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Relativistic Hartree–Fock calculations of transition rates for allowed and forbidden lines in Nd IV

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Abstract
A pseudo-relativistic Hartree–Fock model including a large amount of configuration-interaction effects has been used to compute radiative decay rates for allowed and forbidden transitions in Nd IV. Detailed comparisons of transition probabilities, oscillator strengths and radiative lifetimes with data previously published are also reported and discussed in the present work.

Keywords: atomic data, transition rates, triply ionized lanthanides

1. Introduction

It is well known that triply ionized lanthanides play an important role in different areas such as laser physics, lighting industry, photonics, molecular biology, medical diagnostics, etc (see e.g. Hemmilä 1995, Wybourne 2004, Hasegawa *et al* 2004, Dossing 2005) and their radiative properties were essentially investigated from spectroscopy experiments on ions embedded in compounds or crystal lattices.

In the case of neodymium ($Z = 60$), the emission spectrum of Nd^{3+} ion has been studied in various compounds such as, for example, in NaCl and KCl single crystals (Rao 1973), in yttrium orthovanadate (Wortman *et al* 1974), in neodymium trifluorides (Vaishnava *et al* 1974), in Nd^{3+}:$Y_3Al_5O_{12}$ (Gasparik and Ozvoldova 1974), in $LaCl_3$:Nd^{3+} (Zalucha *et al* 1974, Crosswhite *et al* 1976) or in $Gd_2(MoO_4)_3$ (Spector *et al* 1977).

The free Nd^{3+} ion spectrum was first observed by Irwin (1968) who listed about 1000 of the strongest Nd lines obtained using a spark source in the region 127–311 nm. A number of lines were classified as $4f^3\ ^4I°$–$4f^25d$, $4f^2(^3H)6s$–$4f^2(^3H)6p$, or $4f^2(^3H)5d$–$4f^2(^3H)6p$ transitions in Nd IV, but no connection between any of the three resulting systems was found. Consequently, this study was not considered as reliable enough to be included in the critical compilation by Martin *et al* (1978) who preferred to list the levels of the $4f^3$ configuration taken from the analysis of the Nd^{3+} spectrum in a $LaCl_3$ host crystal due to Crosswhite *et al* (1976).

More recently, the first level structure investigation of the free Nd^{3+} ion was reported by Wyart *et al* (2006) who observed the neodymium emission spectrum produced by vacuum spark sources in the vacuum ultraviolet on two normal-incidence spectrographs. They identified more than 550 lines as transitions from 85 $4f^25d$ levels to the lowest 37 levels of the $4f^3$ ground configuration. Shortly after this work, the same experimental material was used by Wyart *et al* (2007) to extend wavelength measurements in higher excitation conditions. This led to the completion to all 41 levels of the $4f^3$ ground configuration and to the classification of 1426 lines involving the excited configurations $4f^25d$, $4f^26p$, $4f^26s$. A number of new levels were also assigned to the core-excited $5p^54f^4$ configuration. Altogether 111 odd parity and 121 even parity levels were established. In this latter work, theoretical values of lifetimes and transition probabilities, computed with a rather limited relativistic Hartree–Fock (HFR) model, were reported. Furthermore, Wyart *et al* (2008) carried out a detailed theoretical investigation of the $4f^3$ configuration in Nd IV by performing a parametric fit of level

Table 1. Adopted radial parameters (in cm^{-1}) for even-parity configurations of Nd IV.

Configuration	Parameter	HFR	Fitted	Fitted/ HFR	Note[a]
$4f^3$	E_{av}	–	25 954	–	
	$F^2(4f,4f)$	102 658	79 427	0.77	
	$F^4(4f,4f)$	64 418	55 720	0.86	
	$F^6(4f,4f)$	46 345	38 123	0.82	
	α	–	10	–	
	β	–	−324	–	
	γ	–	878	–	
	ζ_{4f}	957	890	0.93	
$4f^26p$	E_{av}	–	164 287	–	
	$F^2(4f,4f)$	110 783	82 525	0.74	
	$F^4(4f,4f)$	69 929	62 129	0.89	
	$F^6(4f,4f)$	50 430	39 513	0.78	
	α	–	19		r1
	β	–	−481		r1
	γ	–	1569		r1
	ζ_{4f}	1059	986	0.93	
	ζ_{6p}	2962	3589	1.21	
	$F^2(4f,6p)$	9951	7762	0.78	
	$G^2(4f,6p)$	2518	2374	0.94	
	$G^4(4f,6p)$	2313	2011	0.87	
$5p^54f^4$	E_{av}	–	183 596	–	
	$F^2(4f,4f)$	96 503	73 412	0.76	
	$F^4(4f,4f)$	60 281	53 344	0.88	
	$F^6(4f,4f)$	43 289	34 742	0.80	
	α	–	20		r2
	β	–	−496		r2
	γ	–	1616		r2
	ζ_{4f}	880	793	0.90	
	ζ_{5p}	16 204	16 522	1.02	
	$F^2(4f,5p)$	51 106	37 082	0.73	
	$G^2(4f,5p)$	29 048	25 046	0.86	
	$G^4(4f,5p)$	22 017	15 532	0.71	
$4f^3-4f^26p$	$R^2(4f4f,4f6p)$	−4973	−4227	0.85	f
	$R^4(4f4f,4f6p)$	−3193	−2714	0.85	f
$4f^3-5p^54f^4$	$R^2(4f5p,4f4f)$	−21791	−18539	0.85	r3
	$R^4(4f5p,4f4f)$	−12092	−10288	0.85	r3
	$R^2(5p5p,4f5p)$	−39045	−33218	0.85	r3

[a] r stands for 'parameters varied in a constant ratio' and f stands for 'fixed parameter value'.

energies, taking into account Coulomb and spin-dependent interactions beyond the first order of perturbation. Note also that systematic Hartree–Fock and relativistic configuration-interaction studies of energy levels and lifetimes of some triply ionized lanthanides, including Nd^{3+}, were published by Dzuba *et al* (2003).

In the present work, the relativistic Hartree–Fock method including a large amount of configuration interaction has been used to compute the radiative parameters corresponding to allowed and forbidden transitions in Nd IV. These calculations are an extension of our previous studies of triply ionized lanthanides La IV (Biémont *et al* 2009), Ce IV (Zhang *et al* 2001a), Pr IV (Enzonga Yoca and Quinet 2013) and Yb IV (Wyart *et al* 2001).

Table 2. Adopted radial parameters (in cm^{-1}) for even-parity configurations of Nd IV.

Configuration	Parameter	HFR	Fitted	Fitted/ HFR	Note[a]
$4f^25d$	E_{av}	–	90 848	–	
	$F^2(4f,4f)$	109 950	85 551	0.78	
	$F^4(4f,4f)$	69 359	62 158	0.90	
	$F^6(4f,4f)$	50 007	42 335	0.85	
	α	–	13	–	
	β	–	−371	–	
	γ	–	822	–	
	ζ_{4f}	1052	1004	0.95	
	ζ_{5d}	1146	1116	0.97	
	$F^2(4f,5d)$	30 830	24 269	0.79	
	$F^4(4f,5d)$	15 288	14 473	0.95	
	$G^1(4f,5d)$	13 343	11 749	0.88	
	$G^3(4f,5d)$	11 335	9718	0.86	
	$G^5(4f,5d)$	8788	8099	0.92	
$4f^26s$	E_{av}	–	123 089	–	
	$F^2(4f,4f)$	110 707	83 730	0.76	
	$F^4(4f,4f)$	69 878	61 732	0.88	
	$F^6(4f,4f)$	50 392	42 942	0.85	
	α	–	14		r1
	β	–	−379		r1
	γ	–	839		r1
	ζ_{4f}	1059	994	0.94	
	$G^3(4f,6s)$	3365	2875	0.85	
$4f^25d$-$4f^26s$	$R^2(4f5d,4f6s)$	974	828	0.85	f
	$R^3(4f5d,4f6s)$	2962	2518	0.85	f

[a] r stands for 'parameters varied in a constant ratio' and f stands for 'fixed parameter value'.

2. Relativistic Hartree–Fock calculations

To correctly describe the structure of a heavy atomic system such as triply ionized neodymium, it is necessary to consider the most important electronic correlation and relativistic effects simultaneously. We have already shown in many previous works on lowly charged lanthanide atoms that the pseudo-relativistic Hartree–Fock method of Cowan (1981) appears as a suitable compromise between a gratifying accuracy of the results (tested by comparison with accurate laser lifetime measurements), the moderate complexity of the codes used and the ability to obtain a large number of new results in a limited CPU time (see e.g. Quinet *et al* 2002, Biémont and Quinet 2003).

Nd^{3+} ion belongs to the La isoelectronic sequence in which two ions, i.e. Ce^{+} and Pr^{2+} have already been studied with the same HFR approach (see Palmeri *et al* 2000a, 2000b, Biémont *et al* 2001, Zhang *et al* 2001b). In those works, Ce^{+} and Pr^{2+} were considered as atomic systems with three valence electrons surrounding a Xe-like ionic core so that most of the intravalence correlation was represented within a configuration-interaction scheme, while core-valence correlation was described by a core-polarization model potential depending on two parameters, i.e. the static dipole polarizability of the ionic core, α_d, and the cut-off radius, r_c. This picture is no more valid in the case of Nd^{3+} due to the fact that some core-excited configurations with an open 5p subshell are expected to

Table 3. Computed oscillator strengths and transition probabilities for electric dipole lines in Nd IV. Only transitions with log $gf \geqslant -1.0$ are listed in the table.

	Lower level[b]			Upper level[b]				
Wavelength[a] (nm)	E (cm^{-1})	J	Parity	E (cm^{-1})	J	Parity	log gf[c]	gA[c] (s^{-1})
106.8300*	86 678.25	7.5	(e)	180 284.95	7.5	(o)	−0.83	8.72E+08
119.2535	81 303.91	6.5	(e)	165 158.58	5.5	(o)	−0.92	5.65E+08
119.4932	77 809.61	4.5	(e)	161 496.05	3.5	(o)	−0.75	8.37E+08
119.6176	75 666.91	3.5	(e)	159 266.55	2.5	(o)	−1.00	4.69E+08
120.0294	77 912.50	5.5	(e)	161 225.30	4.5	(o)	−0.85	6.51E+08
120.8150D	73 366.17	4.5	(e)	156 137.08	4.5	(o)	−0.92	5.55E+08
121.3802	79 189.02	6.5	(e)	161 574.84	5.5	(o)	−0.71	8.83E+08
121.4453*	71 744.57	4.5	(e)	154 086.17	5.5	(o)	−0.67	9.75E+08
122.0447	98 437.09	6.5	(e)	180 284.95	7.5	(o)	−0.69	9.08E+08
122.0632	77 912.50	5.5	(e)	159 837.56	4.5	(o)	−0.54	1.28E+09
122.1247	71 744.57	5.5	(e)	153 628.30	4.5	(o)	−0.64	1.03E+09
122.3860	84 092.98	6.5	(e)	165 802.12	5.5	(o)	−0.38	1.84E+09
122.6015D	74 571.83	5.5	(e)	156 137.08	4.5	(o)	−0.56	1.21E+09
122.6582*	74 673.95	6.5	(e)	156 201.33	6.5	(o)	−0.84	6.36E+08
122.7806*	73 366.17	4.5	(e)	154 812.25	3.5	(o)	−0.86	6.10E+08
123.2369	80 080.41	5.5	(e)	161 225.30	4.5	(o)	−0.77	7.47E+08
123.9323D	74 673.95	6.5	(e)	155 363.06	5.5	(o)	−0.68	9.20E+08
124.1824	81 375.35	3.5	(e)	161 901.81	2.5	(o)	−0.98	4.49E+08
124.5693	81 375.35	3.5	(e)	161 652.20	3.5	(o)	−0.81	6.67E+08
124.5919	73 366.17	4.5	(e)	153 628.30	4.5	(o)	−0.55	1.21E+09
124.6625	74 363.99	3.5	(e)	154 581.00	2.5	(o)	−0.76	7.46E+08
124.9920	78 864.24	7.5	(e)	158 869.30	6.5	(o)	−0.49	1.38E+09
125.1713	79 694.96	4.5	(e)	159 585.52	3.5	(o)	−0.69	8.75E+08
125.1826	81 691.09	5.5	(e)	161 574.84	5.5	(o)	−0.79	6.96E+08
125.3300	78 864.24	7.5	(e)	158 653.53	7.5	(o)	−0.03	3.96E+09
125.3806	80 080.41	5.5	(e)	159 837.56	4.5	(o)	−0.61	1.04E+09
125.4213	80 080.41	5.5	(e)	159 812.28	5.5	(o)	−0.47	1.44E+09
125.4235	76 471.40	6.5	(e)	156 201.33	6.5	(o)	−0.34	1.93E+09
125.5462	73 366.17	4.5	(e)	153 018.22	3.5	(o)	−0.22	2.57E+09
125.7324	81 691.09	5.5	(e)	161 225.30	4.5	(o)	−0.60	1.06E+09
125.7635	74 571.83	5.5	(e)	154 086.17	5.5	(o)	−0.25	2.39E+09
125.8668	100 835.39	7.5	(e)	180 284.95	7.5	(o)	0.04	4.62E+09
125.9253	74 673.95	6.5	(e)	154 086.17	5.5	(o)	−0.17	2.85E+09
125.9461	76 471.40	6.5	(e)	155 870.45	5.5	(o)	−0.56	1.15E+09
126.2202D	73 366.17	4.5	(e)	152 592.92	4.5	(o)	−0.40	1.68E+09
126.3498	75 666.91	3.5	(e)	154 812.25	3.5	(o)	−0.72	8.02E+08
126.3967D	86 067.88	3.5	(e)	165 183.48	2.5	(o)	−0.96	4.57E+08
126.4317	73 616.22	2.5	(e)	152 710.30	2.5	(o)	−0.38	1.73E+09
126.4916	74 571.83	5.5	(e)	153 628.30	4.5	(o)	−0.38	1.75E+09
126.7561*	76 471.40	6.5	(e)	155 363.06	5.5	(o)	−0.96	4.63E+08
126.8857	88 097.78	5.5	(e)	166 908.81	4.5	(o)	−0.94	4.77E+08
126.9077	87 114.16	2.5	(e)	165 911.59	3.5	(o)	−0.77	6.94E+08
126.9217	80 080.41	5.5	(e)	158 869.30	6.5	(o)	−0.50	1.30E+09
127.0048	87 114.16	2.5	(e)	165 851.25	3.5	(o)	−0.67	8.81E+08
127.0172D	81 691.09	5.5	(e)	160 420.64	4.5	(o)	−0.15	2.92E+09
127.0172D	87 072.95	5.5	(e)	165 802.12	5.5	(o)	−0.51	1.29E+09
127.1108	20 005.22	6.5	(o)	98 676.42	5.5	(e)	−0.82	6.25E+08
127.1264	77 539.71	7.5	(e)	156 201.33	6.5	(o)	0.19	6.45E+09
127.2300	80 128.30	2.5	(e)	158 725.98	1.5	(o)	−0.99	4.24E+08
127.3750	81 303.91	6.5	(e)	159 812.28	5.5	(o)	−0.49	1.32E+09
127.5016	81 155.44	4.5	(e)	159 585.52	3.5	(o)	−0.58	1.09E+09
127.6453D	100 976.62	3.5	(e)	179 319.09	2.5	(o)	−0.35	1.82E+09
127.6943D	101 159.67	6.5	(e)	79 471.41	5.5	(o)	−0.30	2.06E+09
127.7694T	83 309.16	6.5	(e)	161 574.84	5.5	(o)	−0.56	1.13E+09
127.8412	80 431.49	8.5	(e)	158 653.53	7.5	(o)	0.41	1.06E+10
127.8787	77 809.61	4.5	(e)	156 008.48	4.5	(o)	−0.22	2.44E+09
128.0334	5988.51	7.5	(o)	84 092.98	6.5	(e)	−0.82	6.15E+08
128.1046	77 809.61	4.5	(e)	155 870.45	5.5	(o)	−0.85	5.82E+08
128.1695D	74 571.83	5.5	(e)	152 592.92	4.5	(o)	−0.22	2.43E+09
128.1963	81 832.25	3.5	(e)	159 837.56	4.5	(o)	−0.82	6.18E+08
128.2737	77 912.50	5.5	(e)	155 870.45	5.5	(o)	−0.77	6.90E+08
128.2836	80 080.41	5.5	(e)	158 032.30	5.5	(o)	−0.16	2.84E+09
128.3841	81 375.35	3.5	(e)	159 266.55	2.5	(o)	−0.86	5.56E+08

