Towards a lattice based neutral magnesium optical frequency standard

W. Ertmer[1], J. Friebe[1], M. Riedmann[1], A. Pape[1], T. Wbbena[1], A. Kulosa[1], S.Amairi[1], H. Kelkar[1], E.-M. Rasel[1], O. Terra[2], G. Grosche[2], B. Lipphardt[2], T. Feldmann[2], H. Schnatz[2], K. Predehl[2,3]

[1]Institut für Quantenoptik
Leibniz Universität Hannover
Welfengarten 1, 30167 Hannover, Germany
e-mail: ertmer@iqo.uni-hannover.de

[2]Physikalisch-Technische Bundesanstalt Braunschweig
Bundesallee 100, 38116 Braunschweig, Germany

[3]Max-Planck-Insitut für Quantenoptik
Hans-Kopfermann-Str. 1,85748 Garching, Germany

Abstract

Magnesium is an interesting candidate for a future high performance neutral atom optical frequency standard. It offers low sensitivity to frequency shifts of the $^1S_0$ to $^3P_0$ clock transition by room temperature blackbody radiation and several isotopes of suitable abundance (two bosonic, one fermionic) to realize an optical clock. In order to reach long spectroscopic times and therefore high resolution, it is necessary to perform spectroscopy on optically trapped atoms. For neutral atom optical clocks, it is possible to trap atoms in an optical lattice at the magic wavelength, where both states of the clock transition experience the same light shift due to the trapping field and can also be confined to the Lamb-Dicke regime.

In this contribution, we report on the recent progress on the neutral atom magnesium frequency standard. We established a 73 km fiber link, which connects the Mg experiment (IQ, Hannover) to the Physikalisch-Technische Bundesanstalt (PTB, Braunschweig) to enable the comparison of the Mg frequency standard to PTB's high performance optical frequency standards. With this fiber link, we compared two ultrastable lasers at IQ and PTB on the 10^{-15} level in fractions of a second. This fiber link was also used to determine the stability and absolute frequency of the current setup of the Mg frequency standard, which probes cold free falling atoms on the $^1S_0$ to $^3P_0$ transition.

On the other hand, we are studying trapping of Mg in an optical dipole trap as a step towards a lattice-based frequency standard. Atoms are precooled in a two-stage MOT. The second MOT has a decay channel to the dark 3P0 state. All cooling stages are running continuously and atoms are accumulated in a 1064 nm optical trap. Routinely, we trap up to 910^4 atoms at a temperature below 100 K with this technique.

In the next step, we plan to implement an optical lattice and measure the value of the magic wavelength, which is theoretically predicted at 470 nm.

Keywords: MAGNESIUM, MG, OPTICAL CLOCK, LATTICE CLOCK, CLOCK, FREQUENCY STANDARD UND METROLOGY