Theoretical Study of Several Oscillator Strengths and Lifetimes of Germanium, Thallium and Bismuth. Measures of Some Relative Transition Probabilities

Cite as: AIP Conference Proceedings **1058**, 152 (2008); <https://doi.org/10.1063/1.3026428>

Published Online: 27 October 2008

A. Alonso-Medina, C. Colón, A. Zanón, J. L. Montero, F. Fernández Martínez, and C. Rivero

View Online

Export Citation

ARTICLES YOU MAY BE INTERESTED IN

[Energy Levels of Germanium, GeI through Ge XXXII](#)

Journal of Physical and Chemical Reference Data **22**, 1213 (1993); <https://doi.org/10.1063/1.555929>

Lock-in Amplifiers up to 600 MHz

starting at

\$6,210

Zurich
Instruments

Watch the Video

Theoretical Study of Several Oscillator Strengths and Lifetimes of Germanium, Thallium and Bismuth. Measures of Some Relative Transition Probabilities

A. Alonso-Medina^a, C. Colón^a, A. Zanón^b, J.L. Montero^c, F. Fernández Martínez^c and C. Rivero^d

^a*Dpto. de Física Aplicada. EUITI. Universidad Politécnica de Madrid (UPM)*

^b*Dpto. de Matemática Aplicada. EUITI. UPM*

^c*Dpto. de Química Industrial y Polímeros. EUITI. UPM*

^d*Dpto. de Tecnologías Aplicadas a la Telecomunicación ETSIT. UPM
Madrid Spain*

Abstract. Transitions probabilities for several lines arising from excited levels of Ge I, Bi I, and Tl I have been determined from emission lines intensities in a hollow-cathode discharge. These values were put on an absolute scale by using, where possible, the experimental lifetimes published by other authors. Oscillator strengths for several lines of interest arising from some configurations and some levels radiative lifetimes of these elements have been calculated.

Keywords: Transitions Probabilities, Oscillator strengths, radiative lifetimes.

PACS: 31.15. A-, 31.15.ag., 32.70.Cs, 32.70.Fw.

PROCEDURE, RESULTS AND DISCUSSION

The presence of Thallium, Bismuth and Germanium in stellar spectra has been reported in a few different types of stars [1-3]. Data on atomic properties are relevant not only for spectroscopy; these values are also of interest in a variety of other fields in physics and technology. Calculations of oscillator strength for different transitions in Thallium, Bismuth and Germanium has been the subject of numerous theoretical studies [4-8].

In this work a complete study of atomic parameters of different species of these elements has been made. We have obtained theoretical values of oscillator strengths in intermediate coupling (IC) using *ab initio* relativistic Hartree-Fock (HFR) calculations. For the IC calculations we used the standard method of least-square fitting of experimental energy levels by means of computer codes from Cowan [9].

In this way we obtained the LS composition of each level and the degree of configuration mixing, when we consider their interaction. To provide level energy for our calculation we have used the Tables of Moore [10].

TABLE . Oscillator Strengths, Transition Probabilities and radiative lifetimes of Ge I, Bi I and Tl I.