Table 3. (Continued.)

	Lower level[b]			Upper level[b]				
Wavelength[a] (nm)	E (cm^{-1})	J	Parity	E (cm^{-1})	J	Parity	log gf[c]	gA[c] (s^{-1})
128.4802	0.00	4.5	(o)	77 833.03	3.5	(e)	−0.78	6.62E+08
128.5379	1897.11	5.5	(o)	79 694.96	4.5	(e)	−0.73	7.55E+08
128.5609	3907.43	6.5	(o)	81 691.09	5.5	(e)	−0.71	7.78E+08
128.6924	88 097.78	5.5	(e)	165 802.12	5.5	(o)	−0.45	1.42E+09
128.7463	83 768.34	5.5	(e)	161 574.84	5.5	(o)	−0.36	1.77E+09
128.7719	88 097.78	5.5	(e)	165 754.41	4.5	(o)	−0.06	3.48E+09
128.8407	76 471.40	6.5	(e)	154 086.17	5.5	(o)	−0.44	1.46E+09
128.8570	79 694.96	4.5	(e)	157 299.94	3.5	(o)	−0.86	5.54E+08
128.8688	83 897.98	2.5	(e)	161 496.05	3.5	(o)	−0.83	5.97E+08
128.9230	81 303.91	6.5	(e)	158 869.30	6.5	(o)	−0.01	3.95E+09
129.0619	84 092.98	6.5	(e)	161 574.84	5.5	(o)	0.14	5.49E+09
129.1412	81 832.25	3.5	(e)	159 266.55	2.5	(o)	−0.78	6.67E+08
129.2804	75 666.91	3.5	(e)	153 018.22	3.5	(o)	−0.29	2.05E+09
129.2831*	81 303.91	6.5	(e)	158 653.53	7.5	(o)	−0.99	4.12E+08
129.3031D	78 864.24	7.5	(e)	156 201.33	6.5	(o)	−0.18	2.61E+09
129.3031D	102 627.40	4.5	(e)	179 964.22	3.5	(o)	−0.14	2.89E+09
129.3286	83 903.04	5.5	(e)	161 225.30	4.5	(o)	−0.16	2.79E+09
129.3559	78 702.59	5.5	(e)	156 008.48	4.5	(o)	−0.27	2.15E+09
129.4602*	84 408.39	4.5	(e)	161 652.20	3.5	(o)	−0.79	6.51E+08
129.4853	102 242.87	5.5	(e)	79 471.41	5.5	(o)	−0.04	3.61E+09
129.4951D	80 080.41	5.5	(e)	157 302.95	5.5	(o)	−0.91	4.82E+08
129.5813*	80 128.30	2.5	(e)	157 299.94	3.5	(o)	−0.96	4.39E+08
129.5871D	78 702.59	5.5	(e)	155 870.45	5.5	(o)	−0.15	2.82E+09
129.5871D	82 669.72	4.5	(e)	159 837.56	4.5	(o)	−0.98	4.18E+08
129.6011	88 642.61	4.5	(e)	165 802.12	5.5	(o)	−0.92	4.75E+08
129.6573D	84 775.85	1.5	(e)	161 901.81	2.5	(o)	−0.49	1.27E+09
129.6813	88 642.61	4.5	(e)	165 754.41	4.5	(o)	−0.45	1.42E+09
129.7223	84 408.39	4.5	(e)	161 496.05	3.5	(o)	−0.37	1.70E+09
129.7842D	73 556.74	5.5	(e)	150 607.31	5.5	(o)	0.06	4.52E+09
129.7842D	77 809.61	4.5	(e)	154 860.81	4.5	(o)	−0.79	6.41E+08
129.7881	88 135.24	2.5	(e)	165 183.48	2.5	(o)	−0.70	7.86E+08
129.8490	79 189.02	6.5	(e)	156 201.33	6.5	(o)	−0.49	1.27E+09
129.8601	101 159.67	6.5	(e)	178 165.59	6.5	(o)	0.01	4.07E+09
129.8634	73 556.74	5.5	(e)	150 560.55	4.5	(o)	−0.08	3.31E+09
129.8990*	77 598.12	2.5	(e)	154 581.00	2.5	(o)	−0.71	7.64E+08
129.9302	83 897.98	2.5	(e)	160 862.38	2.5	(o)	−0.59	1.02E+09
129.9798	76 471.40	6.5	(e)	153 406.25	5.5	(o)	−0.30	1.98E+09
130.0121	82 669.72	4.5	(e)	159 585.52	3.5	(o)	−0.42	1.50E+09
130.1068	88 097.78	5.5	(e)	164 957.81	4.5	(o)	−0.38	1.65E+09
130.1688	84 672.74	3.5	(e)	161 496.05	3.5	(o)	−0.66	8.64E+08
130.2499	81 950.73	1.5	(e)	158 725.98	1.5	(o)	−0.97	4.21E+08
130.2960	77 833.03	3.5	(e)	154 581.00	2.5	(o)	−0.44	1.43E+09
130.3315D	70 817.12	4.5	(e)	147 544.89	4.5	(o)	−0.004	3.89E+09
130.3315D	81 303.91	6.5	(e)	158 032.30	5.5	(o)	−0.24	2.29E+09
130.4085D	79 189.02	6.5	(e)	155 870.45	5.5	(o)	−0.76	6.84E+08
130.4085D	85 352.26	4.5	(e)	162 034.11	4.5	(o)	−0.79	6.42E+08
130.4994	97 727.22	1.5	(e)	174 355.70	1.5	(o)	−0.79	6.40E+08
130.5372	76 411.72	4.5	(e)	153 018.22	3.5	(o)	−0.94	4.57E+08
130.6183	74 571.83	5.5	(e)	151 130.44	4.5	(o)	−0.80	6.19E+08
130.6294	84 672.74	3.5	(e)	161 225.30	4.5	(o)	−0.73	7.27E+08
130.6889	83 903.04	5.5	(e)	160 420.64	4.5	(o)	−0.68	8.24E+08
130.8946	83 768.34	3.5	(e)	160 165.53	3.5	(o)	−0.99	3.97E+08
130.9058	84 266.98	0.5	(e)	160 657.91	1.5	(o)	−0.60	9.77E+08
131.0311	85 716.11	4.5	(e)	162 034.11	4.5	(o)	−0.85	5.55E+08
131.0363	88 642.61	4.5	(e)	164 957.81	4.5	(o)	−0.76	6.72E+08
131.0557	22 043.77	7.5	(o)	98 347.09	6.5	(e)	−0.84	5.61E+08
131.0616	85 352.26	4.5	(e)	161 652.20	3.5	(o)	−0.98	4.08E+08
131.1951	85 352.26	4.5	(e)	161 574.84	5.5	(o)	−0.85	5.47E+08
131.2969	84 698.79	1.5	(e)	160 862.38	2.5	(o)	−0.72	7.30E+08
131.3690D	76 471.40	6.5	(e)	152 592.62	5.5	(o)	−0.75	6.88E+08
131.4293D	84 775.85	1.5	(e)	160 862.38	2.5	(o)	−0.63	9.11E+08
131.4588	83 768.34	3.5	(e)	159 837.56	4.5	(o)	−0.81	5.98E+08
131.5015*	98 541.35	0.5	(e)	174 586.12	1.5	(o)	−0.90	4.87E+08
131.5576	84 408.39	4.5	(e)	160 420.64	4.5	(o)	−0.38	1.62E+09

Table 3. (Continued.)

