

Laser probing of metastable Ba⁺ for lifetime measurements

U Bērziņš, A. Ciniņš¹, A. Bžiškjans¹, H. Hartman², M. Burheim², H. Nilsson²,
D. Hanstorp³,

¹Institute of Atomic Physics and Spectroscopy, University of Latvia

²Department of Materials Science and Applied Mathematics, Malmö University

³Department of Physics, University of Gothenburg.

Metastable levels are responsible for parity forbidden lines occurring in many low-density astrophysical plasmas, found in e.g. gaseous nebulae, planetary nebulae, protostars, stellar chromospheres. Line ratios from forbidden lines are the most reliable tools for diagnostics of temperatures and density of these regions. Measurements of metastable lifetimes is of direct importance for the use of forbidden lines. Such lifetimes can be about 100 ns long and therefore the low temperature and low pressure experimental chambers are demanded in order to avoid the depopulation of metastable levels due to collisions and thermal radiation. The facility Double ElectroStatic Ion-Ring Experiment, DESIREE [1, 2] at Stockholm University demonstrated capacity for such measurements.

The laser probing technique (LPT) was derived by Mannervik and his group at the CRYRING storage ring, and successfully applied to a number of ions of varying complexity [3]. For several complex ions, the measured lifetimes were combined with astrophysical line ratios to derive experimental transition rates [4].

We propose to further develop the laser probing technique to measure lifetimes for stored positive ions using DESIREE. One of the most favorable ions to develop the technique of laser probing of a stored ion beam is Ba⁺. The atomic structure is simple with few levels and the metastable energy levels are located at low excitation energies. This allows for a high population and increased fluorescence signal, making Ba⁺ an ideal target ion. Recently lifetime of Ba⁺ metastable state 5d² D_{5/2} was measured in Paul trap [5] and this can be used as reference.

In our poster we will report a result of our first effort in the development of a LPT for DESIREE, and will discuss the next proposed experiment, what we are going to start on DESIREE in August 29, just after this Symposium.

Acknowledgements

(UB) was supported ERDF project No. 1.1.1.5/19/A/003 "The Development of Quantum Optics and Photonics at the University of Latvia",

References

- [1] Schmidt H. T. et al., *First storage of ion beams in the Double Electrostatic Ion-Ring Experiment: DESIREE* Review of Scientific Instruments 84, 055115 (2013).
- [2] Bäckström E., et al.; *Storing keV Negative Ions for an Hour: The Lifetime of the Metastable P-2(1/2)_o level in S-32(-)* D. Phys. Rev. Lett. 114, 143003 (2015).
- [3] Mannervik, S *Studies of Metastable Levels in Singly Charged Ions by Laser Techniques in an Ion Storage Ring*, S, Physica Scripta, Volume 100, pp. 81-87
- [4] Hartman, H, et al., *Experimental Oscillator Strengths for Forbidden Lines in Complex Spectra*, Hartman, H, Johansson, S, Lundberg, H, Lundin, P, Mannervik, S, Schef, P, Physica Scripta, Volume T119, pp. 40-44 (2005).
- [5] Mohanty, A., et al. Lifetime measurement of the 5d² D_{5/2} state in Ba⁺. *Hyperfine Interact* 233, 113–119 (2015).