# Transition probabilities of forbidden lines in Bi I

Paweł Syty, Józef E. Sienkiewicz
Faculty of Applied Physics and Mathematics, Technical University of Gdańsk
ul. Narutowicza 11/12, 80-952 Gdańsk, Poland

Jerzy Kwela
Institute of Experimental Physics, University of Gdańsk
ul. Wita Stwosza 57, 80-952 Gdańsk, Poland

## Introduction

Decay rates calculated for strong transitions are in reasonable agreement with experiment, but in the case of weak transitions the predictions often strongly disagree with the experimental data. It results from the fact that weak transition rates are especially sensitive to even small modifications to the wave functions and a careful choice of the theoretical method to be used is reqiured.

## Our work

In our calculations the code GRASP92 has been used. It implements the Multiconfiguration Dirac-Fock Method (MCDF). Using this program we have calculated transition amplitudes for the magnetic dipole (M1) forbidden transitions within the ground $6s^2 6p^3$ configuration of neutral bismuth. Moreover, to check the accuracy of the method, we calculated the energies for all five levels of the configuration $6s^2 6p^3$.

## Calculations

- CSF including single and double excitations from the reference configurations ($6s^2 6p^3$, $6p^5$).
- Inclusion of the core polarisation effect (excitations from the inner 5p and 5d shells).
- Generation of atomic wave functions including Breit interactions.
- Calculation of transition properties using GRASP92.

## References

V. A. Dzuba *et al*, Phys. Lett. 141A (**1989**) 147
M. J. D. Macpherson *et al*, J. Physique II 2, (**1992**) 749
M. G. Kozlov *et al*, J. Phys. B 29 (**1996**) 689
C. E. Moore, Atomic Energy Levels 3, NBS Circular No 467 (**1954**)
S. J. Rose *et al*, J. Phys. B 11 (**1978**) 3499
F. A. Parpia *et al*, Comput. Phys. Commun. 94 (**1996**) 249

### *Energies of the low-lying states of bismuth (in $cm^{-1}$)*

| | | Experiment[a] | MBPT[b] | CI[c] | This work |
|---|---|---|---|---|---|
| Odd | $^4S^o_{3/2}$ | 0 | 0 | 0 | 0 |
| | $^2D^o_{3/2}$ | 11 419.0 | 11 672 | 11 521 | 11 550 |
| | $^2D^o_{5/2}$ | 15 437.7 | 15 593 | 15 969 | 15 867 |
| | $^2P^o_{1/2}$ | 21 661.0 | 21 806 | 22 222 | 22 321 |
| | $^2P^o_{3/2}$ | 33 164.8 | 33 337 | 33 185 | 33 180 |
| Even | $^4P_{1/2}$ | 32 588.2 | - | 32 823 | 32 800 |
| | $^4P_{3/2}$ | 44 865.1 | - | 44 418 | 44 873 |
| | $^2P_{1/2}$ | 45 915.6 | - | 45 814 | 46 013 |
| | $^4P_{5/2}$ | 48 498.9 | - | 48 940 | 48 676 |
| | $^2P_{3/2}$ | 49 456.6 | - | 49 599 | 49 612 |

[a] Moore (1958)
[b] Dzuba *et al* (1989)
[c] Kozlov *et al* (1996), 354 relativistic configurations

### *M1 transition amplitudes for the states of configuration $6s^2 6p^3$*

| Transition | $^4S^o_{3/2}$ - $^2D^o_{3/2}$ | $^4S^o_{3/2}$ - $^2D^o_{5/2}$ | $^4S^o_{3/2}$ - $^2P^o_{1/2}$ | X |
|---|---|---|---|---|
| Wavelength | 876 nm | 648 nm | 462 nm | |
| Experiment[a] | - | - | - | 8.75 |
| MBPT[b] | 1.747 | 0.615 | 0.625 | 8.07 |
| MBPT[c] | 1.696 | 0.563 | 0.590 | 9.06 |
| CI[d] | 1.618 | 0.510 | 0.573 | 10.07 |
| This work | 1.603 | 0.523 | 0.598 | 9.39 |

[a] Macpherson *et al* (1992), X is the squared ratio of the first and second amplitudes
[b] Dzuba *et al* (1989), second order in the residual e-e interaction
[c] Dzuba *et al* (1989), semi-empirical higher order corrections
[d] Kozlov *et al* (1996), 354 relativistic configurations