	Lower level[b]			Upper level[b]				
Wavelength[a] (nm)	E (cm^{-1})	J	Parity	E (cm^{-1})	J	Parity	log gf[c]	gA[c] (s^{-1})
131.5666	84 855.30	2.5	(e)	160 862.38	2.5	(o)	−0.76	6.67E+08
131.5807	81 303.91	6.5	(e)	157 302.95	5.5	(o)	−0.89	5.02E+08
131.6498	84 698.79	1.5	(e)	160 657.91	1.5	(o)	−0.58	1.02E+09
131.6941	74 673.95	6.5	(e)	150 607.31	5.5	(o)	0.22	6.44E+09
131.7119	102 242.87	5.5	(e)	178 165.59	6.5	(o)	−0.48	1.28E+09
131.7990	85 352.26	4.5	(e)	161 225.30	4.5	(o)	−0.52	1.16E+09
131.8669	86 067.88	3.5	(e)	161 901.81	2.5	(o)	−0.95	4.27E+08
131.9249	71 744.57	5.5	(e)	147 544.89	4.5	(o)	0.28	7.29E+09
132.0004	84 408.39	4.5	(e)	160 165.53	3.5	(o)	−0.54	1.11E+09
132.1108	83 032.16	1.5	(e)	158 725.98	1.5	(o)	−0.73	7.19E+08
132.2610D	99 195.97	3.5	(e)	174 803.78	2.5	(o)	−0.31	1.87E+09
132.2715	98 347.09	6.5	(e)	173 949.03	6.5	(o)	−0.10	3.00E+09
132.2809	77 809.61	4.5	(e)	153 406.25	5.5	(o)	−0.70	7.67E+08
132.3021	86 067.88	3.5	(e)	161 652.20	3.5	(o)	−0.78	6.29E+08
132.3570	99 033.19	2.5	(e)	174 586.12	1.5	(o)	−0.85	5.41E+08
132.4334D	85 716.11	4.5	(e)	161 225.30	4.5	(o)	−0.79	6.16E+08
132.4334D	104 775.22	8.5	(e)	180 284.95	7.5	(o)	0.49	1.18E+10
132.4611	77 912.50	5.5	(e)	153 406.25	5.5	(o)	−0.07	3.22E+09
132.5755D	84 408.39	4.5	(e)	159 837.56	4.5	(o)	−0.95	4.31E+08
132.5879	90 380.51	6.5	(e)	165 802.12	5.5	(o)	0.22	6.26E+09
132.5906	77 598.12	2.5	(e)	153 018.22	3.5	(o)	−0.31	1.83E+09
132.6090	102 756.25	7.5	(e)	178 165.59	6.5	(o)	0.28	7.24E+09
132.6363	99 409.66	2.5	(e)	174 803.78	2.5	(o)	−0.93	4.42E+08
132.6918	82 669.72	4.5	(e)	158 032.30	5.5	(o)	−0.84	5.50E+08
132.7626	99 033.19	2.5	(e)	174 355.70	1.5	(o)	−0.70	7.50E+08
132.7749	5988.51	7.5	(o)	81 303.91	6.5	(e)	−0.41	1.45E+09
132.7841	84 855.30	2.5	(e)	160 165.53	3.5	(o)	−0.80	6.02E+08
132.8500	98 676.42	5.5	(e)	173 949.03	6.5	(o)	−0.68	7.83E+08
132.9048	79 339.01	1.5	(e)	154 581.00	2.5	(o)	−0.62	9.12E+08
133.0204D	99 409.66	2.5	(e)	174 586.12	1.5	(o)	−0.83	5.57E+08
133.0901	83 588.99	2.5	(e)	158 725.98	1.5	(o)	−0.76	6.53E+08
133.1248D	79 694.96	4.5	(e)	154 812.25	3.5	(o)	−0.12	2.87E+09
133.1248D	81 155.44	4.5	(e)	156 272.69	3.5	(o)	−0.38	1.57E+09
132.1398	83 588.99	2.5	(e)	159 266.55	2.5	(o)	−0.61	9.33E+08
133.1652*	80 663.34	1.5	(e)	155 758.06	2.5	(o)	−0.69	7.71E+08
133.1970D	104 888.37	3.5	(e)	179 964.22	3.5	(o)	−0.63	8.77E+08
133.3523	100 976.62	3.5	(e)	175 965.55	2.5	(o)	−0.65	8.39E+08
133.3657	81 155.44	4.5	(e)	156 137.08	4.5	(o)	−0.30	1.88E+09
133.4023	87 072.95	5.5	(e)	162 034.11	4.5	(o)	−0.61	9.29E+08
133.4297	99 409.66	2.5	(e)	174 355.70	1.5	(o)	−1.00	3.75E+08
133.4468*	82 363.72	3.5	(e)	157 299.94	3.5	(o)	−0.54	1.08E+09
133.4884	84 672.74	3.5	(e)	159 585.52	3.5	(o)	−0.42	1.42E+09
133.5161T	79 189.02	6.5	(e)	154 086.17	5.5	(o)	−0.61	9.18E+08
133.5161T	81 375.35	3.5	(e)	156 272.69	3.5	(o)	−0.90	4.71E+08
133.5508	77 833.03	3.5	(e)	152 710.30	2.5	(o)	−0.14	2.71E+09
133.5225	75 666.91	3.5	(e)	150 560.55	4.5	(o)	−0.42	1.42E+09
133.5248	90 291.23	1.5	(e)	165 183.48	2.5	(o)	−0.18	2.49E+09
133.5420	91 028.86	4.5	(e)	165 911.59	3.5	(o)	−0.50	1.18E+09
133.6009	81 422.92	2.5	(e)	156 272.69	3.5	(o)	−0.22	2.26E+09
133.6119	90 339.84	2.5	(e)	165 183.48	2.5	(o)	−0.43	1.40E+09
133.6399	83 897.98	2.5	(e)	158 725.98	1.5	(o)	−0.86	5.20E+08
133.6498*	91 028.86	4.5	(e)	165 851.25	3.5	(o)	−0.45	1.32E+09
133.6980	3907.43	6.5	(o)	78 702.59	5.5	(e)	−0.49	1.20E+09
133.7285	90 380.51	6.5	(e)	165 158.58	5.5	(o)	−0.37	1.60E+09
133.7322*	84 092.98	6.5	(e)	158 869.30	6.5	(o)	−0.93	4.39E+08
133.7583	81 375.35	3.5	(e)	156 137.08	4.5	(o)	−0.63	8.64E+08
133.7883*	81 013.13	1.5	(e)	155 758.06	2.5	(o)	−0.45	1.32E+09
133.7985	12 800.29	4.5	(o)	87 539.35	5.5	(e)	−0.98	3.86E+08
133.8229	91 028.86	4.5	(e)	165 754.41	4.5	(o)	−0.77	6.29E+08
133.8619D	78 702.59	5.5	(e)	153 406.25	5.5	(o)	−0.48	1.23E+09
133.8619D	85 716.11	4.5	(e)	160 420.64	4.5	(o)	−0.63	8.62E+08
133.9033D	77 912.50	5.5	(e)	152 592.92	4.5	(o)	−0.78	6.23E+08
133.9127	98 347.09	6.5	(e)	173 022.52	5.5	(o)	−0.19	2.43E+09

Table 3. (Continued.)

	Lower level[b]			Upper level[b]				
Wavelength[a] (nm)	E (cm^{-1})	J	Parity	E (cm^{-1})	J	Parity	log gf[c]	gA[c] (s^{-1})
133.9884	87 400.57	3.5	(e)	162 034.11	4.5	(o)	−0.71	7.27E+08
134.0596	84 672.74	3.5	(e)	159 266.55	2.5	(o)	−0.64	8.50E+08
134.1080	98 347.09	6.5	(e)	172 913.80	6.5	(o)	−0.24	2.16E+09
134.2014	1897.11	5.5	(o)	76 411.72	4.5	(e)	−0.53	1.10E+09
134.3139	80 128.30	2.5	(e)	154 581.00	2.5	(o)	−0.84	5.32E+08
134.3255	81 691.09	5.5	(e)	156 137.08	4.5	(o)	−0.31	1.84E+09
134.3527	104 888.37	3.5	(e)	179 319.09	2.5	(o)	−1.00	3.70E+08
134.4736	0.00	4.5	(o)	74 363.99	3.5	(e)	−0.59	9.37E+08
134.4765*	87 539.35	3.5	(e)	161 901.81	2.5	(o)	−0.63	8.70E+08
134.5058	98 676.42	5.5	(e)	173 022.52	5.5	(o)	0.09	4.55E+09
134.5578	81 691.09	5.5	(e)	156 008.48	4.5	(o)	−0.64	8.39E+08
134.5805D	91 497.12	5.5	(e)	165 802.12	5.5	(o)	−0.95	4.09E+08
134.6289	35 136.61	5.5	(o)	109 414.69	4.5	(e)	−1.00	3.71E+08
134.6782D	80 663.34	1.5	(e)	154 914.81	2.5	(o)	−1.00	3.69E+08
134.7030	98 676.42	5.5	(e)	172 913.80	6.5	(o)	−0.82	5.56E+08
134.7104	85 352.26	4.5	(e)	159 585.52	3.5	(o)	−0.57	9.80E+08
134.7396	79 189.02	6.5	(e)	153 406.25	5.5	(o)	−0.41	1.44E+09
134.7792	76 411.72	4.5	(e)	150 607.31	5.5	(o)	−0.45	1.31E+09
134.8574	87 072.95	5.5	(e)	161 225.30	4.5	(o)	−0.53	1.08E+09
134.8637	76 411.72	4.5	(e)	150 560.55	4.5	(o)	0.03	3.96E+09
134.8872	76 471.40	6.5	(e)	150 607.31	5.5	(o)	−0.78	6.04E+08
134.9134	85 716.11	4.5	(e)	159 837.56	4.5	(o)	−0.37	1.55E+09
134.9568	86 067.88	3.5	(e)	160 165.53	3.5	(o)	−0.44	1.34E+09
134.9589	85 716.11	4.5	(e)	159 812.28	5.5	(o)	−0.74	6.67E+08
135.2142	87 539.35	3.5	(e)	161 496.05	3.5	(o)	−0.68	7.61E+08
135.2505	88 097.78	5.5	(e)	162 034.11	4.5	(o)	−0.85	5.23E+08
135.2706	81 832.25	3.5	(e)	155 758.06	2.5	(o)	−0.97	3.90E+08
135.3014	82 363.72	3.5	(e)	156 272.69	3.5	(o)	−0.45	1.29E+09
135.4559	87 400.57	3.5	(e)	161 225.30	4.5	(o)	−0.99	3.67E+08
135.4879*	81 950.73	1.5	(e)	155 758.06	2.5	(o)	−0.52	1.09E+09
135.5028	81 013.13	2.5	(e)	154 812.25	3.5	(o)	−0.88	4.86E+08
135.5621	88 135.24	2.5	(e)	161 901.81	2.5	(o)	−0.99	3.67E+08
135.6643D	79 307.06	3.5	(e)	153 018.22	3.5	(o)	−0.56	1.01E+09
135.7870D	82 363.72	3.5	(e)	156 008.48	4.5	(o)	−0.55	1.01E+09
135.9288	81 013.13	2.5	(e)	154 581.00	2.5	(o)	−0.67	7.67E+08
135.9944D	83 768.34	3.5	(e)	157 299.94	3.5	(o)	−0.90	4.59E+08
136.0230*	88 135.24	2.5	(e)	161 652.20	3.5	(o)	−0.59	9.31E+08
136.0356	101 075.79	0.5	(e)	174 586.12	1.5	(o)	−0.88	4.76E+08
136.1252*	87 400.57	3.5	(e)	160 862.38	2.5	(o)	−0.99	3.68E+08
136.1713*	81 375.35	3.5	(e)	154 812.25	3.5	(o)	−0.98	3.72E+08
136.2926	79 339.01	1.5	(e)	152 710.30	2.5	(o)	−0.45	1.29E+09
136.3363	87 072.95	5.5	(e)	160 420.64	4.5	(o)	−0.50	1.13E+09
136.3825D	87 539.35	3.5	(e)	160 862.38	2.5	(o)	−0.53	1.06E+09
136.4510	79 307.06	3.5	(e)	152 592.92	4.5	(o)	−0.91	4.42E+08
136.6111	5988.51	7.5	(o)	79 189.02	6.5	(e)	−0.75	6.30E+08
136.6472	74 363.99	3.5	(e)	147 544.89	4.5	(o)	−0.58	9.48E+08
136.7730	100 835.39	7.5	(e)	173 949.03	6.5	(o)	−0.11	2.76E+09
136.8897	87 114.16	2.5	(e)	160 165.53	3.5	(o)	−0.66	7.73E+08
136.9486	87 400.57	3.5	(e)	160 420.64	4.5	(o)	−0.63	8.28E+08
136.9503	92 892.71	3.5	(e)	165 911.59	3.5	(o)	−0.49	1.15E+09
136.9679	88 642.61	4.5	(e)	161 652.20	3.5	(o)	−0.89	4.63E+08
137.0234	81 832.25	3.5	(e)	154 812.25	3.5	(o)	−0.90	4.54E+08
137.0638	92 892.71	3.5	(e)	165 851.25	3.5	(o)	−0.38	1.48E+09
137.2202	5988.51	7.5	(o)	78 864.24	7.5	(e)	−0.47	1.19E+09
137.2463	92 892.71	3.5	(e)	165 754.41	4.5	(o)	−0.83	5.31E+08
137.4202	101 586.15	2.5	(e)	174 355.70	1.5	(o)	−0.91	4.37E+08
137.4287D	87 072.95	5.5	(e)	159 837.56	4.5	(o)	−0.46	1.22E+09
137.4997	88 135.24	2.5	(e)	160 862.38	2.5	(o)	−0.99	3.66E+08
137.5427	89 329.54	4.5	(e)	162 034.11	4.5	(o)	−0.68	7.37E+08
137.5797T	83 588.99	2.5	(e)	156 272.69	3.5	(o)	−0.68	7.47E+08
137.5797T	101 900.99	1.5	(e)	174 586.12	1.5	(o)	−0.63	8.25E+08
137.6914*	87 539.35	2.5	(e)	160 165.53	3.5	(o)	−0.68	7.34E+08
137.7741D	88 642.61	4.5	(e)	161 225.30	4.5	(o)	−0.77	5.92E+08
137.7785*	103 385.28	2.5	(e)	175 965.55	2.5	(o)	−0.87	4.69E+08

Table 3. (Continued.)

