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Oscillator strengths for the gallium-like ions Br V – In XIX

ABSTRACT

Electric dipole oscillator strengths have been calculated for the n = 4, Δn = 0 transitions of the ions Br V to In XIX along the gallium isoelectronic sequence. Results are reported here for the $4s^24p$-$4s^24d$ and $4s^24p$ - $4s4p^2$ transitions. The Relativistic Hartree-Fock approach of Cowan (1981) combined with a least-square-fitting procedure of the hamiltonian eigenvalues to the observed energy levels has been used for the calculations. Analytical expressions have also been applied for interpolation or extrapolation of the Slater parameter values.

INTRODUCTION

The transition probabilities for strongly or moderately ionized gallium-like ions (Z>35) are very sparse. The only results available for the E1 transitions have been published by Aashamar et al. (1983). Some radiative lifetime values obtained by BFS have been reported for Br V by Pinnington et al.(1977) and for Kr VI by Irwin et al.(1976), by Livingston(1976) and by Pinnington(1976).

In view of this lack of transition probabilities, we report here the first extensive set of f values for the ions Br V to In XIX.

RESULTS

All the odd configurations (except $4p4f^2$ and $4f^3$) and all the even configurations (except $4d4f^2$) in the n = 4 complex have been considered in the calculations i.e. $4s^24p + 4s^24f + 4s4p4d + 4s4d4f + 4p^3 + 4p^24f + 4p4d^2 + 4d^24f$ and $4s^24d + 4s4p^2 + 4s4p4f + 4s4d^2 + 4s4f^2 + 4p^24d + 4p4d4f + 4d^3$.

The experimental energy levels used for the fitting procedure were due to Budhiraja and Joshi (1971) for Br V, Druetta and Buchet (1976) for Kr VI, Litzén and Reader (1989) for the ions Rb VII to Mo XII, Reader et al. (1986) for the ions Ru XIV to In XIX and Denne et al.(1985) for Ag XVIII.

Moreover, in order to interpolate or extrapolate the parameter values of E_{AV}, F^k, G^k, α and ζ along the sequence, we have used q-expansions of the type:

$$E_{AV} = A + Bq + Cq^2 + Dq^3 + E/q,$$

$$F^k, G^k, \alpha = A + Bq + C/(q+1) \text{ and}$$

$$\zeta = \zeta_0 + \zeta_1 q + \zeta_2 q^2 + \zeta_3 q^3 + \zeta_4 q^4, \text{ where}$$

$q = Z - N + 1$ and where A,B,C,D,E and ζ_i were determined by least-square optimization of the parameter values for the 6 elements Rb to Mo.

The final oscillator strengths obtained with the fitted parameters for the $4s^24p$ - $4s^24d$ and $4s^24p$ - $4s4p^2$ transitions are presented in Table 1. They agree well (within a few percent) with the results of Aashamar et al. (1983) except for the $4s^24p\ ^2P°$ - $4s4p^2\ ^2S$ transition but our results for that transition are compatible with the f values reported by Bahr et al. (1982) for Se IV. The f values obtained in this work for the $4s^24p\ ^2P°$ - $4s4p^2\ ^2D$ transition agree reasonably well with the results reported by Pinnington et al.(1977) for Br V and by Irwin et al. (1976) for Kr VI. They are larger for the $4s^24p\ ^2P°$ - $4s^24d\ ^2D$ transition but this discrepancy between theory and experiment has been discussed in detail by Aashamar et al. (1983).

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Table 1 - Calculated oscillator strengths (log gf) for the $4s^24p - 4s^24d$ and $4s^24p - 4s4p^2$ transitions of gallium-like ions.