Transition Levels		λ (nm) ^a	f-values	Transition Probabilities (10 ⁷ s ⁻¹)			Lifetimes (ns)			
Upper	Lower			This work		NIST ^a	This	Others		
							work			
Ge I										
5s ³ P ₀	4p ² ³ P ₁	270.96	0.100	24.5 ± 2.5	27.3	28.0		3.67	4.81± 0.04 ^b	
5s ³ P ₁	4p ² ³ P ₀	265.16	0.281	8.2 ± 0.8	8.9	8.5		3.61	4.68 ± 0.20 ^b	
	4p ² ³ P ₁	269.13	0.067	5.1 ± 0.6	6.2	6.1				
	4p ² ³ P ₂	275.46	0.074	10.0 ± 0.9	10.8	11.0				
	4p ² ¹ D ₂	326.95	0.016	2.0 ± 0.3	1.7	2.9				
	4p ² ¹ S ₀	468.58	0.006	0.7 ± 0.1	0.059	0.95				
5s ³ P ₂	4p ² ³ P ₁	259.25	0.364	7.0 ± 0.8	7.9	7.1		3.38	4.50± 0.18 ^b	
	4p ² ³ P ₂	265.12	0.229	18.0 ± 2.4	21.7	20.0				
	4p ² ¹ D ₂	312.48	0.0008		0.055	0.31				
5s ¹ P ₁	4p ² ³ P ₀	249.80	0.028	0.9 ± 0.1	1.0	1.3		3.70	4.23± 0.14 ^b	
	4p ² ³ P ₁	253.32	0.007	0.7 ± 0.1	0.8	1.0				
	4p ² ³ P ₂	258.92	0.003	0.5 ± 0.09	0.44	0.51				
	4p ² ¹ D ₂	303.91	0.199	24.0 ± 2.2	23.9	28.0				
	4p ² ¹ S ₀	422.66	0.075	1.9 ± 0.2	0.93	2.1				
Bi I										
7s ⁴ P _{5/2}	6p ³ ⁴ S _{3/2}	206.17	0.217	9.8 ± 0.9	11.7	9.9		5.35	5.70± 0.40 ^c	
	6p ³ ² D _{3/2}	269.67	0.005	0.4 ± 0.08	0.29	0.64				
	6p ³ ² D _{5/2}	302.46	0.092	7.8 ± 0.7	6.7	8.8				
	6p ³ ² P _{3/2}	652.37			0.003					
7s ² P _{3/2}	6p ³ ⁴ S _{3/2}	202.12	0.021	0.9 ± 0.1	1.7	0.6		3.76		
	6p ³ ² D _{3/2}	262.79	0.057	5.0 ± 0.6	5.5	4.7				
	6p ³ ² D _{5/2}	292.84	0.134	11.3± 1.0	15.6	12.3				
	6p ³ ² P _{1/2}	359.61	0.147	2.8 ± 0.3	3.8	2.0				
	6p ³ ² P _{3/2}	613.64	0.003		0.055					
Tl I										
8s ² S _{1/2}	6p ² P _{1/2}	258.01	0.020	2.0 ± 0.2	2.0	1.7 ^d	1.8			
	6p ² P _{3/2}	322.97	0.018	1.9 ± 0.2	2.3	2.2 ^d	1.7			
9s ² S _{1/2}	6p ² P _{1/2}	231.60	0.007	0.70 ± 0.09	0.82	0.74 ^d	0.78			
	6p ² P _{3/2}	282.62	0.006	0.91 ± 0.09	1.0	0.94 ^d	0.80			
10s ² S _{1/2}	6p ² P _{1/2}	220.71	0.004	1.1 ± 0.1	0.59	0.39 ^d				
				1.3 ± 0.1 ^e						
	6p ² P _{3/2}	266.56	0.003	0.55 ± 0.06	0.60	0.50 ^d	0.57			
				0.60 ± 0.06 ^e						
6d ² D _{3/2}	6p ² P _{1/2}	276.79	0.422	13.6±1.2	18.4	16.5 ^d	12.6			
	6p ² P _{3/2}	352.94	0.037	1.9 ± 0.2	2.0	2.2 ^d	2.2			

^aNIST ^bBiemont et al (1999) ^cCaiyan et al (1995) ^dAlonso-Medina(1996a) ^eAlonso-Medina(1997)

Also in this work we present experimental values for several lines corresponding to different transitions of Tl I, Tl II, Ge I, Ge II, Bi I and Bi II. Relative values have been obtained from measures of emission line intensities in hollow cathode lamp discharges operating with a typically current of 10 mA.

The wavelengths of the measured transitions are the UV, Visible and IR. The infrared spectra were obtained using a Czerny-Turner monochromator (Digikrom CVI). A IHR55 Jobin-Ibon monochromator was used to obtain the visible and UV spectrum. We used in both cases a CCD to detect the optical signal.

We have used two different methods in order to place data on an absolute scale. We have use the experimental lifetimes present in the bibliography and using line-strength sum rules applied to our relativistic calculations. Our results have been compared with the values presents in the literature [8, 11, 12].

FIGURE 1. Emission lines of Ge I, Bi I, Bi II and Tl II (hollow-cathode lamp filled with neon).

ACKNOWLEDGMENTS

This work has been supported by the project CCG07-UPM/ESP-1632 of the TECHNICAL UNIVERSITY OF MADRID (UPM). Support to the lines of UPM investigation groups included in the IV PRICIT of the CAM (Comunidad Autónoma de Madrid), SPAIN.

REFERENCES

1. S. Vennes, P. Chayer and J. Dupuis, *ApJ* **622**, L121-L124 (2005).
2. G. M. Wahlgren, Proceedings IAU Symposium 224, 291-299 (2004).
3. S. Goriely and L. Siess, *A&A* **378**, L25-L28 (2001).
4. L. Caiyan, U. Berzinsh, R. Zerne and S. Svanberg, *Phys. Rev. A* **52**, 1936-1941 (1995).
5. E. Biemont, C. Lynga, Z. S. Li, S. Svanberg, H. P. Garmir and P. S. Doidge, *MNRAS* **303**, 721-724 (1999).
6. E. Biemont, P. Palmeri, P. Quinet, Z. Dai, S. Svanberg and H. L. Xu, *J. Phys. B.* **38**, 3547-3558 (2005).
7. U. I. Safronova, M. S. Safronova and W. R. Johnson, *Phys. Rev. A* **71**, 052506-18 (2005).
8. A. Alonso-Medina, *An. Phys.* **92**, 71-84 (1996a).
9. R. D. Cowan, Theory of Atomic Structure and Spectra, edited by University Press, Los Angeles, 1981.
10. C. E. Moore, in Atomic Energy Levels, edited by NBS 467, Washington D. C., 1958.
11. A. Alonso-Medina, *JQSRT* **56**, 557-562 (1996b).
12. A. Alonso-Medina, *J. Phys. B.* **30**, 1377-1384 (1997).