	Lower level[b]			Upper level[b]				
Wavelength[a] (nm)	E (cm^{-1})	J	Parity	E (cm^{-1})	J	Parity	log gf[c]	gA[c] (s^{-1})
137.8093	3907.43	6.5	(o)	76 471.40	6.5	(e)	−0.56	9.73E+08
137.8137D	83 309.16	6.5	(e)	155 870.45	5.5	(o)	0.04	3.83E+09
137.9224D	83 768.34	3.5	(e)	156 272.69	3.5	(o)	−0.55	9.99E+08
137.9671	16 161.53	5.5	(o)	88 642.61	4.5	(e)	−0.88	4.60E+08
138.0363	84 855.30	2.5	(e)	157 299.94	3.5	(o)	−0.68	7.26E+08
138.0509	87 400.57	3.5	(e)	159 837.56	4.5	(o)	−0.38	1.43E+09
138.1809	83 768.34	5.5	(e)	156 137.08	4.5	(o)	−0.72	6.71E+08
138.2687D	89 329.54	4.5	(e)	161 652.20	3.5	(o)	−0.91	4.32E+08
138.2814	85 716.11	4.5	(e)	158 032.30	5.5	(o)	−0.46	1.22E+09
138.3309	92 892.71	3.5	(e)	165 183.48	2.5	(o)	−0.69	7.14E+08
138.3327	91 497.12	5.5	(e)	163 786.31	4.5	(o)	−0.94	3.98E+08
138.4068*	81 155.44	6.5	(e)	153 406.25	5.5	(o)	−0.95	3.89E+08
138.4384	83 903.04	5.5	(e)	156 137.08	4.5	(o)	−0.70	6.97E+08
138.4819	32 563.57	8.5	(o)	104 775.22	8.5	(e)	−0.79	5.60E+08
138.5211	86 678.25	7.5	(e)	158 869.30	6.5	(o)	0.29	6.84E+09
138.5682	89 329.54	4.5	(e)	161 496.05	3.5	(o)	−0.26	1.92E+09
138.7377	100 835.39	7.5	(e)	172 913.80	6.5	(o)	−0.25	1.98E+09
138.8308D	88 135.24	2.5	(e)	160 165.53	3.5	(o)	−0.48	1.15E+09
139.1540	101 159.67	6.5	(e)	173 022.52	5.5	(o)	−0.72	6.57E+08
139.1621	30 179.93	5.5	(o)	102 038.54	4.5	(e)	−0.76	5.96E+08
139.3193	84 092.98	6.5	(e)	155 870.45	5.5	(o)	−0.43	1.29E+09
139.4304	31 036.00	7.5	(o)	102 756.25	7.5	(e)	−0.95	3.81E+08
139.4575	102 242.87	5.5	(e)	173 949.03	6.5	(o)	−0.84	4.90E+08
139.5486*	1897.11	5.5	(o)	73 556.74	5.5	(e)	−0.75	6.08E+08
139.7393	90 339.84	2.5	(e)	161 901.81	2.5	(o)	−0.61	8.52E+08
139.7648	83 032.16	1.5	(e)	154 581.00	2.5	(o)	−0.89	4.41E+08
140.0201T	107 900.68	3.5	(e)	179 319.09	2.5	(o)	−0.44	1.23E+09
140.0571	21 493.39	4.5	(o)	92 892.71	3.5	(e)	−0.85	4.80E+08
140.2287	90 339.84	2.5	(e)	161 652.20	3.5	(o)	−0.96	3.70E+08
140.3436	79 307.06	3.5	(e)	150 560.55	4.5	(o)	−0.46	1.16E+09
140.4599D	88 642.61	4.5	(e)	159 837.56	4.5	(o)	−0.61	8.24E+08
140.4599D	90 380.51	6.5	(e)	161 574.84	5.5	(o)	−0.77	5.81E+08
140.4637*	102 756.25	7.5	(e)	173 949.03	6.5	(o)	−0.67	7.23E+08
140.8766	102 038.54	4.5	(e)	173 022.52	5.5	(o)	−0.31	1.63E+09
140.9038*	103 385.28	2.5	(e)	174 355.70	1.5	(o)	−0.90	4.20E+08
141.1708	89 329.54	4.5	(e)	160 165.53	3.5	(o)	−0.99	3.40E+08
141.2089	0.00	4.5	(o)	70 817.12	4.5	(e)	−0.82	5.12E+08
141.2886	83 309.16	6.5	(e)	154 086.17	5.5	(o)	−0.09	2.72E+09
141.3698	82 669.72	4.5	(e)	153 406.25	5.5	(o)	−0.12	2.55E+09
141.5010	102 242.87	5.5	(e)	172 913.80	6.5	(o)	−0.97	3.58E+08
141.5221	31 582.85	6.5	(o)	102 242.87	5.5	(e)	−0.53	9.94E+08
141.5963	91 028.86	4.5	(e)	161 652.20	3.5	(o)	−0.80	5.25E+08
141.7695	91 497.12	5.5	(e)	162 034.11	4.5	(o)	0.01	3.42E+09
141.9101	91 028.86	4.5	(e)	161 496.05	3.5	(o)	−0.99	3.38E+08
142.0552	102 627.40	4.5	(e)	173 022.52	5.5	(o)	−0.62	7.91E+08
142.3369	89 329.54	4.5	(e)	159 585.52	3.5	(o)	−0.46	1.15E+09
142.4646	32 563.57	8.5	(o)	102 756.25	7.5	(e)	−0.92	3.98E+08
142.5362	102 756.25	7.5	(e)	172 913.80	6.5	(o)	−0.82	4.97E+08
142.6048	31 036.00	7.5	(o)	101 159.67	6.5	(e)	−0.31	1.59E+09
142.7419	109 414.69	4.5	(e)	79 471.41	5.5	(o)	−0.02	3.15E+09
143.1242	13 719.82	3.5	(o)	83 588.99	2.5	(e)	−0.85	4.58E+08
143.4145	91 497.12	5.5	(e)	161 225.30	4.5	(o)	−0.49	1.04E+09
143.5176	14 994.87	4.5	(o)	84 672.74	3.5	(e)	−0.84	4.63E+08
143.8372	86 678.25	7.5	(e)	156 201.33	6.5	(o)	−0.60	8.02E+08
143.8789	83 903.04	5.5	(e)	153 406.25	5.5	(o)	−0.95	3.61E+08
144.1136*	88 642.61	4.5	(e)	158 032.30	5.5	(o)	−1.00	3.26E+08
144.5283	16 161.53	5.5	(o)	85 352.26	4.5	(e)	−0.82	4.81E+08
144.6414	91 028.86	4.5	(e)	160 165.53	3.5	(o)	−0.87	4.33E+08
144.7932	87 072.95	5.5	(e)	156 137.08	4.5	(o)	−0.61	7.77E+08
145.3308	91 028.86	4.5	(e)	159 837.56	4.5	(o)	−0.85	4.45E+08
145.5008	81 832.25	3.5	(e)	150 560.55	4.5	(o)	−0.57	8.55E+08
145.9929	30 179.93	5.5	(o)	98 676.42	5.5	(e)	−0.91	3.88E+08
146.0099	90 380.51	6.5	(e)	158 869.30	6.5	(o)	−0.79	5.04E+08
146.2951	12 800.29	4.5	(o)	81 155.44	4.5	(e)	−0.88	4.08E+08

Table 3. (Continued.)

	Lower level[b]			Upper level[b]				
Wavelength[a] (nm)	E (cm^{-1})	J	Parity	E (cm^{-1})	J	Parity	log gf[c]	gA[c] (s^{-1})
146.3262*	91 497.12	4.5	(e)	159 837.56	4.5	(o)	−0.79	5.00E+08
146.3342	22 043.77	7.5	(o)	90 380.51	6.5	(e)	−0.29	1.60E+09
146.4733	32 563.57	8.5	(o)	100 835.39	7.5	(e)	−0.12	2.35E+09
146.8597	20 005.22	6.5	(o)	88 097.78	5.5	(e)	−0.76	5.34E+08
146.9186	107 900.68	3.5	(e)	175 965.55	2.5	(o)	−0.73	5.76E+08
146.9413D	31 355.04	3.5	(o)	99 409.66	2.5	(e)	−0.94	3.57E+08
146.9413D	85 352.26	4.5	(e)	153 406.25	5.5	(o)	−0.61	7.56E+08
146.9747	88 097.78	5.5	(e)	156 137.08	4.5	(o)	−0.97	3.29E+08
147.7652	14 994.87	4.5	(o)	82 669.72	4.5	(e)	−0.79	4.92E+08
148.1685	35 136.61	5.5	(o)	102 627.40	4.5	(e)	−0.89	3.93E+08
148.5636	31 036.00	7.5	(o)	98 347.09	6.5	(e)	−0.53	9.00E+08
148.5923	83 309.16	6.5	(e)	150 607.31	5.5	(o)	−0.61	7.39E+08
149.1032	20 005.22	6.5	(o)	87 072.95	5.5	(e)	−0.50	6.22E+08
150.1613	22 047.39	5.5	(o)	88 642.61	4.5	(e)	−0.77	5.03E+08
151.2907	19 969.79	4.5	(o)	86 067.88	3.5	(e)	−0.99	2.99E+08
154.7165	22 043.77	7.5	(o)	86 678.25	7.5	(e)	−0.75	4.94E+08
155.1864	19 969.79	4.5	(o)	84 408.39	4.5	(e)	−0.98	2.93E+08
155.7078	21 493.39	4.5	(o)	85 716.11	4.5	(e)	−0.81	4.30E+08
156.2088*	98 017.24	4.5	(e)	162 034.11	4.5	(o)	−0.88	3.65E+08
156.7342	24 333.10	2.5	(o)	88 135.24	2.5	(e)	−0.98	2.84E+08
157.2139	109 414.69	4.5	(e)	173 022.52	5.5	(o)	−0.53	8.08E+08
157.9678	20 005.22	6.5	(o)	83 309.16	6.5	(e)	−0.98	2.78E+08
159.0324	35 136.61	5.5	(o)	98 017.24	4.5	(e)	−0.69	5.35E+08
159.1871	33 741.15	3.5	(o)	96 560.31	3.5	(e)	−0.63	6.16E+08
163.2244	22 043.77	7.5	(o)	83 309.16	6.5	(e)	−0.87	3.38E+08
166.9054	31 582.85	6.5	(o)	91 497.12	5.5	(e)	−0.42	9.09E+08
169.0625	30 179.93	5.5	(o)	89 329.54	4.5	(e)	−0.57	6.33E+08
170.2756	49 172.45	4.5	(o)	107 900.68	3.5	(e)	−0.45	8.17E+08
172.3130*	100 835.39	7.5	(e)	158 869.30	6.5	(o)	−0.85	3.19E+08
172.4261	50 160.95	3.5	(o)	108 156.67	2.5	(e)	−0.53	6.60E+08
177.4297	35 136.61	5.5	(o)	91 497.12	5.5	(e)	−0.85	2.96E+08
184.7928	32 563.57	8.5	(o)	86 678.25	7.5	(e)	−0.50	6.22E+08
191.3024	31 036.00	7.5	(o)	83 309.16	6.5	(e)	−0.79	2.94E+08
214.0192*	118 448.53	4.5	(e)	165 158.58	5.5	(o)	−0.71	2.80E+08
218.2341	115 767.20	6.5	(e)	161 574.84	5.5	(o)	−0.62	3.34E+08
218.5090	113 118.93	5.5	(e)	158 869.30	6.5	(o)	−0.88	1.85E+08
220.5014	116 697.38	5.5	(e)	162 034.11	4.5	(o)	−0.35	6.19E+08
220.9923*	110 634.11	4.5	(e)	155 870.45	5.5	(o)	−0.52	4.11E+08
222.5816*	113 118.93	5.5	(e)	158 032.30	5.5	(o)	−0.87	1.84E+08
222.7597*	116 697.38	5.5	(e)	161 574.84	5.5	(o)	−0.74	2.44E+08
223.5000	110 634.11	4.5	(e)	155 363.06	5.5	(o)	−0.47	4.57E+08
224.5073	116 697.38	5.5	(e)	161 225.30	4.5	(o)	−0.56	3.66E+08
224.5252	110 056.47	3.5	(e)	154 581.00	2.5	(o)	0.18	2.00E+09
224.8424	110 056.47	3.5	(e)	154 518.38	3.5	(o)	−0.76	2.30E+08
225.1895	122 515.64	4.5	(e)	166 908.81	4.5	(o)	−0.77	2.27E+08
225.7510*	116 375.04	2.5	(e)	160 657.91	1.5	(o)	−0.94	1.50E+08
226.1341	68 803.16	3.5	(o)	113 010.89	2.5	(e)	−0.83	1.93E+08
226.9218	122 854.37	3.5	(e)	166 908.81	4.5	(o)	−0.74	2.36E+08
226.9695	115 767.20	6.5	(e)	159 812.28	5.5	(o)	−0.26	7.04E+08
227.3630	136 316.05	6.5	(e)	180 284.95	7.5	(o)	0.79	8.00E+09
228.0413	113 461.85	4.5	(e)	157 299.94	3.5	(o)	0.19	2.01E+09
228.2891	116 375.04	2.5	(e)	160 165.53	3.5	(o)	−0.48	4.21E+08
128.3275	102 038.54	4.5	(e)	179 964.22	3.5	(o)	−0.44	1.46E+09
228.6387	116 697.38	5.5	(e)	160 420.64	4.5	(o)	−0.37	5.42E+08
229.3627	118 448.53	4.5	(e)	162 034.11	4.5	(o)	0.11	1.66E+09
229.3756	117 912.91	3.5	(e)	161 496.05	3.5	(o)	0.27	2.33E+09
229.4351	110 056.47	3.5	(e)	153 628.30	4.5	(o)	0.04	1.37E+09
230.0682	110 634.11	4.5	(e)	154 086.17	5.5	(o)	0.60	4.99E+09
230.2417	118 482.80	2.5	(e)	161 901.81	2.5	(o)	−0.02	1.20E+09
230.3665D	122 515.64	4.5	(e)	165 911.59	3.5	(o)	−0.46	4.37E+08
230.5463	115 904.51	1.5	(e)	159 266.55	2.5	(o)	−0.12	9.56E+08
230.6859	122 515.64	4.5	(e)	165 851.25	3.5	(o)	−0.37	5.41E+08
230.8096	117 912.91	3.5	(e)	161 225.30	4.5	(o)	0.33	2.66E+09
230.9481	122 515.64	4.5	(e)	165 802.12	5.5	(o)	0.64	5.39E+09

Table 3. (Continued.)

