2P$
258 798	258 803	–5	1.219	2.5	93% $4p^4(^1D)6s\ ^2D$ + 5% $4p^4(^3P)6s\ ^4P$
258 906	258 899	7	0.833	1.5	94% $4p^4(^1D)6s\ ^2D$ + 5% $4p^4(^3P)6s\ ^2P$
259 427	259 435	–8	0.907	3.5	93% $4p^4(^1D)5d\ ^2G$
259 431.37	259 530	–99	1.123	4.5	94% $4p^4(^1D)5d\ ^2G$ + 5% $4p^4(^3P)5d\ ^4F$
261 225	261 226	–1	0.999	2.5	59% $4p^4(^1D)5d\ ^2F$ + 37% $4p^4(^1D)5d\ ^2D$
261 764	261 690	74	1.149	3.5	95% $4p^4(^1D)5d\ ^2F$
261 769	261 449	320	1.325	1.5	82% $4p^4(^1D)5d\ ^2P$ + 5% $4p^4(^3P)5d\ ^2P$
262 146	262 209	–63	1.088	2.5	51% $4p^4(^1D)5d\ ^2D$ + 35% $4p^4(^1D)5d\ ^2F$ + 6% $4p^4(^3P)5d\ ^2D$
262 577	262 505	72	1.122	0.5	57% $4p^4(^1D)5d\ ^2P$ + 27% $4p^4(^1D)5d\ ^2S$ + 6% $4p^4(^3P)5d\ ^2P$
263 351	263 594	–243	0.811	1.5	74% $4p^4(^1D)5d\ ^2D$ + 15% $4p^4(^3P)5d\ ^2D$
263 829	263 860	–31	1.566	0.5	61% $4p^4(^1D)5d\ ^2S$ + 21% $4p^4(^1D)5d\ ^2P$ + 9% $4p^4(^3P)5d\ ^2P$
	277 345		1.999	0.5	92% $4p^4(^1S)6s\ ^2S$ + 5% $4p^4(^3P)6s\ ^4P$
	280 713		1.197	2.5	85% $4p^4(^1S)5d\ ^2D$
	280 800		0.826	1.5	76% $4p^4(^1S)5d\ ^2D$ + 9% $4p^4(^3P)6d\ ^2D$

[a]From [26]. [b]Only the first three components larger than 5% are given.

Table 5. Weighted oscillator strengths ($\log gf$) and weighted transition probabilities (gA) for Rb III spectral lines.

λ^{a} (Å)	Lower level[b]			Upper level[b]			$\log gf^{c}$	gA^{c} (s^{-1})
	E (cm^{-1})	Parity	J	E (cm^{-1})	Parity	J		
379.033*	0	(odd)	1.5	263 829	(even)	0.5	–1.16	3.24E+09
379.721*	0	(odd)	1.5	263 351	(even)	1.5	–1.12	3.56E+09
380.841*	0	(odd)	1.5	262 577	(even)	0.5	–0.38	1.92E+10
381.467*	0	(odd)	1.5	262 146	(even)	2.5	–0.25	2.55E+10
382.016*	0	(odd)	1.5	261 769	(even)	1.5	–0.21	2.79E+10
382.812*	0	(odd)	1.5	261 225	(even)	2.5	–1.31	2.25E+09
386.402*	0	(odd)	1.5	258 798	(even)	2.5	–0.61	1.10E+10
389.933*	7375	(odd)	0.5	263 829	(even)	0.5	–0.30	2.21E+10
390.661*	7375	(odd)	0.5	263 351	(even)	1.5	–0.17	2.97E+10
391.846*	7375	(odd)	0.5	262 577	(even)	0.5	–1.38	1.83E+09
393.090*	7375	(odd)	0.5	261 769	(even)	1.5	–0.81	6.66E+09
395.219*	0	(odd)	1.5	253 024	(even)	1.5	–1.68	9.03E+08
395.524*	0	(odd)	1.5	252 829	(even)	2.5	0.05	4.83E+10
397.565*	7375	(odd)	0.5	258 906	(even)	1.5	–0.80	6.67E+09
399.736*	0	(odd)	1.5	250 165	(even)	2.5	–1.39	1.71E+09
399.805*	0	(odd)	1.5	250 122	(even)	1.5	–0.52	1.27E+10
401.168*	0	(odd)	1.5	249 272	(even)	2.5	–1.33	1.95E+09
402.015*	0	(odd)	1.5	248 747	(even)	0.5	–1.01	4.06E+09
403.700*	0	(odd)	1.5	247 709	(even)	1.5	–1.85	5.77E+08
405.727*	0	(odd)	1.5	246 471	(even)	2.5	–0.32	1.96E+10
405.983*	0	(odd)	1.5	246 316	(even)	1.5	–0.44	1.46E+10
407.084*	7375	(odd)	0.5	253 024	(even)	1.5	–0.38	1.68E+10
408.080*	0	(odd)	1.5	245 050	(even)	0.5	–1.05	3.55E+09
411.951*	7375	(odd)	0.5	250 122	(even)	1.5	–1.08	3.24E+09
412.720*	0	(odd)	1.5	242 295	(even)	1.5	–0.92	4.70E+09
413.155*	0	(odd)	1.5	242 040	(even)	1.5	–0.94	4.53E+09
413.492*	7375	(odd)	0.5	249 217	(even)	1.5	–1.95	4.39E+08
414.297*	7375	(odd)	0.5	248 747	(even)	0.5	–0.92	4.66E+09
415.917*	7375	(odd)	0.5	247 807	(even)	0.5	–1.73	7.15E+08
416.087*	7375	(odd)	0.5	247 709	(even)	1.5	–1.50	1.23E+09

Table 5. Continued.