Trans.	2J-2J'	Br V	Kr VI	Rb VII	Sr VIII	Y IX	Zr X	Nb XI
				$4s^24p - 4s^24d$				
2P-2D	1-3	0.46	0.45	0.43	0.42	0.40	0.39	0.38
2P-2D	3-3	-0.17	-0.20	-0.22	-0.23	-0.25	-0.26	-0.27
2P-2D	3-5	0.71	0.70	0.68	0.66	0.65	0.63	0.62
				$4s^24p - 4s4p^2$				
2P-2P	1-1	-0.19	-0.27	-0.36	-0.45	-0.54	-0.62	-0.71
2P-2P	1-3	-0.18	-0.22	-0.24	-0.27	-0.29	-0.32	-0.34
2P-2S	1-1	-0.09	-0.06	-0.03	-0.01	0.00	0.01	0.02
2P-2D	1-3	-0.57	-0.48	-0.43	-0.39	-0.36	-0.33	-0.31
2P-4P	1-1	-2.61	-2.46	-2.32	-2.19	-2.08	-1.97	-1.87
2P-4P	1-3	-4.18	-3.97	-3.80	-3.66	-3.54	-3.43	-3.33
2P-2P	3-1	-0.01	-0.01	-0.01	-0.02	-0.03	-0.04	-0.05
2P-2P	3-3	0.48	0.47	0.46	0.45	0.44	0.43	0.42
2P-2S	3-1	-1.09	-1.36	-1.69	-2.16*	-2.99*	-3.82*	-2.58*
2P-2D	3-3	-1.99	-2.01	-2.11	-2.27*	-2.51*	-2.89*	-3.71*
2D-2D	3-5	-0.42	-0.35	-0.31	-0.29	-0.27	-0.27	-0.27
2P-4P	3-1	-2.95	-2.84	-2.74	-2.66	-2.58	-2.52	-2.47
2P-4P	3-3	-2.86	-2.72	-2.59	-2.49	-2.39	-2.31	-2.23
2P-4P	3-5	-2.19	-2.00	-1.84	-1.70	-1.58	-1.46	-1.36

Trans.	2J-2J'	Mo XII	Ru XIV	Rh XV	Pd XVI	Ag XVII	Cd XVIII	In XIX
				$4s^24p - 4s^24d$				
2P-2D	1-3	0.36	0.34	0.32	0.31	0.30	0.29	0.28
2P-2D	3-3	-0.28	-0.30	-0.31	-0.31	-0.31	-0.31	-0.31
2P-2D	3-5	0.60	0.57	0.56	0.55	0.53	0.52	0.51
				$4s^24p - 4s4p^2$				
2P-2P	1-1	-0.79	-0.95	-1.03	-1.10	-1.18	-1.25	-1.32
2P-2P	1-3	-0.36	-0.40	-0.42	-0.44	-0.46	-0.48	-0.49
2P-2S	1-1	0.02	0.01	0.01	0.01	0.00	-0.00	-0.01
2P-2D	1-3	-0.29	-0.26	-0.25	-0.24	-0.22	-0.21	-0.20
2P-4P	1-1	-1.78	-1.61	-1.54	-1.47	-1.40	-1.34	-1.29
2P-4P	1-3	-3.25	-3.09	-3.02	-2.96	-2.90	-2.84	-2.79
2P-2P	3-1	-0.06	-0.08	-0.10	-0.11	-0.12	-0.13	-0.14
2P-2P	3-3	0.42	0.40	0.39	0.38	0.37	0.36	0.35
2P-2S	3-1	-2.13*	-1.69	-1.56	-1.46	-1.38	-1.31	-1.25
2P-2D	3-3	-4.13*	-2.50*	-2.20*	-1.97	-1.79	-1.65	-1.53
2P-2D	3-5	-0.27	-0.29	-0.31	-0.32	-0.34	-0.36	-0.37
2P-4P	3-1	-2.42	-2.36	-2.33	-2.32	-2.31	-2.31	-2.31
2P-4P	3-3	-2.16	-2.04	-1.99	-1.94	-1.89	-1.85	-1.81
2P-4P	3-5	-1.26	-1.10	-1.03	-0.97	-0.92	-0.87	-0.83

* Cancellation effects present.