	Lower level[b]			Upper level[b]				
Wavelength[a] (nm)	E (cm^{-1})	J	Parity	E (cm^{-1})	J	Parity	log gf[c]	gA[c] (s^{-1})
231.2031	122 515.64	4.5	(e)	165 754.41	4.5	(o)	0.16	1.79E+09
231.3537	116 375.04	2.5	(e)	159 585.52	3.5	(o)	0.38	3.00E+09
231.3899	118 448.53	4.5	(e)	161 652.20	3.5	(o)	−0.33	5.79E+08
231.5761	118 482.80	2.5	(e)	161 652.20	3.5	(o)	−0.74	2.27E+08
231.6496D	136 316.05	6.5	(e)	79 471.41	5.5	(o)	0.30	2.49E+09
231.6496D	136 316.06	5.5	(e)	79 471.41	5.5	(o)	0.07	1.44E+09
231.7312	116 697.38	5.5	(e)	159 837.56	4.5	(o)	0.41	3.16E+09
231.8065	118 448.53	4.5	(e)	161 574.84	5.5	(o)	0.59	4.78E+09
231.8675	116 697.38	5.5	(e)	159 812.28	5.5	(o)	−0.01	1.20E+09
231.9360	115 767.20	6.5	(e)	158 869.30	6.5	(o)	0.32	2.55E+09
232.0426	113 118.93	5.5	(e)	156 201.33	6.5	(o)	0.67	5.72E+09
232.1782	122 854.37	3.5	(e)	165 911.59	3.5	(o)	0.05	1.40E+09
232.2301*	118 448.53	4.5	(e)	161 496.05	3.5	(o)	−1.00	1.23E+08
232.3877	113 118.93	5.5	(e)	156 137.08	4.5	(o)	−0.42	4.66E+08
232.4154	118 482.80	2.5	(e)	161 496.05	3.5	(o)	0.13	1.67E+09
232.5037	122 854.37	3.5	(e)	165 851.25	3.5	(o)	0.18	1.86E+09
232.5185	110 634.11	4.5	(e)	153 628.30	4.5	(o)	−0.33	5.67E+08
232.6943	110 056.47	3.5	(e)	153 018.22	3.5	(o)	0.26	2.24E+09
232.7600	117 912.91	3.5	(e)	160 862.38	2.5	(o)	−0.19	7.92E+08
233.0273D	119 133.54	3.5	(e)	162 034.11	4.5	(o)	0.28	2.36E+09
233.0273D	122 854.37	3.5	(e)	165 754.41	4.5	(o)	0.05	1.38E+09
233.0760	116 375.04	2.5	(e)	159 266.55	2.5	(o)	0.06	1.42E+09
233.0859	113 118.93	5.5	(e)	156 008.48	4.5	(o)	−0.10	9.66E+08
233.1033	115 767.20	6.5	(e)	158 653.53	7.5	(o)	0.70	6.23E+09
233.4554	115 904.51	1.5	(e)	158 725.98	1.5	(o)	0.07	1.45E+09
233.7007	118 448.53	4.5	(e)	161 225.30	4.5	(o)	−0.15	8.60E+08
233.7254*	110 634.11	4.5	(e)	153 406.25	5.5	(o)	−0.87	1.63E+08
233.7462	119 133.54	2.5	(e)	161 901.81	2.5	(o)	0.07	1.43E+09
233.8384	113 118.93	5.5	(e)	155 870.45	5.5	(o)	0.25	2.19E+09
234.2564	113 461.85	4.5	(e)	156 137.08	4.5	(o)	−0.12	9.14E+08
234.3738	110 056.47	3.5	(e)	152 710.30	2.5	(o)	−0.02	1.17E+09
234.4339	122 515.64	4.5	(e)	165 158.58	5.5	(o)	−0.02	1.17E+09
234.9646	113 461.85	4.5	(e)	156 008.48	4.5	(o)	0.09	1.47E+09
235.0191	110 056.47	3.5	(e)	152 592.92	4.5	(o)	−0.09	9.91E+08
235.1193	119 133.54	3.5	(e)	161 652.20	3.5	(o)	0.26	2.22E+09
235.1791D	117 912.91	3.5	(e)	160 420.64	4.5	(o)	0.11	1.54E+09
235.1791D	137 456.41	3.5	(e)	179 964.22	3.5	(o)	0.32	2.54E+09
235.5433	122 515.64	4.5	(e)	164 957.81	4.5	(o)	−0.14	8.68E+08
235.7298	113 461.85	4.5	(e)	155 870.45	5.5	(o)	0.40	3.01E+09
235.8658	110 634.11	4.5	(e)	153 018.22	3.5	(o)	0.10	1.50E+09
235.8904	118 482.80	2.5	(e)	160 862.38	2.5	(o)	0.05	1.34E+09
235.9849	119 133.54	3.5	(e)	161 496.05	3.5	(o)	−0.98	1.26E+08
236.0504	116 375.04	2.5	(e)	158 725.98	1.5	(o)	−0.63	2.83E+08
236.1722	122 854.37	3.5	(e)	165 183.48	2.5	(o)	0.38	2.87E+09
236.5294	115 767.20	6.5	(e)	158 032.30	5.5	(o)	−0.002	1.21E+09
236.6471	113 118.93	5.5	(e)	155 363.06	5.5	(o)	−0.78	2.00E+08
237.0342	118 482.80	2.5	(e)	160 657.91	1.5	(o)	0.04	1.31E+09
237.0513	116 697.38	5.5	(e)	158 869.30	6.5	(o)	0.54	4.11E+09
237.4371	122 854.37	3.5	(e)	164 957.81	4.5	(o)	−0.30	5.89E+08
238.2556D	110 634.11	4.5	(e)	152 592.62	5.5	(o)	−0.36	5.17E+08
238.2556D	110 634.11	4.5	(e)	152 592.92	4.5	(o)	0.11	1.50E+09
238.5840	113 461.85	4.5	(e)	155 363.06	5.5	(o)	−0.49	3.82E+08
238.8787D	136 316.05	6.5	(e)	178 165.59	6.5	(o)	0.18	1.77E+09
238.8787D	136 316.06	5.5	(e)	178 165.59	6.5	(o)	0.49	3.66E+09
239.4951	113 118.93	5.5	(e)	154 860.81	4.5	(o)	−0.67	2.48E+08
239.5698	119 133.54	3.5	(e)	160 862.38	2.5	(o)	−0.15	8.16E+08
239.8927*	117 912.91	3.5	(e)	159 585.52	3.5	(o)	−0.71	2.25E+08
240.6841	115 767.20	6.5	(e)	157 302.95	5.5	(o)	−0.83	1.69E+08
241.4791	113 461.85	4.5	(e)	154 860.81	4.5	(o)	−0.78	1.91E+08
241.5371	118 448.53	4.5	(e)	159 837.56	4.5	(o)	−0.56	3.14E+08
241.7628	113 461.85	4.5	(e)	154 812.25	3.5	(o)	−0.11	8.90E+08
241.8523	116 697.38	5.5	(e)	158 032.30	5.5	(o)	0.22	1.92E+09
242.1330	119 133.54	3.5	(e)	160 420.64	4.5	(o)	−0.54	3.30E+08
243.2178	118 482.80	2.5	(e)	159 585.52	3.5	(o)	−0.63	2.62E+08

Table 3. (Continued.)

	Lower level[b]			Upper level[b]				
Wavelength[a] (nm)	E (cm^{-1})	J	Parity	E (cm^{-1})	J	Parity	log gf[c]	gA[c] (s^{-1})
243.3890	110 056.47	3.5	(e)	151 130.44	4.5	(o)	−0.64	2.58E+08
243.6384*	119 133.54	3.5	(e)	160 165.53	3.5	(o)	−0.87	1.50E+08
244.0243	113 118.93	5.5	(e)	154 086.17	5.5	(o)	−0.66	2.42E+08
244.2351	122 854.37	3.5	(e)	163 786.31	4.5	(o)	−0.81	1.72E+08
246.1611	68 803.16	3.5	(o)	109 414.69	4.5	(e)	−0.91	1.36E+08
246.1979	116 697.38	5.5	(e)	157 302.95	5.5	(o)	−0.41	4.22E+08
246.8141*	110 056.47	3.5	(e)	150 560.55	4.5	(o)	−0.94	1.27E+08
246.8617	110 634.11	4.5	(e)	151 130.44	4.5	(o)	−0.58	2.87E+08
247.2416	115 767.20	6.5	(e)	156 201.33	6.5	(o)	−0.49	3.52E+08
248.1421*	113 118.93	5.5	(e)	153 406.25	5.5	(o)	−0.76	1.89E+08
250.0924	110 634.11	4.5	(e)	150 607.31	5.5	(o)	−0.52	3.23E+08
250.3854	110 634.11	4.5	(e)	150 560.55	4.5	(o)	−0.55	2.99E+08
252.5534	118 448.53	4.5	(e)	158 032.30	5.5	(o)	−0.65	2.39E+08
252.9713	122 515.64	4.5	(e)	162 034.11	4.5	(o)	−0.57	2.86E+08
253.2565	113 118.93	5.5	(e)	152 592.62	5.5	(o)	−0.58	2.72E+08
253.4752	116 697.38	5.5	(e)	156 137.08	4.5	(o)	−0.47	3.55E+08
253.8144	117 912.91	3.5	(e)	157 299.94	3.5	(o)	−0.68	2.18E+08
255.2000	116 697.38	5.5	(e)	155 870.45	5.5	(o)	−0.98	1.07E+08
255.4376	122 515.64	4.5	(e)	161 652.20	3.5	(o)	−0.72	1.95E+08
255.4734	113 461.85	4.5	(e)	152 592.92	4.5	(o)	−0.55	2.88E+08
256.2655	115 904.51	1.5	(e)	154 914.81	2.5	(o)	−0.70	2.03E+08
258.2556	122 515.64	4.5	(e)	161 225.30	4.5	(o)	−0.38	4.20E+08
258.4771	115 904.51	1.5	(e)	154 581.00	2.5	(o)	−0.44	3.66E+08
259.6009*	137 456.40	2.5	(e)	175 965.55	2.5	(o)	−0.35	4.44E+08
260.0858	116 375.04	2.5	(e)	154 812.25	3.5	(o)	−0.87	1.32E+08
260.5373	122 854.37	3.5	(e)	161 225.30	4.5	(o)	−0.27	5.31E+08
261.6621	116 375.04	2.5	(e)	154 581.00	2.5	(o)	−0.43	3.65E+08
262.4196	117 912.91	3.5	(e)	156 008.48	4.5	(o)	−0.61	2.39E+08
262.9998	113 118.93	5.5	(e)	151 130.44	4.5	(o)	−0.98	1.02E+08
263.7390	122 515.64	4.5	(e)	160 420.64	4.5	(o)	−0.19	6.21E+08
264.3027	118 448.53	4.5	(e)	156 272.69	3.5	(o)	0.39	2.34E+09
263.9049	117 912.91	3.5	(e)	155 794.06	2.5	(o)	−0.94	1.12E+08
264.1562	117 912.91	3.5	(e)	155 758.06	2.5	(o)	0.12	1.25E+09
265.2535	118 448.53	4.5	(e)	156 137.08	4.5	(o)	0.01	9.71E+08
265.5263	122 515.64	4.5	(e)	160 165.53	3.5	(o)	0.30	1.87E+09
265.6021	115 767.20	6.5	(e)	153 406.25	5.5	(o)	0.44	2.59E+09
265.6454D	136 316.05	6.5	(e)	173 949.03	6.5	(o)	0.30	1.89E+09
265.6454D	136 316.06	5.5	(e)	173 949.03	6.5	(o)	−0.10	7.52E+08
266.1170	122 854.37	3.5	(e)	160 420.64	4.5	(o)	−0.31	4.60E+08
266.1616	118 448.53	4.5	(e)	156 008.48	4.5	(o)	−0.39	3.83E+08
266.6698D	110 056.47	3.5	(e)	147 544.89	4.5	(o)	0.32	1.96E+09
266.6698D	113 118.93	5.5	(e)	150 607.31	5.5	(o)	0.40	2.33E+09
267.0032	113 118.93	5.5	(e)	150 560.55	4.5	(o)	0.34	2.04E+09
267.3797	116 697.38	5.5	(e)	154 086.17	5.5	(o)	−0.86	1.28E+08
267.6769*	137 456.40	2.5	(e)	174 803.78	2.5	(o)	−0.99	9.50E+07
267.8586	122 515.64	4.5	(e)	159 837.56	4.5	(o)	−0.37	3.98E+08
267.9366	122 854.37	3.5	(e)	160 165.53	3.5	(o)	−0.22	5.62E+08
268.1946	118 482.80	2.5	(e)	155 758.06	2.5	(o)	−0.61	2.28E+08
269.1319	113 461.85	4.5	(e)	150 607.31	5.5	(o)	0.30	1.83E+09
269.1777	119 133.54	3.5	(e)	156 272.69	3.5	(o)	−0.20	5.85E+08
269.2461*	137 456.40	1.5	(e)	174 586.12	1.5	(o)	0.003	9.26E+08
269.6809	122 515.64	4.5	(e)	159 585.52	3.5	(o)	−0.54	2.64E+08
270.1642	119 133.54	3.5	(e)	156 137.08	4.5	(o)	0.11	1.18E+09
270.1759	117 912.91	3.5	(e)	154 914.81	2.5	(o)	−0.49	2.98E+08
270.3133	122 854.37	3.5	(e)	159 837.56	4.5	(o)	−0.02	8.65E+08
270.8434	110 634.11	4.5	(e)	147 544.89	4.5	(o)	0.27	1.70E+09
270.9271D	117 912.91	3.5	(e)	154 812.25	3.5	(o)	−0.15	6.42E+08
270.9271D	137 456.41	2.5	(e)	174 355.70	1.5	(o)	−0.80	1.44E+08
271.1061	119 133.54	3.5	(e)	156 008.48	4.5	(o)	−0.41	3.51E+08
271.6162	115 904.51	1.5	(e)	152 710.30	2.5	(o)	−0.09	7.39E+08
272.1686	122 854.37	3.5	(e)	159 585.52	3.5	(o)	−0.94	1.03E+08
272.3338	116 697.38	5.5	(e)	153 406.25	5.5	(o)	0.22	1.48E+09
272.3512D	136 316.05	6.5	(e)	173 022.52	5.5	(o)	0.21	1.46E+09
272.3512D	136 316.06	5.5	(e)	173 022.52	5.5	(o)	0.39	2.23E+09

Table 3. (Continued.)