λ^{a} (Å)	Lower level[b]			Upper level[b]			$\log gf^{c}$	gA^{c} (s^{-1})
	E (cm^{-1})	Parity	J	E (cm^{-1})	Parity	J		
418.512*	7375	(odd)	0.5	246 316	(even)	1.5	–1.46	1.31E+09
420.742*	7375	(odd)	0.5	245 050	(even)	0.5	–1.90	4.75E+08
424.779*	7375	(odd)	0.5	242 791	(even)	0.5	–1.93	4.33E+08
425.676*	7375	(odd)	0.5	242 295	(even)	1.5	–1.61	9.04E+08
465.853	0	(odd)	1.5	214 660	(even)	0.5	0.00	3.05E+10
468.101	0	(odd)	1.5	213 628	(even)	1.5	–1.31	1.51E+09
482.431	7375	(odd)	0.5	214 660	(even)	0.5	–0.05	2.57E+10
482.472	0	(odd)	1.5	207 263	(even)	0.5	–0.16	1.96E+10
482.826	0	(odd)	1.5	207 114	(even)	2.5	0.70	1.42E+11
484.841	7375	(odd)	0.5	213 628	(even)	1.5	0.65	1.26E+11
489.660	0	(odd)	1.5	204 224	(even)	1.5	0.64	1.22E+11
489.964	0	(odd)	1.5	204 096	(even)	0.5	0.06	3.16E+10
493.476	0	(odd)	1.5	202 644	(even)	2.5	0.44	7.63E+10
497.818	0	(odd)	1.5	200 876	(even)	1.5	–0.47	9.13E+09
500.278	7375	(odd)	0.5	207 263	(even)	0.5	0.21	4.26E+10
508.333	7375	(odd)	0.5	204 096	(even)	0.5	–0.70	5.13E+09
516.793	7375	(odd)	0.5	200 876	(even)	1.5	–0.14	1.78E+10
533.636	0	(odd)	1.5	187 393	(even)	2.5	–0.45	8.33E+09
534.278	0	(odd)	1.5	187 168	(even)	1.5	–1.88	3.05E+08
535.859	0	(odd)	1.5	186 616	(even)	2.5	–0.12	1.76E+10
556.193	7375	(odd)	0.5	187 168	(even)	1.5	–0.18	1.44E+10
558.359	0	(odd)	1.5	179 096	(even)	0.5	–0.50	6.80E+09
566.707	0	(odd)	1.5	176 458	(even)	1.5	–0.31	1.02E+10
576.653	0	(odd)	1.5	173 416	(even)	2.5	–1.16	1.40E+09
579.628	0	(odd)	1.5	172 526	(even)	1.5	–0.54	5.76E+09
581.256	0	(odd)	1.5	172 042	(even)	1.5	–0.30	9.81E+09
582.340	7375	(odd)	0.5	179 096	(even)	0.5	–0.44	7.19E+09
586.774	0	(odd)	1.5	170 424	(even)	1.5	–1.42	7.43E+08
591.424	7375	(odd)	0.5	176 458	(even)	1.5	–1.35	8.60E+08
593.647	0	(odd)	1.5	168 450	(even)	0.5	–1.56	5.26E+08
594.938	0	(odd)	1.5	168 085	(even)	1.5	–1.34	8.58E+08
595.026*	7375	(odd)	0.5	175 434	(even)	0.5	–1.83	2.80E+08
595.877	0	(odd)	1.5	167 820	(even)	2.5	–1.71	3.68E+08
607.285	7375	(odd)	0.5	172 042	(even)	1.5	–1.32	8.57E+08
613.310	7375	(odd)	0.5	170 424	(even)	1.5	–1.81	2.74E+08
769.042	0	(odd)	1.5	130 032	(even)	0.5	–1.42	4.33E+08
815.276	7375	(odd)	0.5	130 032	(even)	0.5	–1.62	2.42E+08
1083.785*	130 032	(even)	0.5	222 301	(odd)	0.5	–1.46	1.97E+08
1127.665*	130 032	(even)	0.5	218 711	(odd)	1.5	–1.11	4.06E+08
1460.486*	170 424	(even)	1.5	238 894	(odd)	0.5	–1.59	7.92E+07
1480.473*	172 042	(even)	1.5	239 588	(odd)	1.5	–1.93	3.61E+07
1538.164*	174 575	(even)	2.5	239 588	(odd)	1.5	–1.65	6.36E+07
1578.346*	200 472	(odd)	0.5	263 829	(even)	0.5	–1.96	2.93E+07
1599.363*	177 063	(even)	2.5	239 588	(odd)	1.5	–2.00	2.61E+07
1689.979*	204 657	(odd)	1.5	263 829	(even)	0.5	–1.92	2.79E+07
1697.852*	204 931	(odd)	0.5	263 829	(even)	0.5	–1.57	6.22E+07
1726.509*	204 657	(odd)	1.5	262 577	(even)	0.5	–1.74	4.05E+07
1743.269*	206 466	(odd)	1.5	263 829	(even)	0.5	–1.54	6.41E+07
1750.935*	204 657	(odd)	1.5	261 769	(even)	1.5	–1.61	5.30E+07
1759.388*	204 931	(odd)	0.5	261 769	(even)	1.5	–1.72	4.10E+07
1782.166*	206 466	(odd)	1.5	262 577	(even)	0.5	–1.28	1.10E+08
1808.204*	206 466	(odd)	1.5	261 769	(even)	1.5	–1.33	9.55E+07
1809.350*	206 878	(odd)	2.5	262 146	(even)	2.5	–1.75	3.65E+07
1825.860*	166 088	(even)	0.5	220 857	(odd)	1.5	–1.56	5.36E+07
1827.715*	209 116	(odd)	1.5	263 829	(even)	0.5	–1.75	3.56E+07
1843.706*	154 877	(even)	2.5	209 116	(odd)	1.5	–1.66	4.32E+07
1843.823*	209 116	(odd)	1.5	263 351	(even)	1.5	–1.42	7.56E+07
1847.017*	204 657	(odd)	1.5	258 798	(even)	2.5	–1.67	4.21E+07

Table 5. Continued.

λ^a (Å)	Lower level[b]			Upper level[b]			log gf^c	gA^c (s^{-1})
	E (cm^{-1})	Parity	J	E (cm^{-1})	Parity	J		
1848.020*	209 717	(odd)	0.5	263 829	(even)	0.5	–1.10	1.54E+08
1851.038*	209 327	(odd)	1.5	263 351	(even)	1.5	–1.72	3.72E+07
1852.711*	204 931	(odd)	0.5	258 906	(even)	1.5	–1.87	2.60E+07
1870.518*	209 116	(odd)	1.5	262 577	(even)	0.5	–1.26	1.05E+08
1887.792*	186 616	(even)	2.5	239 588	(odd)	1.5	–1.88	2.50E+07
1891.791*	209 717	(odd)	0.5	262 577	(even)	0.5	–1.74	3.35E+07
1894.959*	168 085	(even)	1.5	220 857	(odd)	1.5	–1.96	2.04E+07
1899.222*	209 116	(odd)	1.5	261 769	(even)	1.5	–1.49	5.93E+07
1902.861*	200 472	(odd)	0.5	253 024	(even)	1.5	–1.31	9.12E+07
1910.858*	206 466	(odd)	1.5	258 798	(even)	2.5	–1.28	9.61E+07
1915.895*	187 393	(even)	2.5	239 588	(odd)	1.5	–1.64	4.18E+07
1917.310	154 721	(even)	3.5	206 878	(odd)	2.5	–1.07	1.53E+08
1921.001*	198 109	(odd)	2.5	250 165	(even)	2.5	–1.45	6.37E+07
1921.157*	209 717	(odd)	0.5	261 769	(even)	1.5	–1.38	7.48E+07
1923.062	154 877	(even)	2.5	206 878	(odd)	2.5	–1.56	4.97E+07
1927.615*	170 424	(even)	1.5	222 301	(odd)	0.5	–1.88	2.33E+07
1929.564*	198 340	(odd)	1.5	250 165	(even)	2.5	–1.49	5.72E+07
1934.979*	201 149	(odd)	2.5	252 829	(even)	2.5	–1.22	1.08E+08
1938.427*	154 877	(even)	2.5	206 466	(odd)	1.5	–1.68	3.70E+07
1948.813*	155 564	(even)	1.5	206 878	(odd)	2.5	–1.96	1.94E+07
1954.530*	198 109	(odd)	2.5	249 272	(even)	2.5	–1.35	7.74E+07
1963.396*	198 340	(odd)	1.5	249 272	(even)	2.5	–0.87	2.33E+08
1964.588*	155 564	(even)	1.5	206 466	(odd)	1.5	–1.51	5.32E+07
1967.869	155 564	(even)	1.5	206 381	(odd)	0.5	–1.31	8.35E+07
1975.473*	170 424	(even)	1.5	221 045	(odd)	2.5	–1.66	3.68E+07
1997.123*	156 393	(even)	0.5	206 466	(odd)	1.5	–1.87	2.25E+07
1999.863*	156 393	(even)	0.5	206 381	(odd)	0.5	–1.72	3.16E+07
2003.950*	171 159	(even)	3.5	221 045	(odd)	2.5	–1.49	5.31E+07
2008.210	154 877	(even)	2.5	204 657	(odd)	1.5	–1.21	1.01E+08
2008.364*	172 526	(even)	1.5	222 301	(odd)	0.5	–1.65	3.66E+07
2012.146*	209 116	(odd)	1.5	258 798	(even)	2.5	–1.39	6.69E+07
2020.891*	198 340	(odd)	1.5	247 807	(even)	0.5	–1.85	2.32E+07
2025.000*	155 564	(even)	1.5	204 931	(odd)	0.5	–1.72	3.12E+07
2032.323*	209 717	(odd)	0.5	258 906	(even)	1.5	–1.65	3.61E+07
2040.042*	172 042	(even)	1.5	221 045	(odd)	2.5	–1.64	3.70E+07
2047.886*	172 042	(even)	1.5	220 857	(odd)	1.5	–1.83	2.36E+07
2050.816*	200 472	(odd)	0.5	249 217	(even)	1.5	–1.57	4.29E+07
2056.301*	200 472	(odd)	0.5	249 087	(even)	0.5	–1.84	2.29E+07
2059.600	156 393	(even)	0.5	204 931	(odd)	0.5	–1.39	6.34E+07
2060.395*	172 526	(even)	1.5	221 045	(odd)	2.5	–1.61	3.81E+07
2066.859*	200 905	(odd)	3.5	249 272	(even)	2.5	–1.76	2.71E+07
2067.070*	198 109	(odd)	2.5	246 471	(even)	2.5	–1.26	8.61E+07
2070.276	170 424	(even)	1.5	218 711	(odd)	1.5	–1.51	4.78E+07
2073.717*	198 109	(odd)	2.5	246 316	(even)	1.5	–0.85	2.17E+08
2075.218*	204 657	(odd)	1.5	252 829	(even)	2.5	–1.92	1.88E+07
2076.994*	198 340	(odd)	1.5	246 471	(even)	2.5	–0.71	2.98E+08
2077.340*	201 149	(odd)	2.5	249 272	(even)	2.5	–1.83	2.26E+07
2078.644*	204 931	(odd)	0.5	253 024	(even)	1.5	–0.80	2.46E+08
2098.893*	173 416	(even)	2.5	221 045	(odd)	2.5	–1.57	4.04E+07
2121.770*	216 235	(odd)	2.5	263 351	(even)	1.5	–0.92	1.80E+08
2140.187*	198 340	(odd)	1.5	245 050	(even)	0.5	–0.77	2.50E+08
2142.061*	172 042	(even)	1.5	218 711	(odd)	1.5	–1.70	2.88E+07
2143.254*	206 381	(odd)	0.5	253 024	(even)	1.5	–1.76	2.54E+07
2147.159*	206 466	(odd)	1.5	253 024	(even)	1.5	–1.56	4.02E+07
2151.262	174 575	(even)	2.5	221 045	(odd)	2.5	–1.75	2.55E+07
2153.214	154 721	(even)	3.5	201 149	(odd)	2.5	–1.02	1.35E+08
2156.191*	206 466	(odd)	1.5	252 829	(even)	2.5	–0.31	7.08E+08
2160.474	154 877	(even)	2.5	201 149	(odd)	2.5	–1.78	2.39E+07