Wavelength[a] (nm)	Lower level[b] E (cm^{-1})	J	Parity	Upper level[b] E (cm^{-1})	J	Parity	log gf[c]	gA[c] (s^{-1})
272.9603*	119 133.54	3.5	(e)	155 758.06	2.5	(o)	−0.77	1.50E+08
273.1597D	136 316.05	6.5	(e)	172 913.80	6.5	(o)	0.18	1.36E+09
273.1597D	136 316.06	5.5	(e)	172 913.80	6.5	(o)	−0.24	5.13E+08
274.4035	118 482.80	2.5	(e)	154 914.81	2.5	(o)	−0.81	1.39E+08
274.5511	118 448.53	4.5	(e)	154 860.81	4.5	(o)	−0.87	1.20E+08
275.1333	116 375.04	2.5	(e)	152 710.30	2.5	(o)	−0.31	4.34E+08
275.1775	118 482.80	2.5	(e)	154 812.25	3.5	(o)	0.06	1.02E+09

[a] Vacuum (below 200 nm) and air (above 200 nm) wavelengths from Wyart *et al* (2007); D : doubly classified line; T : triply classified line; * deduced from available experimental energy level values.
[b] Experimental energy levels from Wyart *et al* (2007).
[c] This work.

strongly interact with lower configurations. More precisely, in their analysis of the Nd IV spectrum, Wyart *et al* (2007) showed that, owing to configuration mixing between $5p^64f^26p$ and the core-excited $5p^54f^4$, numerous $5p^64f^25d$–$5p^54f^4$ transitions, normally dipole-forbidden, were observed experimentally. They also showed that the addition of the $5p^54f^35d$ configuration (still unknown) to $5p^64f^2(5d+6s)$ in a three-configuration basis improved significantly the calculated energies in $4f^25d$ and $4f^26s$ configurations and reduced the transition probabilities for $5p^64f^3$–$5p^64f^25d$ by a factor of about 2. To give an idea, the increasing influence of $5p^54f^4$ along the lanthanum isoelectronic sequence is illustrated on figure 1 in which calculated HFR average energies corresponding to odd-parity configurations are plotted for La I, Ce II, Pr III and Nd IV. When looking at this figure, it is clear that the $5p^54f^4$ configuration must play a much more important role in Nd IV than in the previous ions of the sequence for the description of lower configurations. Consequently, it is obvious that a core-polarization model potential is not sufficient to take such core-valence interactions into account which can only be considered by the explicit inclusion of core-excited configurations in the multiconfiguration expansions. The following HFR model was thus adopted for Nd IV : $4f^3$ + $4f^26p$ + $4f^25f$ + $4f^26f$ + $4f5d^2$ + $4f6s^2$ + $4f6p^2$ + $4f6d^2$ + $4f5d6s$ + $4f5d6d$ + $5d6s6p$ + $5d^26p$ + $6s^26p$ + $6p^3$ + $5p^54f^4$ for the odd parity and $4f^25d$ + $4f^26s$ + $4f^26d$ + $4f^25g$ + $4f5d6p$ + $4f5d5f$ + $4f6s6p$ + $5d^3$ + $5d^26s$ + $5d^26d$ + $5d6s^2$ + $5d6p^2$ + $6s6p^2$ + $5p^54f^35d$ for the even parity.

In addition, average energies, E_{av}, Slater parameters, F^k and G^k, spin-orbit integrals, ζ_{nl} and effective interaction parameters were adjusted with a least-squares optimization program minimizing the discrepancies between the calculated and the experimental energy levels reported by Wyart *et al* (2007) for $4f^3$, $4f^26p$, $5p^54f^4$ odd-parity configurations and $4f^25d$, $4f^26s$ even-parity configurations. For electrostatic interaction Slater parameters (F^k, G^k, R^k) not adjusted in the fitting process, a scaling factor of 0.85 was applied to the HFR *ab initio* values, as recommended by Cowan (1981). The standard deviations of the fits were found to be equal to 89 cm^{-1} and 115 cm^{-1} in the odd parity (111 levels fitted with 29 adjustable parameters) and even parity (121 levels fitted with 21 parameters), respectively. Details about the final radial parameters adopted in our calculations are given in tables 1 and 2.

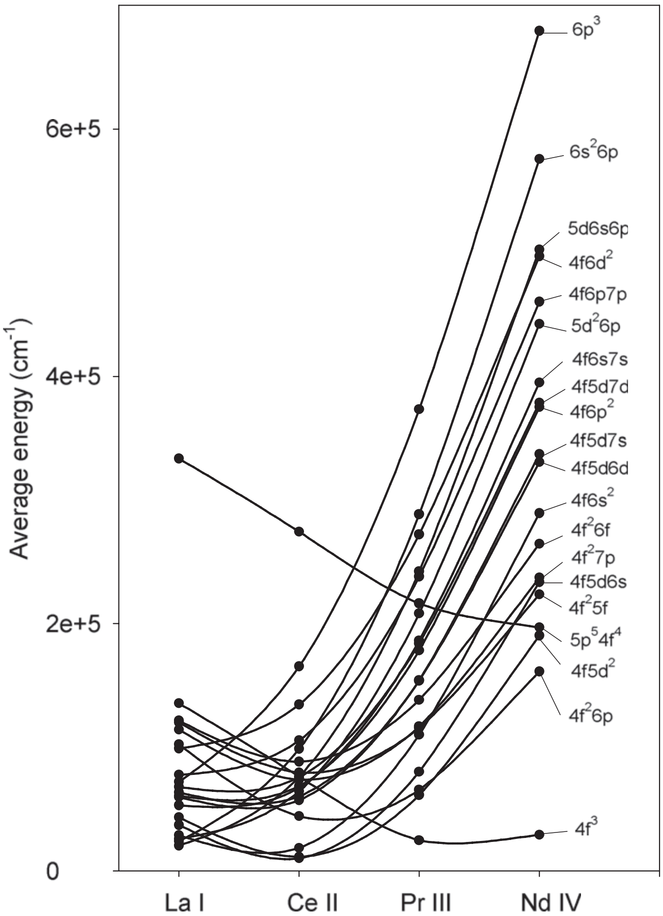

Figure 1. Computed average energies for odd-parity configurations along the lanthanum isoelectronic sequence from La I to Nd IV.

3. Results and discussion

3.1. Electric dipole transitions

Radiative parameters (oscillator strengths and transition probabilities) computed in this work are reported in table 3 for Nd IV electric dipole lines between 106.8 and 275.2 nm.

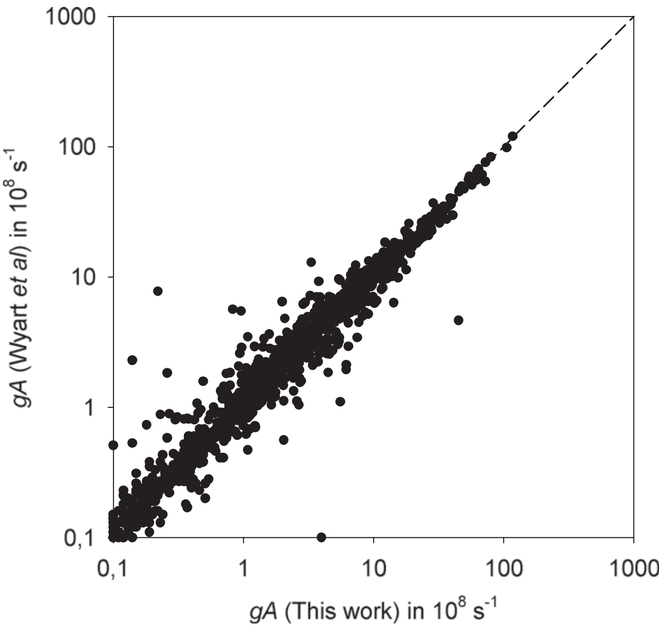

Figure 2. Comparison between calculated radiative transition probabilities as obtained in the present work and those published by Wyart *et al* (2007) for allowed electric dipole lines in Nd IV.

Table 4. Comparison of computed radiative lifetimes for some levels belonging to the $4f^{2}5d$ configuration of Nd IV.

Level[a]	E(cm^{-1})[a]	Lifetime (ns) This work	Dzuba *et al*[b]	Wyart *et al*[c]
$(^{3}H)^{2}H_{9/2}$	70 817.12	16	6.6	14.5
$(^{3}H)^{4}K_{11/2}$	71 744.57	134	68.5	116
$(^{3}H)^{4}I_{9/2}$	73 366.17	21.4	9.4	16.9
$(^{3}H)^{4}I_{11/2}$	73 556.74	16.1	17.5	16.6
$(^{3}H)^{4}G_{5/2}$	73 616.22	31.8	23.7	29.9
$(^{3}H)^{4}I_{11/2}$	74 571.83	25.4	6.4	17.0
$(^{3}H)^{4}K_{13/2}$	74 673.95	157	75.2	133
$(^{3}H)^{4}G_{7/2}$	75 666.91	24.3	15.4	21.2
$(^{3}H)^{4}I_{13/2}$	76 471.40	13.2	5.5	10.8
$(^{3}H)^{4}K_{15/2}$	77 539.71	159	79.2	134
$(^{3}H)^{4}G_{9/2}$	77 809.61	23.1	10.8	20.1
$(^{3}H)^{4}I_{15/2}$	78 864.24	13.0	5.4	10.7
$(^{3}H)^{4}G_{11/2}$	80 080.41	26.5	13.0	23.7
$(^{3}H)^{4}K_{17/2}$	80 431.49	156	77.5	134

[a] From Wyart *et al* (2007).
[b] Calculations from Dzuba *et al* (2003).
[c] Calculations from Wyart *et al* (2007).

The results presented in this table are limited to transitions for which log gf is greater than -1.0.

To our knowledge, prior to our work, transition probabilities in Nd IV were only published by Wyart *et al* (2007) who also used the HFR method combined with parametric least-squares fits but including a rather limited set of interacting configurations, i.e. $5p^{6}4f5d^{2}$ + $5p^{6}4f5d6s$ + $5p^{6}4f6s^{2}$ + $5p^{6}4f^{3}$ + $5p^{6}4f^{2}6p$ + $5p^{5}4f^{4}$ for the odd parity and $5p^{6}4f^{2}5d$ + $5p^{6}4f^{2}6s$ + $5p^{5}4f^{3}5d$ for the even parity. The comparison between Wyart *et al*'s results and our gA-values is illustrated in figure 2, showing a general good agreement (within 25%) between both sets of data.

Table 5. Transition probabilities for forbidden lines within the $4f^{3}$ ground-state configuration of Nd IV. Only transitions with $gA \geqslant 0.1\ s^{-1}$ are listed in the table.

Wavelength[a] (nm)	Transition	Type[b]	gA (This work) (s^{-1})	gA (Other)[c] (s^{-1})
175.0323	$^{2}H^{\circ}_{9/2}2$–$^{2}F^{\circ}_{5/2}1$	E2	5.36E+00	
178.1258	$^{4}S^{\circ}_{3/2}$–$^{2}F^{\circ}_{5/2}1$	E2	2.24E−01	
181.7829	$^{4}S^{\circ}_{3/2}$–$^{2}F^{\circ}_{7/2}1$	E2	1.05E+00	
185.8450	$^{4}F^{\circ}_{9/2}$–$^{2}F^{\circ}_{7/2}1$	M1+E2	9.34E−01	
189.9637	$^{2}H^{\circ}_{11/2}2$–$^{2}F^{\circ}_{7/2}1$	E2	6.14E+00	
191.2870	$^{2}G^{\circ}_{7/2}2$–$^{2}F^{\circ 5/2}1$	M1+E2	5.15E+00	
198.4450	$^{4}G^{\circ}_{7/2}$–$^{2}F^{\circ}_{5/2}1$	M1+E2	4.10E+00	
202.9294	$^{4}G^{\circ}_{7/2}$–$^{2}F^{\circ}_{7/2}1$	E2	4.19E−01	
204.7124	$^{4}G^{\circ}_{9/2}$–$^{2}F^{\circ}_{7/2}1$	M1+E2	4.61E+00	
207.2664	$^{2}D^{\circ}_{3/2}1$–$^{2}F^{\circ}_{5/2}1$	M1+E2	2.65E+00	
211.3059	$^{2}G^{\circ}_{9/2}2$–$^{2}F^{\circ}_{7/2}1$	M1+E2	6.63E+00	
212.2369	$^{2}D^{\circ}_{3/2}1$–$^{2}F^{\circ}_{7/2}1$	E2	5.92E+00	
216.6465	$^{2}P^{\circ}_{1/2}$–$^{2}F^{\circ}_{5/2}1$	E2	8.87E+00	
224.8007	$^{2}D^{\circ}_{5/2}1$–$^{2}F^{\circ}_{7/2}1$	M1	1.35E+00	
231.5637	$^{2}P^{\circ}_{3/2}$–$^{2}F^{\circ}_{5/2}1$	M1	6.33E−01	
237.7850	$^{2}P^{\circ}_{3/2}$–$^{2}F^{\circ}_{7/2}1$	E2	7.32E+00	
244.2923	$^{4}D^{\circ}_{3/2}$–$^{2}F^{\circ}_{5/2}1$	M1+E2	3.85E+00	
245.3746	$^{4}D^{\circ}_{5/2}$–$^{2}F^{\circ}_{5/2}1$	E2	3.56E−01	
247.4979	$^{4}D^{\circ}_{1/2}$–$^{2}F^{\circ}_{5/2}1$	E2	2.84E−01	
251.2265	$^{4}D^{\circ}_{3/2}$–$^{2}F^{\circ}_{7/2}1$	E2	2.78E−01	
252.3712	$^{4}D^{\circ}_{5/2}$–$^{2}F^{\circ}_{3.5}1$	M1+E2	5.05E+00	
258.8341	$^{2}I^{\circ}_{11/2}$–$^{2}F^{\circ}_{7/2}1$	E2	1.76E+00	
267.2073	$^{4}F^{\circ}_{5/2}$–$^{2}G^{\circ}_{7/2}1$	M1	1.06E+00	
276.2268	$^{2}H^{\circ}_{9/2}1$–$^{2}F^{\circ}_{5/2}1$	E2	1.10E+01	
280.3642	$^{2}D^{\circ}_{3/2}2$–$^{2}F^{\circ}_{5/2}1$	M1+E2	2.88E+00	
285.1252	$^{2}H^{\circ}_{9/2}1$–$^{2}F^{\circ}_{7/2}1$	M1+E2	1.10E+00	
287.9450	$^{2}D^{\circ}_{5/2}2$–$^{2}F^{\circ}_{5/2}1$	E2	1.10E+00	
296.9440	$^{2}H^{\circ}_{11/2}1$–$^{2}F^{\circ}_{3.5}1$	E2	1.02E+01	
297.6275	$^{2}D^{\circ}_{5/2}2$–$^{2}F^{\circ}_{7/2}1$	E2	1.25E+00	
302.8419	$^{2}H^{\circ}_{11/2}2$–$^{2}G^{\circ}_{9/2}1$	M1+E2	7.78E−01	
308.0410	$^{4}G^{\circ}_{5/2}$–$^{2}G^{\circ}_{7/2}1$	M1+E2	4.12E+00	
320.1208	$^{4}I^{\circ}_{13/2}$–$^{2}H^{\circ}_{11/2}1$	M1+E2	9.64E−01	2.89E+00
331.2507	$^{4}I^{\circ}_{9/2}$–$^{2}I^{\circ}_{11/2}$	M1+E2	2.93E+00	2.62E+01
341.9607	$^{2}F^{\circ}_{5/2}2$–$^{2}F^{\circ}_{7/2}1$	E2	7.61E−01	
345.6838	$^{2}F^{\circ}_{7/2}2$–$^{2}F^{\circ}_{5/2}1$	E2	2.71E−01	
351.2693	$^{2}D^{\circ}_{3/2}1$–$^{2}G^{\circ}_{7/2}1$	E2	2.92E−01	
353.6964	$^{4}F^{\circ}_{5/2}$–$^{2}F^{\circ}_{7/2}2$	M1+E2	3.30E+00	
354.3527	$^{2}H^{\circ}_{9/2}2$–$^{2}F^{\circ}_{7/2}2$	M1	1.14E+00	
358.7073	$^{4}F^{\circ}_{3/2}$–$^{2}F^{\circ}_{5/2}2$	M1+E2	5.01E+00	9.61E+00
359.7331	$^{2}F^{\circ}_{7/2}2$–$^{2}F^{\circ}_{7/2}1$	E2	7.30E−01	
368.5102	$^{4}I^{\circ}_{13/2}$–$^{2}L^{\circ}_{15/2}$	M1+E2	4.86E−01	4.79E−01
368.5579	$^{4}G^{\circ}_{11/2}$–$^{2}G^{\circ}_{9/2}1$	M1+E2	5.60E+00	
373.4724	$^{2}H^{\circ}_{9/2}2$–$^{2}F^{\circ}_{5/2}2$	E2	9.71E−01	3.6E−01
376.1858	$^{4}I^{\circ}_{15/2}$–$^{2}L^{\circ}_{17/2}$	M1+E2	2.78E−01	2.93E−01
380.5181	$^{4}I^{\circ}_{13/2}$–$^{2}I^{\circ}_{11/2}$	M1	4.23E−01	4.68E+00
384.2428	$^{4}F^{\circ}_{9/2}$–$^{2}F^{\circ}_{7/2}2$	M1	8.99E+00	
386.7585	$^{4}F^{\circ}_{7/2}$–$^{2}F^{\circ}_{5/2}2$	M1+E2	1.42E+00	2.31E+00
390.6007	$^{4}I^{\circ}_{15/2}$–$^{2}I^{\circ}_{13/2}$	M1	4.37E+00	2.55E+01
402.2818	$^{2}H^{\circ}_{11/2}2$–$^{2}F^{\circ}_{7/2}2$	E2	1.82E+00	
402.4733	$^{2}D^{\circ}_{5/2}1$–$^{2}G^{\circ}_{9/2}1$	E2	5.62E−01	
406.8267	$^{4}F^{\circ}_{9/2}$–$^{2}F^{\circ}_{5/2}2$	E2	3.07E−01	1.03E−01
425.1330	$^{4}F^{\circ}_{3/2}$–$^{2}D^{\circ}_{5/2}2$	M1	1.39E+00	2.30E+00
444.9926	$^{4}F^{\circ}_{5/2}$–$^{2}D^{\circ}_{5/2}2$	M1+E2	5.17E−01	5.97E−01
446.0319	$^{2}H^{\circ}_{9/2}2$–$^{2}D^{\circ}_{5/2}2$	E2	2.45E−01	
456.2158	$^{2}G^{\circ}_{7/2}2$–$^{2}F^{\circ}_{5/2}2$	M1+E2	1.23E+01	1.22E+01

Table 5. (Continued.)