Table 5. Continued.

λ^a (Å)	Lower level[b] E (cm^{-1})	Parity	J	Upper level[b] E (cm^{-1})	Parity	J	$\log gf^c$	gA^c (s^{-1})
2164.520	172 526	(even)	1.5	218 711	(odd)	1.5	–1.21	8.76E+07
2164.590	154 721	(even)	3.5	200 905	(odd)	3.5	–0.38	5.93E+08
2171.928	154 877	(even)	2.5	200 905	(odd)	3.5	–1.29	7.19E+07
2175.527*	206 878	(odd)	2.5	252 829	(even)	2.5	–0.74	2.59E+08
2177.466*	216 235	(odd)	2.5	262 146	(even)	2.5	–0.16	9.75E+08
2180.638	200 472	(odd)	0.5	246 316	(even)	1.5	–0.06	1.22E+09
2180.638	176 458	(even)	1.5	222 301	(odd)	0.5	–1.45	4.95E+07
2182.168	170 424	(even)	1.5	216 235	(odd)	2.5	–0.81	2.17E+08
2189.215*	198 109	(odd)	2.5	243 773	(even)	3.5	–1.06	1.21E+08
2193.926*	200 905	(odd)	3.5	246 471	(even)	2.5	–1.92	1.67E+07
2195.496*	216 235	(odd)	2.5	261 769	(even)	1.5	–1.69	2.78E+07
2195.737*	216 235	(odd)	2.5	261 764	(even)	3.5	–1.59	3.58E+07
2196.713*	204 657	(odd)	1.5	250 165	(even)	2.5	–0.82	2.09E+08
2198.791*	204 657	(odd)	1.5	250 122	(even)	1.5	–1.17	9.30E+07
2205.760	201 149	(odd)	2.5	246 471	(even)	2.5	–0.07	1.18E+09
2207.037*	173 416	(even)	2.5	218 711	(odd)	1.5	–1.22	8.29E+07
2212.143*	204 931	(odd)	0.5	250 122	(even)	1.5	–0.09	1.11E+09
2213.309*	201 149	(odd)	2.5	246 316	(even)	1.5	–1.27	7.24E+07
2215.722*	218 711	(odd)	1.5	263 829	(even)	0.5	–0.72	2.58E+08
2217.776	171 159	(even)	3.5	216 235	(odd)	2.5	–1.26	7.34E+07
2222.046*	216 235	(odd)	2.5	261 225	(even)	2.5	–0.22	8.14E+08
2226.122	155 564	(even)	1.5	200 472	(odd)	0.5	–1.01	1.30E+08
2227.292*	217 262	(odd)	3.5	262 146	(even)	2.5	–0.79	2.18E+08
2239.450*	218 711	(odd)	1.5	263 351	(even)	1.5	–1.95	1.50E+07
2240.686*	204 657	(odd)	1.5	249 272	(even)	2.5	–0.49	4.30E+08
2242.131*	176 458	(even)	1.5	221 045	(odd)	2.5	–1.68	2.77E+07
2242.585	200 472	(odd)	0.5	245 050	(even)	0.5	–0.18	8.72E+08
2243.452*	204 657	(odd)	1.5	249 217	(even)	1.5	–0.95	1.49E+08
2246.410	217 262	(odd)	3.5	261 764	(even)	3.5	0.18	1.98E+09
2248.957	198 340	(odd)	1.5	242 791	(even)	0.5	–0.06	1.15E+09
2250.017*	204 657	(odd)	1.5	249 087	(even)	0.5	–1.40	5.28E+07
2262.450*	198 109	(odd)	2.5	242 295	(even)	1.5	–0.65	2.92E+08
2264.000*	204 931	(odd)	0.5	249 087	(even)	0.5	–0.44	4.74E+08
2265.028*	174 575	(even)	2.5	218 711	(odd)	1.5	–1.01	1.29E+08
2267.997	156 393	(even)	0.5	200 472	(odd)	0.5	–0.75	2.30E+08
2272.968	177 063	(even)	2.5	221 045	(odd)	2.5	–1.65	2.84E+07
2274.342*	198 340	(odd)	1.5	242 295	(even)	1.5	–0.48	4.30E+08
2275.572	198 109	(odd)	2.5	242 040	(even)	1.5	–0.39	5.27E+08
2276.779*	209 116	(odd)	1.5	253 024	(even)	1.5	–0.66	2.84E+08
2278.968*	218 711	(odd)	1.5	262 577	(even)	0.5	–0.31	6.27E+08
2279.963*	173 416	(even)	2.5	217 262	(odd)	3.5	–1.29	6.65E+07
2281.570*	204 931	(odd)	0.5	248 747	(even)	0.5	–0.24	7.45E+08
2282.706	177 063	(even)	2.5	220 857	(odd)	1.5	–1.38	5.27E+07
2286.936	209 116	(odd)	1.5	252 829	(even)	2.5	0.34	2.80E+09
2287.122	172 526	(even)	1.5	216 235	(odd)	2.5	–1.81	1.97E+07
2287.644	198 340	(odd)	1.5	242 040	(even)	1.5	0.17	1.86E+09
2287.650*	206 466	(odd)	1.5	250 165	(even)	2.5	–0.28	6.61E+08
2287.794*	209 327	(odd)	1.5	253 024	(even)	1.5	–0.94	1.49E+08
2289.918	206 466	(odd)	1.5	250 122	(even)	1.5	–0.04	1.15E+09
2294.971	198 109	(odd)	2.5	241 669	(even)	2.5	0.14	1.75E+09
2298.050*	209 327	(odd)	1.5	252 829	(even)	2.5	–0.83	1.86E+08
2300.125	154 877	(even)	2.5	198 340	(odd)	1.5	–0.48	4.19E+08
2301.584*	218 711	(odd)	1.5	262 146	(even)	2.5	–0.38	5.22E+08
2304.144	154 721	(even)	3.5	198 109	(odd)	2.5	–0.09	1.01E+09
2304.446	198 109	(odd)	2.5	241 489	(even)	3.5	0.52	4.15E+09
2307.248	198 340	(odd)	1.5	241 669	(even)	2.5	0.22	2.07E+09
2308.421	209 717	(odd)	0.5	253 024	(even)	1.5	0.20	1.97E+09
2309.455	206 878	(odd)	2.5	250 165	(even)	2.5	–0.13	9.20E+08

Table 5. Continued.