Wavelength[a] (nm)	Transition	Type[b]	*gA* (This work) (s^{-1})	*gA* (Other)[c] (s^{-1})
457.30222	$^{4}G^{\circ}_{5/2}$–$^{2}F^{\circ}_{5/2}$2	M1	9.77E+00	9.42E+00
464.3970	$^{4}F^{\circ}_{5/2}$–$^{2}D^{\circ}_{3/2}$2	M1+E2	7.24E−01	7.24E−01
465.1137	$^{4}F^{\circ}_{7/2}$–$^{2}D^{\circ}_{5/2}$2	M1+E2	6.91E−01	5.97E−01
475.0866	$^{4}G^{\circ}_{9/2}$–$^{2}F^{\circ}_{7/2}$2	M1	1.28E+01	
476.7375	$^{4}D^{\circ}_{5/2}$–$^{2}G^{\circ}_{7/2}$1	M1	1.39E−01	
481.5577	$^{2}G^{\circ}_{9/2}$1–$^{2}F^{\circ}_{5/2}$1	E2	1.52E−01	
499.1712	$^{4}G^{\circ}_{7/2}$–$^{2}F^{\circ}_{5/2}$2	M1+E2	4.01E+00	4.23E+00
500.3354	$^{2}I^{\circ}_{11/2}$–$^{2}G^{\circ}_{7/2}$1	E2	7.96E−01	
505.6340	$^{2}G^{\circ}_{7/2}$1–$^{2}F^{\circ}_{7/2}$1	M1+E2	7.22E+00	
509.2640	$^{2}G^{\circ}_{9/2}$1–$^{2}F^{\circ}_{7/2}$1	M1+E2	8.22E+00	
510.1588	$^{4}I^{\circ}_{11/2}$–$^{2}G^{\circ}_{9/2}$2	M1+E2	3.55E−01	2.79E−01
512.1705	$^{2}G^{\circ}_{9/2}$2–$^{2}F^{\circ}_{7/2}$2	M1+E2	6.07E+00	
526.3766	$^{2}I^{\circ}_{11/2}$–$^{2}G^{\circ}_{9/2}$1	M1+E2	1.22E+00	
536.2680	$^{2}G^{\circ}_{7/2}$1–$^{2}F^{\circ}_{7/2}$1	M1+E2	1.13E+01	
537.2799	$^{4}F^{\circ}_{5/2}$–$^{4}D^{\circ}_{7/2}$	M1+E2	1.17E−01	1.86E−01
551.1160	$^{4}I^{\circ}_{13/2}$–$^{4}G^{\circ}_{11/2}$	M1+E2	1.10E+00	1.28E+00
551.2260	$^{4}I^{\circ}_{13/2}$–$^{2}K^{\circ}_{15/2}$	M1	1.63E+01	1.56E+01
552.0854	$^{4}I^{\circ}_{11/2}$–$^{2}K^{\circ}_{13/2}$	M1	1.53E+01	1.74E+01
553.1677	$^{4}I^{\circ}_{11/2}$–$^{4}G^{\circ}_{9/2}$	M1+E2	1.68E+00	1.70E+00
559.5194	$^{2}D^{\circ}_{3/2}$1–$^{2}F^{\circ}_{5/2}$2	M1+E2	1.25E+00	1.72E+00
564.5863	$^{4}I^{\circ}_{9/2}$–$^{4}G^{\circ}_{5/2}$	E2	2.92E−01	1.01E−01
566.2511	$^{4}I^{\circ}_{9/2}$–$^{2}G^{\circ}_{7/2}$2	M1+E2	4.20E−01	4.36E−01
566.6176	$^{4}I^{\circ}_{11/2}$–$^{4}G^{\circ}_{7/2}$	E2	2.22E−01	1.01E−01
568.3601	$^{2}I^{\circ}_{13/2}$–$^{2}G^{\circ}_{9/2}$1	E2	6.97E−01	
568.4777	$^{4}I^{\circ}_{13/2}$–$^{2}G^{\circ}_{9/2}$2	E2	1.16E−01	6.71E−02
569.2355	$^{4}S^{\circ}_{3/2}$–$^{4}D^{\circ}_{7/2}$	E2	1.76E−01	5.13E−01
569.3567	$^{2}G^{\circ}_{7/2}$2–$^{2}D^{\circ}_{5/2}$2	M1+E2	1.57E+00	1.35E+00
571.0498	$^{4}G^{\circ}_{5/2}$–$^{2}D^{\circ}_{5/2}$2	M1	2.48E+00	2.30E+00
571.5176	$^{4}F^{\circ}_{3/2}$–$^{4}D^{\circ}_{5/2}$	M1+E2	4.53E−01	7.06E−01
575.2264	$^{2}H^{\circ}_{9/2}$2–$^{2}I^{\circ}_{11/2}$	M1+E2	1.11E+00	1.74E+00
599.3687	$^{2}D^{\circ}_{5/2}$1–$^{2}F^{\circ}_{7/2}$2	M1+E2	7.32E−01	
608.8523	$^{2}H^{\circ}_{9/2}$1–$^{2}G^{\circ}_{7/2}$1	M1+E2	4.26E+00	
611.0714	$^{4}F^{\circ}_{9/2}$–$^{4}D^{\circ}_{7/2}$	M1+E2	1.70E−01	1.67E−01
621.4851	$^{2}G^{\circ}_{7/2}$2–$^{2}H^{\circ}_{9/2}$1	M1+E2	4.92E−01	4.33E−01
622.4013	$^{4}I^{\circ}_{13/2}$–$^{4}G^{\circ}_{9/2}$	E2	1.88E−01	8.12E−02
622.5362	$^{4}I^{\circ}_{15/2}$–$^{4}G^{\circ}_{11/2}$	E2	3.14E−01	2.18E−01
634.8290	$^{4}S^{\circ}_{3/2}$–$^{4}D^{\circ}_{1/2}$	M1+E2	1.01E−01	1.01E−01
637.8587	$^{4}G^{\circ}_{7/2}$–$^{2}D^{\circ}_{5/2}$2	M1	1.34E+00	1.31E+00
646.1883	$^{4}F^{\circ}_{7/2}$–$^{4}D^{\circ}_{5/2}$	M1+E2	1.93E−01	6.26E−02
648.2738	$^{2}H^{\circ}_{11/2}$2–$^{2}I^{\circ}_{13/2}$	M1+E2	1.40E+00	1.22E+00
649.2379	$^{4}S^{\circ}_{3/2}$–$^{4}D^{\circ}_{5/2}$	M1+E2	2.56E−01	2.55E−01
656.1883	$^{2}D^{\circ}_{5/2}$1–$^{2}F^{\circ}_{5/2}$2	M1+E2	3.51E−01	1.84E−01
656.9377	$^{4}S^{\circ}_{3/2}$–$^{4}D^{\circ}_{3/2}$	M1+E2	2.56E−01	2.64E−01
659.1519	$^{4}G^{\circ}_{9/2}$–$^{2}H^{\circ}_{11/2}$1	M1+E2	9.34E+00	9.57E+00
660.6953	$^{2}K^{\circ}_{13/2}$–$^{2}H^{\circ}_{11/2}$1	M1+E2	9.45E−01	9.21E−01
663.7083	$^{4}F^{\circ}_{3/2}$–$^{2}P^{\circ}_{3/2}$	M1	1.44E+00	1.29E+00
668.8446	$^{2}D^{\circ}_{5/2}$2–$^{2}G^{\circ}_{7/2}$1	M1	1.71E−01	
704.0139	$^{4}G^{\circ}_{7/2}$–$^{2}H^{\circ}_{9/2}$1	M1+E2	5.84E+00	5.37E+00
712.2655	$^{2}H^{\circ}_{11/2}$1–$^{2}G^{\circ}_{9/2}$1	M1+E2	2.46E+00	
713.4137	$^{4}F^{\circ}_{5/2}$–$^{2}P^{\circ}_{3/2}$	M1	3.62E+00	3.43E+00
727.8171	$^{2}K^{\circ}_{13/2}$–$^{2}H^{\circ}_{9/2}$1	E2	1.08E−01	5.74E−02
739.8232	$^{2}D^{\circ}_{3/2}$1–$^{2}D^{\circ}_{5/2}$2	M1+E2	2.40E−01	2.63E−01
763.2792	$^{4}I^{\circ}_{11/2}$–$^{4}F^{\circ}_{9/2}$	M1	2.74E+00	2.51E+00
770.8751	$^{4}S^{\circ}_{3/2}$–$^{2}P^{\circ}_{3/2}$	M1	3.09E+00	3.15E+00
780.5942	$^{2}P^{\circ}_{3/2}$–$^{2}F^{\circ}_{5/2}$2	M1+E2	1.25E+00	1.31E+00
791.2591	$^{4}F^{\circ}_{3/2}$–$^{2}D^{\circ}_{5/2}$1	M1	5.73E−01	5.06E−01
815.8291	$^{4}I^{\circ}_{13/2}$–$^{2}H^{\circ}_{11/2}$2	M1	1.23E+01	1.11E+01
826.8725	$^{4}F^{\circ}_{3/2}$–$^{2}P^{\circ}_{1/2}$	M1	2.23E−01	2.46E−01
846.2036	$^{4}G^{\circ}_{7/2}$–$^{4}D^{\circ}_{7/2}$	M1	1.65E−01	1.62E−01
866.6286	$^{2}G^{\circ}_{7/2}$2–$^{4}D^{\circ}_{5/2}$	M1+E2	1.22E−01	1.18E−01
870.5573	$^{4}G^{\circ}_{5/2}$–$^{4}D^{\circ}_{5/2}$	M1+E2	4.94E−01	4.69E−01
878.0883	$^{4}G^{\circ}_{9/2}$–$^{4}D^{\circ}_{7/2}$	M1+E2	1.07E−01	9.90E−02
906.3054	$^{2}K^{\circ}_{13/2}$–$^{2}L^{\circ}_{15/2}$	M1	1.09E+01	1.08E+01
916.9120	$^{4}I^{\circ}_{11/2}$–$^{2}H^{\circ}_{9/2}$2	M1	7.72E+00	7.61E+00
941.9574	$^{4}F^{\circ}_{7/2}$–$^{2}D^{\circ}_{5/2}$1	M1	8.00E+00	7.80E+00
943.8026	$^{2}F^{\circ}_{5/2}$2–$^{2}G^{\circ}_{7/2}$1	M1+E2	3.16E−01	
946.8902	$^{4}D^{\circ}_{3/2}$–$^{2}F^{\circ}_{5/2}$2	M1+E2	3.38E−01	2.73E−01
948.4515	$^{4}S^{\circ}_{3/2}$–$^{2}D^{\circ}_{5/2}$1	M1	2.81E−01	2.89E−01
950.3277	$^{2}K^{\circ}_{15/2}$–$^{2}L^{\circ}_{17/2}$	M1	1.08E+01	1.06E+01
953.3655	$^{2}P^{\circ}_{1/2}$–$^{2}D^{\circ}_{3/2}$2	M1+E2	5.65E−01	4.54E−01
979.1500	$^{4}G^{\circ}_{9/2}$–$^{2}I^{\circ}_{11/2}$	M1	7.16E−01	6.00E−01
982.5596	$^{2}K^{\circ}_{13/2}$–$^{2}I^{\circ}_{11/2}$	M1+E2	1.50E+00	1.48E+00
999.4850	$^{4}F^{\circ}_{3/2}$–$^{2}D^{\circ}_{3/2}$1	M1	2.89E+00	2.85E+00
1000.0819	$^{4}S^{\circ}_{3/2}$–$^{2}P^{\circ}_{1/2}$	M1	1.69E+00	1.64E+00
1005.5470	$^{2}D^{\circ}_{5/2}$1–$^{2}D^{\circ}_{3/2}$2	M1	3.57E+00	3.73E+00
1048.0319	$^{2}K^{\circ}_{15/2}$–$^{2}I^{\circ}_{13/2}$	M1	1.48E+00	1.17E+00
1116.6432	$^{4}F^{\circ}_{5/2}$–$^{2}D^{\circ}_{3/2}$1	M1	3.64E+00	3.69E+00
1182.7260	$^{2}P^{\circ}_{3/2}$–$^{2}D^{\circ}_{5/2}$2	M1	2.37E+00	1.97E+00
1217.1925	$^{4}D^{\circ}_{7/2}$–$^{2}F^{\circ}_{5/2}$2	M1	1.87E+00	1.57E+00
1225.1925	$^{2}F^{\circ}_{7/2}$2–$^{2}G^{\circ}_{9/2}$1	M1+E2	2.30E−01	
1264.1257	$^{4}S^{\circ}_{3/2}$–$^{2}D^{\circ}_{3/2}$1	M1	4.55E+00	4.32E+00
1275.2411	$^{2}D^{\circ}_{3/2}$1–$^{4}D^{\circ}_{1/2}$	M1	1.97E−01	2.44E−01
1286.0584	$^{4}F^{\circ}_{7/2}$–$^{2}G^{\circ}_{9/2}$2	M1	2.93E+00	2.52E+00
1334.7467	$^{2}D^{\circ}_{3/2}$1–$^{4}D^{\circ}_{5/2}$	M1	2.10E+00	1.91E+00
1417.5454	$^{4}F^{\circ}_{9/2}$–$^{4}G^{\circ}_{11/2}$	M1+E2	1.46E−01	3.21E−01
1471.7317	$^{4}F^{\circ}_{5/2}$–$^{4}G^{\circ}_{7/2}$	M1	1.34E+00	1.06E+00
1497.0474	$^{2}G^{\circ}_{7/2}$2–$^{2}D^{\circ}_{5/2}$1	M1	1.37E−01	1.86E−01
1538.3915	$^{4}F^{\circ}_{9/2}$–$^{2}G^{\circ}_{9/2}$2	M1	9.19E+00	7.80E+00
1599.5707	$^{4}F^{\circ}_{7/2}$–$^{4}G^{\circ}_{9/2}$	M1	4.23E−01	4.77E−01
1611.5555	$^{4}D^{\circ}_{3/2}$–$^{2}D^{\circ}_{5/2}$2	M1	3.25E+00	3.10E+00
1663.8045	$^{4}F^{\circ}_{3/2}$–$^{4}G^{\circ}_{5/2}$	M1+E2	3.14E−02	
1717.4547	$^{4}F^{\circ}_{7/2}$–$^{4}G^{\circ}_{7/2}$	M1	1.34E+00	
1724.0298	$^{2}D^{\circ}_{5/2}$2–$^{2}F^{\circ}_{7/2}$2	M1	4.37E+00	
1738.2082	$^{2}P^{\circ}_{1/2}$–$^{4}D^{\circ}_{1/2}$	M1	2.12E−01	
1875.0061	$^{2}H^{\circ}_{11/2}$2–$^{2}G^{\circ}_{9/2}$2	M1	3.23E+00	
1888.6971	$^{2}D^{\circ}_{3/2}$2–$^{2}F^{\circ}_{5/2}$2	M1	1.89E+00	
1898.8961	$^{4}D^{\circ}_{3/2}$–$^{2}D^{\circ}_{3/2}$2	M1	1.27E+00	
1914.6357	$^{2}P^{\circ}_{1/2}$–$^{4}D^{\circ}_{3/2}$	M1+E2	6.89E−01	
1966.3023	$^{4}D^{\circ}_{5/2}$–$^{2}D^{\circ}_{3/2}$2	M1	6.37E−01	
1975.6320	$^{2}D^{\circ}_{3/2}$1–$^{2}P^{\circ}_{3/2}$	M1	4.28E+00	

[a] Vacuum (below 200 nm) and air (above 200 nm) wavelengths deduced from the experimental energy level values of Wyart *et al* (2007).
[b] Contributions larger than 1%.
[c] From Dodson and Zia (2012).

Another comparison can be made for radiative lifetimes which were also reported for some $4f^25d$ levels by Wyart *et al* (2007) and by Dzuba *et al* (2003). Such a comparison is given in table 4. As seen from this table, while a satisfactory agreement (within 20%) is found between our results and those of Wyart *et al* (2007), larger discrepancies (generally reaching a factor of 2 or even more) are observed when comparing our computed lifetimes with those of Dzuba *et al* (2003). However,

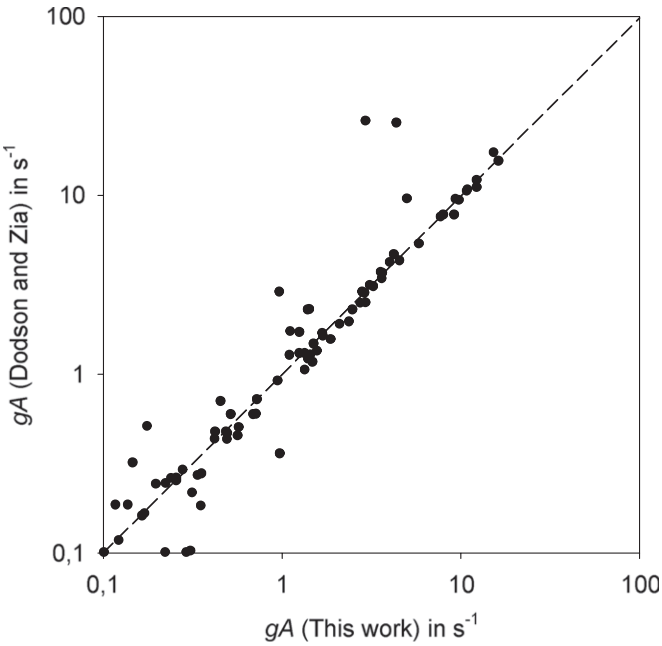

Figure 3. Comparison between calculated radiative transition probabilities as obtained in the present work and those published by Dodson and Zia (2012) for forbidden lines in Nd IV.

it is worth mentioning that these latter authors did not include core-polarization and correlation effects in their calculations and, as a consequence, estimated their computed lifetimes to be too small by a factor of 3 or 4.

3.2. Forbidden transitions

Triply ionized lanthanides are known to exhibit very characteristic emission lines in the visible and near infrared regions due to 4f → 4f transitions. These transitions, forbidden by the electric dipole selection rules, are characterized by long lifetimes which facilitate 'time gated' emission experiments leading to significant improvement of signal-to-noise ratios compared with more traditional steady-state measurements. For this reason, radiative properties of such forbidden lines within the $4f^3$ configurations were also computed in the present work. Transition probabilities for the most intense magnetic dipole (M1) and electric quadrupole (E2) lines are reported in table 5 where they are compared to the data recently published by Dodson and Zia (2012). These latter authors reported radiative transition probabilities for some M1 and E2 Nd IV lines using a detailed free ion Hamiltonian including electrostatic and spin-orbit terms as well as two-body, three-body, spin-spin, spin-other-orbit and electrostatically correlated spin-orbit interactions. As seen from table 5, for M1 lines, our *gA*-values are generally in good agreement (within a few per cent) with those of Dodson and Zia while larger discrepancies (reaching 30%–40%) can be observed for some E2 lines. Nevertheless, as illustrated in figure 3 showing the overall comparison between both sets of transition probabilities, it is clear that a satisfactory agreement is observed for the most intense forbidden lines, i.e. for those characterized by *gA*-values larger than 1 s^{-1}.

4. Conclusion

A new set of radiative parameters has been obtained for electric dipole, magnetic dipole and electric quadrupole lines in triply ionized neodymium using a pseudo-relativistic Hartree–Fock model combined with a semi-empirical optimization of electrostatic and spin-orbit radial integrals. Computed transition probabilities, oscillator strengths and radiative lifetimes have been compared with other available theoretical data. For electric dipole transitions, our results are expected to be more accurate than those previously published in view of the much more extended amount of electronic correlation effects (including core-excited correlation) considered in our physical model. In the case of magnetic dipole and electric quadrupole lines, our results have been found to be in good agreement with theoretical data recently published for the most intense transitions.

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