λ^a (Å)	Lower level[b]			Upper level[b]			$\log gf^c$	gA^c (s^{-1})
	E (cm^{-1})	Parity	J	E (cm^{-1})	Parity	J		
2311.723*	206 878	(odd)	2.5	250 122	(even)	1.5	–1.15	8.90E+07
2312.456	154 877	(even)	2.5	198 109	(odd)	2.5	–0.29	6.40E+08
2313.804	179 096	(even)	0.5	222 301	(odd)	0.5	–0.85	1.75E+08
2314.566	216 235	(odd)	2.5	259 427	(even)	3.5	0.69	6.11E+09
2316.767*	204 657	(odd)	1.5	247 807	(even)	0.5	–0.92	1.50E+08
2321.738*	218 711	(odd)	1.5	261 769	(even)	1.5	0.11	1.56E+09
2322.041*	204 657	(odd)	1.5	247 709	(even)	1.5	–1.08	1.02E+08
2323.378	166 088	(even)	0.5	209 116	(odd)	1.5	–1.63	2.82E+07
2323.742	198 109	(odd)	2.5	241 129	(even)	2.5	0.30	2.46E+09
2326.378*	220 857	(odd)	1.5	263 829	(even)	0.5	–1.50	3.88E+07
2331.594*	204 931	(odd)	0.5	247 807	(even)	0.5	–1.43	4.56E+07
2332.019*	200 905	(odd)	3.5	243 773	(even)	3.5	–1.02	1.17E+08
2333.799	206 381	(odd)	0.5	249 217	(even)	1.5	0.32	2.55E+09
2335.421	206 466	(odd)	1.5	249 272	(even)	2.5	0.24	2.12E+09
2336.333	198 340	(odd)	1.5	241 129	(even)	2.5	–0.56	3.34E+08
2336.954	204 931	(odd)	0.5	247 709	(even)	1.5	–0.48	4.05E+08
2337.070	155 564	(even)	1.5	198 340	(odd)	1.5	–0.42	4.63E+08
2338.382*	206 466	(odd)	1.5	249 217	(even)	1.5	–0.97	1.32E+08
2341.899	174 575	(even)	2.5	217 262	(odd)	3.5	–0.64	2.80E+08
2342.818*	216 235	(odd)	2.5	258 906	(even)	1.5	0.04	1.32E+09
2345.371	201 149	(odd)	2.5	243 773	(even)	3.5	0.70	5.99E+09
2345.515*	206 466	(odd)	1.5	249 087	(even)	0.5	–1.26	6.67E+07
2348.764*	216 235	(odd)	2.5	258 798	(even)	2.5	–0.66	2.63E+08
2349.807	155 564	(even)	1.5	198 109	(odd)	2.5	–1.00	1.21E+08
2351.483	218 711	(odd)	1.5	261 225	(even)	2.5	–0.05	1.08E+09
2352.549*	220 857	(odd)	1.5	263 351	(even)	1.5	0.09	1.50E+09
2358.076*	206 878	(odd)	2.5	249 272	(even)	2.5	–1.33	5.58E+07
2359.644*	206 381	(odd)	0.5	248 747	(even)	0.5	–1.18	7.98E+07
2362.254	200 472	(odd)	0.5	242 791	(even)	0.5	–0.49	3.89E+08
2362.986*	221 045	(odd)	2.5	263 351	(even)	1.5	–1.40	4.79E+07
2364.378*	206 466	(odd)	1.5	248 747	(even)	0.5	–1.31	5.83E+07
2365.974	176 458	(even)	1.5	218 711	(odd)	1.5	–0.52	3.61E+08
2366.634*	167 086	(even)	2.5	209 327	(odd)	1.5	–1.55	3.38E+07
2370.687*	217 262	(odd)	3.5	259 431	(even)	4.5	0.81	7.63E+09
2370.932*	217 262	(odd)	3.5	259 427	(even)	3.5	–0.54	3.41E+08
2383.272	156 393	(even)	0.5	198 340	(odd)	1.5	–1.02	1.11E+08
2390.272	200 472	(odd)	0.5	242 295	(even)	1.5	–0.32	5.60E+08
2390.824	204 657	(odd)	1.5	246 471	(even)	2.5	0.34	2.54E+09
2393.849*	179 096	(even)	0.5	220 857	(odd)	1.5	–1.54	3.39E+07
2396.197*	220 857	(odd)	1.5	262 577	(even)	0.5	–0.39	4.69E+08
2399.632	174 575	(even)	2.5	216 235	(odd)	2.5	–1.64	2.69E+07
2399.691*	204 657	(odd)	1.5	246 316	(even)	1.5	–0.07	9.78E+08
2400.331	177 063	(even)	2.5	218 711	(odd)	1.5	–1.48	3.84E+07
2406.841	217 262	(odd)	3.5	258 798	(even)	2.5	0.23	1.97E+09
2407.305*	222 301	(odd)	0.5	263 829	(even)	0.5	–0.16	7.98E+08
2413.191*	206 381	(odd)	0.5	247 807	(even)	0.5	–0.47	3.91E+08
2415.603*	204 931	(odd)	0.5	246 316	(even)	1.5	–1.49	3.65E+07
2418.142*	206 466	(odd)	1.5	247 807	(even)	0.5	–0.51	3.56E+08
2418.463	165 541	(even)	3.5	206 878	(odd)	2.5	–0.45	4.04E+08
2420.803	167 820	(even)	2.5	209 116	(odd)	1.5	–1.54	3.33E+07
2421.212*	220 857	(odd)	1.5	262 146	(even)	2.5	–0.13	8.54E+08
2423.908	206 466	(odd)	1.5	247 709	(even)	1.5	–0.43	4.27E+08
2429.626	201 149	(odd)	2.5	242 295	(even)	1.5	–0.04	1.02E+09
2432.269*	221 045	(odd)	2.5	262 146	(even)	2.5	0.20	1.80E+09
2435.339*	222 301	(odd)	0.5	263 351	(even)	1.5	–0.09	9.18E+08
2435.366*	209 116	(odd)	1.5	250 165	(even)	2.5	–0.94	1.27E+08
2436.485	168 085	(even)	1.5	209 116	(odd)	1.5	–1.46	3.93E+07
2437.920*	209 116	(odd)	1.5	250 122	(even)	1.5	–1.04	1.04E+08

Table 5. Continued.

λ^{a} (Å)	Lower level[b]			Upper level[b]			$\log gf^{c}$	gA^{c} (s^{-1})
	E (cm^{-1})	Parity	J	E (cm^{-1})	Parity	J		
2443.525*	220 857	(odd)	1.5	261 769	(even)	1.5	–1.01	1.08E+08
2444.777*	201 149	(odd)	2.5	242 040	(even)	1.5	–0.45	3.92E+08
2447.999	209 327	(odd)	1.5	250 165	(even)	2.5	0.34	2.39E+09
2448.370	206 878	(odd)	2.5	247 709	(even)	1.5	0.04	1.23E+09
2450.554*	209 327	(odd)	1.5	250 122	(even)	1.5	–0.54	3.20E+08
2452.446	200 905	(odd)	3.5	241 669	(even)	2.5	–0.17	7.52E+08
2454.787*	221 045	(odd)	2.5	261 769	(even)	1.5	–0.24	6.34E+08
2455.084	221 045	(odd)	2.5	261 764	(even)	3.5	0.55	3.92E+09
2458.321	168 450	(even)	0.5	209 116	(odd)	1.5	–1.22	6.64E+07
2463.270	200 905	(odd)	3.5	241 489	(even)	3.5	0.24	1.92E+09
2467.162*	201 149	(odd)	2.5	241 669	(even)	2.5	–1.21	6.85E+07
2474.196*	209 717	(odd)	0.5	250 122	(even)	1.5	–1.05	9.68E+07
2474.908*	204 657	(odd)	1.5	245 050	(even)	0.5	–0.59	2.83E+08
2475.902	166 088	(even)	0.5	206 466	(odd)	1.5	–1.20	6.58E+07
2476.494	220 857	(odd)	1.5	261 225	(even)	2.5	0.22	1.79E+09
2478.174	201 149	(odd)	2.5	241 489	(even)	3.5	–0.78	1.81E+08
2482.144*	222 301	(odd)	0.5	262 577	(even)	0.5	–1.00	1.07E+08
2485.335	200 905	(odd)	3.5	241 129	(even)	2.5	0.09	1.31E+09
2486.840	177 063	(even)	2.5	217 262	(odd)	3.5	–0.82	1.63E+08
2487.123*	218 711	(odd)	1.5	258 906	(even)	1.5	–0.61	2.66E+08
2488.068	221 045	(odd)	2.5	261 225	(even)	2.5	–0.19	6.88E+08
2489.578	209 116	(odd)	1.5	249 272	(even)	2.5	–0.05	9.67E+08
2492.943*	209 116	(odd)	1.5	249 217	(even)	1.5	–0.85	1.51E+08
2493.825*	218 711	(odd)	1.5	258 798	(even)	2.5	–0.10	8.59E+08
2498.903*	206 466	(odd)	1.5	246 471	(even)	2.5	–1.67	2.28E+07
2500.488*	201 149	(odd)	2.5	241 129	(even)	2.5	–1.87	1.44E+07
2501.051*	209 116	(odd)	1.5	249 087	(even)	0.5	–0.76	1.84E+08
2502.752	209 327	(odd)	1.5	249 272	(even)	2.5	–0.20	6.68E+08
2506.155*	209 327	(odd)	1.5	249 217	(even)	1.5	–1.08	8.84E+07
2508.623*	206 466	(odd)	1.5	246 316	(even)	1.5	–1.31	5.18E+07
2512.348	167 086	(even)	2.5	206 878	(odd)	2.5	–1.78	1.74E+07
2514.349*	209 327	(odd)	1.5	249 087	(even)	0.5	–0.71	2.06E+08
2522.509*	209 116	(odd)	1.5	248 747	(even)	0.5	–0.32	5.01E+08
2523.528	179 096	(even)	0.5	218 711	(odd)	1.5	–1.15	7.53E+07
2524.909*	206 878	(odd)	2.5	246 471	(even)	2.5	–1.25	5.92E+07
2530.887*	209 717	(odd)	0.5	249 217	(even)	1.5	–1.77	1.74E+07
2532.963*	222 301	(odd)	0.5	261 769	(even)	1.5	–0.73	1.93E+08
2534.833*	206 878	(odd)	2.5	246 316	(even)	1.5	–1.00	1.03E+08
2538.634*	167 086	(even)	2.5	206 466	(odd)	1.5	–1.56	2.88E+07
2539.245*	209 717	(odd)	0.5	249 087	(even)	0.5	–0.48	3.41E+08
2552.038*	177 063	(even)	2.5	216 235	(odd)	2.5	–1.93	1.20E+07
2559.540	167 820	(even)	2.5	206 878	(odd)	2.5	–0.93	1.21E+08
2561.366*	209 717	(odd)	0.5	248 747	(even)	0.5	–1.39	4.16E+07
2561.863	178 240	(even)	4.5	217 262	(odd)	3.5	0.23	1.73E+09
2567.292	178 322	(even)	3.5	217 262	(odd)	3.5	–0.98	1.08E+08
2569.697*	170 424	(even)	1.5	209 327	(odd)	1.5	–1.64	2.31E+07
2573.711	166 088	(even)	0.5	204 931	(odd)	0.5	–0.69	1.97E+08
2577.071	168 085	(even)	1.5	206 878	(odd)	2.5	–0.93	1.18E+08
2582.439*	200 876	(even)	1.5	239 588	(odd)	1.5	–1.48	3.38E+07
2583.746	170 424	(even)	1.5	209 116	(odd)	1.5	–1.69	2.04E+07
2583.798*	209 116	(odd)	1.5	247 807	(even)	0.5	–1.08	8.28E+07
2586.833	167 820	(even)	2.5	206 466	(odd)	1.5	–0.40	3.98E+08
2590.359*	209 116	(odd)	1.5	247 709	(even)	1.5	–1.33	4.68E+07
2597.993*	209 327	(odd)	1.5	247 807	(even)	0.5	–0.55	2.78E+08
2604.583*	221 045	(odd)	2.5	259 427	(even)	3.5	–1.69	1.99E+07
2604.646	209 327	(odd)	1.5	247 709	(even)	1.5	–0.40	3.88E+08
2604.733*	168 085	(even)	1.5	206 466	(odd)	1.5	–1.99	1.01E+07
2610.503*	168 085	(even)	1.5	206 381	(odd)	0.5	–1.48	3.23E+07

Table 5. Continued.

λ^a (Å)	Lower level[b]			Upper level[b]			$\log gf^c$	gA^c (s^{-1})
	E (cm^{-1})	Parity	J	E (cm^{-1})	Parity	J		
2622.051	168 751	(even)	1.5	206 878	(odd)	2.5	–1.31	4.83E+07
2624.581*	209 717	(odd)	0.5	247 807	(even)	0.5	–1.54	2.79E+07
2627.401*	220 857	(odd)	1.5	258 906	(even)	1.5	–0.29	4.92E+08
2629.524	200 876	(even)	1.5	238 894	(odd)	0.5	–0.65	2.20E+08
2631.351*	209 717	(odd)	0.5	247 709	(even)	1.5	–1.70	1.92E+07
2631.752	162 919	(even)	4.5	200 905	(odd)	3.5	0.22	1.60E+09
2634.880*	220 857	(odd)	1.5	258 798	(even)	2.5	–0.74	1.74E+08
2635.601	168 450	(even)	0.5	206 381	(odd)	0.5	–1.20	6.01E+07
2636.830	178 322	(even)	3.5	216 235	(odd)	2.5	0.07	1.15E+09
2640.426*	221 045	(odd)	2.5	258 906	(even)	1.5	–0.82	1.45E+08
2647.979*	221 045	(odd)	2.5	258 798	(even)	2.5	–0.15	6.73E+08
2650.704	168 751	(even)	1.5	206 466	(odd)	1.5	–1.05	8.56E+07
2656.076	204 657	(odd)	1.5	242 295	(even)	1.5	–0.49	3.06E+08
2656.677	168 751	(even)	1.5	206 381	(odd)	0.5	–0.38	3.98E+08
2660.871	167 086	(even)	2.5	204 657	(odd)	1.5	–1.43	3.49E+07
2674.194*	204 657	(odd)	1.5	242 040	(even)	1.5	–0.69	1.90E+08
2675.581*	204 931	(odd)	0.5	242 295	(even)	1.5	–1.78	1.53E+07
2676.212*	209 116	(odd)	1.5	246 471	(even)	2.5	–0.70	1.85E+08
2681.210*	172 042	(even)	1.5	209 327	(odd)	1.5	–1.18	6.15E+07
2687.364*	209 116	(odd)	1.5	246 316	(even)	1.5	–1.55	2.57E+07
2688.004	172 526	(even)	1.5	209 717	(odd)	0.5	–0.69	1.87E+08
2691.444*	209 327	(odd)	1.5	246 471	(even)	2.5	–1.07	7.83E+07
2693.968*	204 931	(odd)	0.5	242 040	(even)	1.5	–1.55	2.57E+07
2701.000*	204 657	(odd)	1.5	241 669	(even)	2.5	–1.09	7.42E+07
2702.723*	209 327	(odd)	1.5	246 316	(even)	1.5	–0.50	2.87E+08
2706.019*	202 644	(even)	2.5	239 588	(odd)	1.5	–0.49	2.88E+08
2713.861	167 820	(even)	2.5	204 657	(odd)	1.5	–0.46	3.19E+08
2716.478	172 526	(even)	1.5	209 327	(odd)	1.5	–0.57	2.41E+08
2717.431*	216 235	(odd)	2.5	253 024	(even)	1.5	–1.96	9.96E+06
2731.089*	222 301	(odd)	0.5	258 906	(even)	1.5	–0.34	4.07E+08
2731.912*	216 235	(odd)	2.5	252 829	(even)	2.5	–1.73	1.66E+07
2732.176	172 526	(even)	1.5	209 116	(odd)	1.5	–1.02	8.48E+07
2733.579	168 085	(even)	1.5	204 657	(odd)	1.5	–0.85	1.26E+08
2740.993*	204 657	(odd)	1.5	241 129	(even)	2.5	–1.65	2.01E+07
2745.662*	206 381	(odd)	0.5	242 791	(even)	0.5	–1.51	2.76E+07
2752.073*	206 466	(odd)	1.5	242 791	(even)	0.5	–1.65	1.95E+07
2761.097	168 450	(even)	0.5	204 657	(odd)	1.5	–0.82	1.33E+08
2763.116*	168 751	(even)	1.5	204 931	(odd)	0.5	–1.43	3.27E+07
2773.748	170 424	(even)	1.5	206 466	(odd)	1.5	–0.85	1.21E+08
2780.290*	170 424	(even)	1.5	206 381	(odd)	0.5	–1.72	1.62E+07
2783.786	173 416	(even)	2.5	209 327	(odd)	1.5	–0.49	2.78E+08
2790.173*	206 466	(odd)	1.5	242 295	(even)	1.5	–0.91	1.06E+08
2798.512*	209 327	(odd)	1.5	245 050	(even)	0.5	–0.88	1.13E+08
2798.863	171 159	(even)	3.5	206 878	(odd)	2.5	–0.08	7.05E+08
2800.270	173 416	(even)	2.5	209 116	(odd)	1.5	–0.66	1.87E+08
2803.490*	206 381	(odd)	0.5	242 040	(even)	1.5	–1.61	2.10E+07
2807.581	165 541	(even)	3.5	201 149	(odd)	2.5	–0.10	6.75E+08
2810.797*	217 262	(odd)	3.5	252 829	(even)	2.5	–1.58	2.22E+07
2816.790	204 096	(even)	0.5	239 588	(odd)	1.5	0.04	9.09E+08
2826.887*	204 224	(even)	1.5	239 588	(odd)	1.5	–1.92	9.97E+06
2826.954	165 541	(even)	3.5	200 905	(odd)	3.5	–1.06	7.39E+07
2829.386*	209 717	(odd)	0.5	245 050	(even)	0.5	–1.78	1.37E+07
2843.105*	206 878	(odd)	2.5	242 040	(even)	1.5	–1.63	1.96E+07
2845.444	187 168	(even)	1.5	222 301	(odd)	0.5	–0.22	4.94E+08
2869.768	172 042	(even)	1.5	206 878	(odd)	2.5	–0.55	2.25E+08
2872.920	204 096	(even)	0.5	238 894	(odd)	0.5	–0.24	4.63E+08
2873.424*	206 878	(odd)	2.5	241 669	(even)	2.5	–1.30	4.09E+07
2876.678	174 575	(even)	2.5	209 327	(odd)	1.5	–0.48	2.72E+08

Table 5. Continued.

λ^a (Å)	Lower level[b]			Upper level[b]			$\log gf^c$	gA^c (s^{-1})
	E (cm^{-1})	Parity	J	E (cm^{-1})	Parity	J		
2884.033*	206 466	(odd)	1.5	241 129	(even)	2.5	–1.63	1.86E+07
2894.284*	174 575	(even)	2.5	209 116	(odd)	1.5	–1.07	6.92E+07
2897.089	170 424	(even)	1.5	204 931	(odd)	0.5	–0.91	9.75E+07
2903.692	186 616	(even)	2.5	221 045	(odd)	2.5	0.00	7.87E+08
2904.120	172 042	(even)	1.5	206 466	(odd)	1.5	–0.59	2.02E+08
2910.200	172 526	(even)	1.5	206 878	(odd)	2.5	–0.62	1.89E+08
2911.293*	172 042	(even)	1.5	206 381	(odd)	0.5	–1.77	1.34E+07
2913.497*	218 711	(odd)	1.5	253 024	(even)	1.5	–1.26	4.39E+07
2916.072	175 434	(even)	0.5	209 717	(odd)	0.5	–1.62	1.91E+07
2918.727*	206 878	(odd)	2.5	241 129	(even)	2.5	–1.38	3.32E+07
2920.311	170 424	(even)	1.5	204 657	(odd)	1.5	–0.88	1.03E+08
2930.150*	218 711	(odd)	1.5	252 829	(even)	2.5	–0.86	1.07E+08
2945.536*	172 526	(even)	1.5	206 466	(odd)	1.5	–1.18	5.08E+07
2949.617	175 434	(even)	0.5	209 327	(odd)	1.5	–0.41	2.98E+08
2950.160*	216 235	(odd)	2.5	250 122	(even)	1.5	–1.73	1.42E+07
2951.010	187 168	(even)	1.5	221 045	(odd)	2.5	–0.46	2.65E+08
2952.908	172 526	(even)	1.5	206 381	(odd)	0.5	–1.53	2.22E+07
2956.071	167 086	(even)	2.5	200 905	(odd)	3.5	0.37	1.80E+09
2967.453	187 168	(even)	1.5	220 857	(odd)	1.5	0.06	8.68E+08
2968.130	175 434	(even)	0.5	209 116	(odd)	1.5	–0.53	2.25E+08
2968.683*	209 116	(odd)	1.5	242 791	(even)	0.5	–1.77	1.29E+07
2970.739	187 393	(even)	2.5	221 045	(odd)	2.5	0.05	8.39E+08
2987.404	187 393	(even)	2.5	220 857	(odd)	1.5	–0.07	6.29E+08
2987.404	209 327	(odd)	1.5	242 791	(even)	0.5	–1.47	2.53E+07
2987.596*	173 416	(even)	2.5	206 878	(odd)	2.5	–1.85	1.07E+07
2999.504	167 820	(even)	2.5	201 149	(odd)	2.5	–1.20	4.73E+07
3005.834	176 458	(even)	1.5	209 717	(odd)	0.5	–0.70	1.46E+08
3023.607	168 085	(even)	1.5	201 149	(odd)	2.5	–0.20	4.61E+08
3024.839	173 416	(even)	2.5	206 466	(odd)	1.5	–0.74	1.32E+08
3032.385*	209 327	(odd)	1.5	242 295	(even)	1.5	–1.11	5.61E+07
3036.401*	209 116	(odd)	1.5	242 040	(even)	1.5	–1.94	8.38E+06
3039.616	172 042	(even)	1.5	204 931	(odd)	0.5	–0.48	2.38E+08
3041.478	176 458	(even)	1.5	209 327	(odd)	1.5	–0.35	3.18E+08
3061.162	176 458	(even)	1.5	209 116	(odd)	1.5	–1.62	1.68E+07
3065.185	172 042	(even)	1.5	204 657	(odd)	1.5	–0.37	3.02E+08
3068.668*	209 717	(odd)	0.5	242 295	(even)	1.5	–1.39	2.86E+07
3069.746	165 541	(even)	3.5	198 109	(odd)	2.5	–1.19	4.60E+07
3070.704	188 488	(even)	3.5	221 045	(odd)	2.5	–0.06	6.09E+08
3078.444	207 114	(even)	2.5	239 588	(odd)	1.5	–0.23	4.16E+08
3085.018*	172 526	(even)	1.5	204 931	(odd)	0.5	–1.47	2.37E+07
3085.698	168 751	(even)	1.5	201 149	(odd)	2.5	–1.14	5.19E+07
3086.841	168 085	(even)	1.5	200 472	(odd)	0.5	–0.30	3.53E+08
3091.081*	209 327	(odd)	1.5	241 669	(even)	2.5	–1.40	2.82E+07
3092.740*	207 263	(even)	0.5	239 588	(odd)	1.5	–0.84	1.03E+08
3094.841	174 575	(even)	2.5	206 878	(odd)	2.5	–0.97	7.60E+07
3098.488	177 063	(even)	2.5	209 327	(odd)	1.5	–0.61	1.68E+08
3099.719*	166 088	(even)	0.5	198 340	(odd)	1.5	–1.29	3.43E+07
3107.867*	220 857	(odd)	1.5	253 024	(even)	1.5	–0.90	8.90E+07
3111.364	172 526	(even)	1.5	204 657	(odd)	1.5	–0.34	3.10E+08
3114.822	186 616	(even)	2.5	218 711	(odd)	1.5	–0.18	4.56E+08
3118.925	177 063	(even)	2.5	209 116	(odd)	1.5	–0.30	3.42E+08
3121.978	168 450	(even)	0.5	200 472	(odd)	0.5	–1.11	5.40E+07
3122.812*	209 116	(odd)	1.5	241 129	(even)	2.5	–1.89	8.74E+06
3126.107*	221 045	(odd)	2.5	253 024	(even)	1.5	–1.52	2.09E+07
3126.822*	220 857	(odd)	1.5	252 829	(even)	2.5	–1.75	1.22E+07
3134.835	174 575	(even)	2.5	206 466	(odd)	1.5	–0.95	7.67E+07
3143.570*	209 327	(odd)	1.5	241 129	(even)	2.5	–1.23	3.94E+07
3145.286*	221 045	(odd)	2.5	252 829	(even)	2.5	–0.77	1.14E+08

Table 5. Continued.

λ^{a} (Å)	Lower level[b]			Upper level[b]			$\log gf^{c}$	gA^{c} (s^{-1})
	E (cm^{-1})	Parity	J	E (cm^{-1})	Parity	J		
3151.588	168 751	(even)	1.5	200 472	(odd)	0.5	–1.22	4.10E+07
3160.551*	207 263	(even)	0.5	238 894	(odd)	0.5	–1.33	3.20E+07
3169.338	187 168	(even)	1.5	218 711	(odd)	1.5	–0.46	2.32E+08
3178.330*	218 711	(odd)	1.5	250 165	(even)	2.5	–1.71	1.26E+07
3182.682*	218 711	(odd)	1.5	250 122	(even)	1.5	–1.36	2.90E+07
3192.101*	187 393	(even)	2.5	218 711	(odd)	1.5	–0.91	8.10E+07
3198.697	167 086	(even)	2.5	198 340	(odd)	1.5	0.00	6.55E+08
3199.996	173 416	(even)	2.5	204 657	(odd)	1.5	–0.73	1.22E+08
3221.656	175 434	(even)	0.5	206 466	(odd)	1.5	–0.43	2.43E+08
3222.595	167 086	(even)	2.5	198 109	(odd)	2.5	0.29	1.25E+09
3230.489	175 434	(even)	0.5	206 381	(odd)	0.5	–0.26	3.55E+08
3253.995*	222 301	(odd)	0.5	253 024	(even)	1.5	–1.76	1.12E+07
3262.057	186 616	(even)	2.5	217 262	(odd)	3.5	0.02	6.60E+08
3264.779*	179 096	(even)	0.5	209 717	(odd)	0.5	–0.28	3.34E+08
3286.409	176 458	(even)	1.5	206 878	(odd)	2.5	0.13	8.27E+08
3291.129*	218 711	(odd)	1.5	249 087	(even)	0.5	–2.00	6.20E+06
3300.572*	167 820	(even)	2.5	198 109	(odd)	2.5	–1.44	2.26E+07
3304.323	168 085	(even)	1.5	198 340	(odd)	1.5	–0.72	1.17E+08
3306.881	179 096	(even)	0.5	209 327	(odd)	1.5	–0.48	2.01E+08
3323.344	174 575	(even)	2.5	204 657	(odd)	1.5	–0.93	7.11E+07
3327.087	170 424	(even)	1.5	200 472	(odd)	0.5	–1.39	2.46E+07
3328.385*	218 711	(odd)	1.5	248 747	(even)	0.5	–1.35	2.71E+07
3329.868	168 085	(even)	1.5	198 109	(odd)	2.5	–1.08	5.08E+07
3330.155	179 096	(even)	0.5	209 116	(odd)	1.5	–0.09	4.96E+08
3331.542	176 458	(even)	1.5	206 466	(odd)	1.5	–0.33	2.76E+08
3333.539	171 159	(even)	3.5	201 149	(odd)	2.5	–0.46	2.04E+08
3344.661	168 450	(even)	0.5	198 340	(odd)	1.5	–0.83	8.83E+07
3346.918	187 393	(even)	2.5	217 262	(odd)	3.5	0.11	7.64E+08
3375.167	186 616	(even)	2.5	216 235	(odd)	2.5	–0.29	3.04E+08
3400.075*	177 063	(even)	2.5	206 466	(odd)	1.5	–1.84	8.32E+06
3416.062*	220 857	(odd)	1.5	250 122	(even)	1.5	–1.80	9.23E+06
3421.092	175 434	(even)	0.5	204 657	(odd)	1.5	–0.78	9.40E+07
3433.035*	221 045	(odd)	2.5	250 165	(even)	2.5	–1.94	6.38E+06
3434.601*	172 042	(even)	1.5	201 149	(odd)	2.5	–0.30	2.82E+08
3438.111*	221 045	(odd)	2.5	250 122	(even)	1.5	–1.45	2.00E+07
3439.262	187 168	(even)	1.5	216 235	(odd)	2.5	0.18	8.52E+08
3447.530*	218 711	(odd)	1.5	247 709	(even)	1.5	–1.19	3.60E+07
3474.346	188 488	(even)	3.5	217 262	(odd)	3.5	–0.54	1.58E+08
3492.677	172 526	(even)	1.5	201 149	(odd)	2.5	–0.16	3.77E+08
3501.003*	178 322	(even)	3.5	206 878	(odd)	2.5	–1.79	9.03E+06
3511.088	176 458	(even)	1.5	204 931	(odd)	0.5	–0.54	1.56E+08
3516.429*	172 042	(even)	1.5	200 472	(odd)	0.5	–1.45	1.90E+07
3541.309*	220 857	(odd)	1.5	249 087	(even)	0.5	–1.48	1.78E+07
3577.339	172 526	(even)	1.5	200 472	(odd)	0.5	–0.84	7.48E+07
3581.151*	170 424	(even)	1.5	198 340	(odd)	1.5	–1.95	5.75E+06
3602.945*	188 488	(even)	3.5	216 235	(odd)	2.5	–1.81	7.99E+06
3604.745*	173 416	(even)	2.5	201 149	(odd)	2.5	–1.05	4.58E+07
3621.505*	218 711	(odd)	1.5	246 316	(even)	1.5	–1.81	7.79E+06
3622.964*	177 063	(even)	2.5	204 657	(odd)	1.5	–1.80	7.95E+06
3636.744*	173 416	(even)	2.5	200 905	(odd)	3.5	–0.38	2.12E+08
3664.006*	179 096	(even)	0.5	206 381	(odd)	0.5	–1.75	8.81E+06
3723.047*	220 857	(odd)	1.5	247 709	(even)	1.5	–1.90	6.04E+06

Table 5. Continued.

λ^{a} (Å)	Lower level[b]			Upper level[b]			$\log gf^{c}$	gA^{c} (s^{-1})
	E (cm^{-1})	Parity	J	E (cm^{-1})	Parity	J		
3732.289*	222 301	(odd)	0.5	249 087	(even)	0.5	–1.38	2.00E+07
3762.046*	174 575	(even)	2.5	201 149	(odd)	2.5	–1.88	6.31E+06
3780.275*	222 301	(odd)	0.5	248 747	(even)	0.5	–1.38	1.96E+07
3796.911*	174 575	(even)	2.5	200 905	(odd)	3.5	–1.23	2.73E+07
3835.171*	172 042	(even)	1.5	198 109	(odd)	2.5	–1.54	1.31E+07
3851.092*	213 628	(even)	1.5	239 588	(odd)	1.5	–1.24	2.58E+07
3869.601*	179 096	(even)	0.5	204 931	(odd)	0.5	–1.80	7.16E+06
3872.756*	172 526	(even)	1.5	198 340	(odd)	1.5	–1.23	2.58E+07
3911.142*	179 096	(even)	0.5	204 657	(odd)	1.5	–1.16	3.03E+07
3931.807*	221 045	(odd)	2.5	246 471	(even)	2.5	–1.67	9.30E+06
3934.718*	222 301	(odd)	0.5	247 709	(even)	1.5	–1.91	5.29E+06
3956.800*	213 628	(even)	1.5	238 894	(odd)	0.5	–0.59	1.08E+08
4010.500*	214 660	(even)	0.5	239 588	(odd)	1.5	–0.72	7.89E+07
4011.020*	173 416	(even)	2.5	198 340	(odd)	1.5	–1.57	1.11E+07
4048.548*	173 416	(even)	2.5	198 109	(odd)	2.5	–1.30	2.02E+07
4048.941*	176 458	(even)	1.5	201 149	(odd)	2.5	–1.10	3.19E+07
4125.270*	214 660	(even)	0.5	238 894	(odd)	0.5	–1.06	3.41E+07
4206.737*	174 575	(even)	2.5	198 340	(odd)	1.5	–1.55	1.08E+07
4238.976*	218 711	(odd)	1.5	242 295	(even)	1.5	–1.30	1.85E+07
4285.312*	218 711	(odd)	1.5	242 040	(even)	1.5	–1.22	2.17E+07
4364.567*	175 434	(even)	0.5	198 340	(odd)	1.5	–1.72	6.67E+06
4379.660*	178 322	(even)	3.5	201 149	(odd)	2.5	–1.67	7.67E+06
4433.494*	187 168	(even)	1.5	209 717	(odd)	0.5	–1.44	1.25E+07
4443.203	186 616	(even)	2.5	209 116	(odd)	1.5	–1.45	1.20E+07
4507.038*	239 588	(odd)	1.5	261 769	(even)	1.5	–1.64	7.28E+06
4666.092*	200 876	(even)	1.5	222 301	(odd)	0.5	–0.82	4.76E+07
5000.208*	222 301	(odd)	0.5	242 295	(even)	1.5	–1.99	2.75E+06
5003.429*	200 876	(even)	1.5	220 857	(odd)	1.5	–1.31	1.31E+07
5204.092*	239 588	(odd)	1.5	258 798	(even)	2.5	–1.97	2.63E+06
5241.629*	187 393	(even)	2.5	206 466	(odd)	1.5	–1.47	8.05E+06
5433.095*	202 644	(even)	2.5	221 045	(odd)	2.5	–0.89	2.79E+07
5436.451*	188 488	(even)	3.5	206 878	(odd)	2.5	–1.78	3.72E+06
5489.083*	202 644	(even)	2.5	220 857	(odd)	1.5	–1.61	5.21E+06
5605.447*	200 876	(even)	1.5	218 711	(odd)	1.5	–1.40	8.75E+06
5790.831*	187 393	(even)	2.5	204 657	(odd)	1.5	–1.57	5.32E+06
5943.268*	204 224	(even)	1.5	221 045	(odd)	2.5	–1.21	1.16E+07
5964.714*	204 096	(even)	0.5	220 857	(odd)	1.5	–1.95	2.11E+06
6010.328*	204 224	(even)	1.5	220 857	(odd)	1.5	–1.00	1.79E+07
6222.200*	202 644	(even)	2.5	218 711	(odd)	1.5	–0.79	2.69E+07
6508.940*	200 876	(even)	1.5	216 235	(odd)	2.5	–1.96	1.77E+06
6647.936*	207 263	(even)	0.5	222 301	(odd)	0.5	–0.98	1.63E+07
6838.816*	202 644	(even)	2.5	217 262	(odd)	3.5	–1.69	2.75E+06
6840.519*	204 096	(even)	0.5	218 711	(odd)	1.5	–1.27	7.62E+06
6900.579*	204 224	(even)	1.5	218 711	(odd)	1.5	–0.80	2.19E+07
7176.412*	207 114	(even)	2.5	221 045	(odd)	2.5	–1.76	2.28E+06
7274.416*	207 114	(even)	2.5	220 857	(odd)	1.5	–1.68	2.65E+06
7354.366*	207 263	(even)	0.5	220 857	(odd)	1.5	–1.32	6.22E+06
7896.360*	188 488	(even)	3.5	201 149	(odd)	2.5	–1.80	1.66E+06
8620.447*	207 114	(even)	2.5	218 711	(odd)	1.5	–1.16	6.40E+06
8732.950*	207 263	(even)	0.5	218 711	(odd)	1.5	–1.90	1.19E+06

[a]Experimental wavelengths from [26]. Values with an asterisk * were deduced from experimental energy levels. [b]Experimental energy levels from [26]. [c]This work.

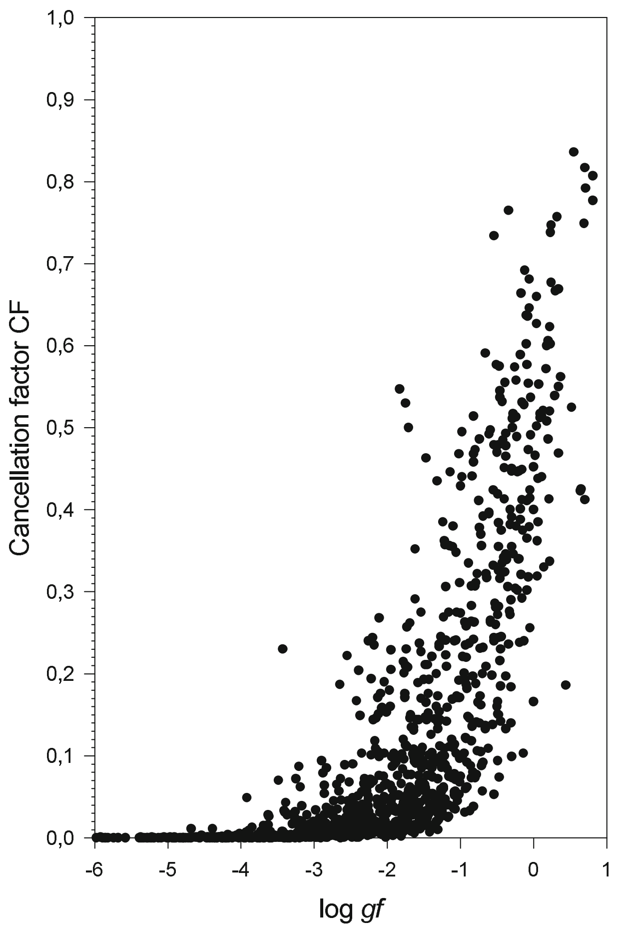

Fig. 1. Cancellation factors plotted as a function of log gf-values as obtained in the present work for Rb III spectral lines.

when using the value published in [35] for the dipole polarizabilty of Rb X, i.e. $\alpha_d = 0.13$ a.u., instead of the one taken from [34] and adopted in the present work ($\alpha_d = 0.1576$ a.u.), all the calculated gA- and gf-values were found to be modified by less than 1%.

Unfortunately, no experimental neither previous theoretical radiative rates in Rb III are available for comparison. Nevertheless, an argument for estimating the reliability of the present results can be obtained from many of our recent works related to lowly charged ions of the same group in which a similar computational strategy was developed and compared to experimental data [5–25]. In these investigations, HFR + CPOL calculations were found to be in excellent agreement (within a few percent) with accurate lifetimes measured using the time-resolved laser-induced fluorescence (TR-LIF) technique. Consequently, uncertainties of the order of 10–20% are probably to be expected for the transition rates quoted in Table 5, at least for the most intense lines. However, laboratory measurements of accurate radiative lifetimes and branching fractions in Rb III would be welcome to definitely assess the accuracy of the theoretical results obtained in the present work.

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