PhD Student - Quantum Optics - Optical Clocks

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Demonstration of a Magic Lattice Clock Based on 24-Magnesium Atoms

The development of optical clocks was revolutionized by the proposal of spectroscopy in optical lattices by Katori et al. in 2005. In lattices atoms can be confined in region smaller than the trapping wavelength, allowing for Doppler free spectroscopy. Nowadays optical lattice clocks could demonstrate the predicted accuracies and stabilities, both in the 10^-18 regime.

Attractive candidates for optical clocks are alkaline-earth or alkaline-earth like elements like magnesium which is used as an atomic reference at the Leibniz University in Hannover (LUH). Magnesium is the lightest species being demonstrated for optical clocks. By trying to clarify the question of the drift of the fine structure constant the atomic mass is relevant. Measurements between two different species with the maximal difference in the weight can decrease the required measuring time. Magnesium additionally offers a low uncertainty to shifts due to the black body radiation. Other species have to reduce this uncertainty by more precisely determine the polarizability.

The Magnesium experiment at the LUH demonstrated a frequency measurement on free falling atoms with an accuracy of 7·10^-14 which was limited by the Doppler shift in 2009. In lattice clocks at the magic wavelength this shift is suppressed.

In our experiment, we recently demonstrated the first spectroscopy of the strictly forbidden
transition 1S0 → 3P0 in lattice-trapped magnesium. In the open position, developments of methods for precision metrology and measurements in lattices will be pursued. In detail, the task will be:

- Strategies for establishing a stable and reliable setup for an optical lattice by using an enhancement cavity.
- Development of efficient loading schemes for the optical lattice.
- Advanced stabilization schemes for sub Hz lasers.
- Characterization of Mg optical frequency standard via 70 km long fiber link between the IQ Hannover and the Physikalisch-Technische Bundesanstalt (PTB). The fiber link enables a remote comparison to an optical frequency standard, a hydrogen maser and a Cs fountain clock at PTB.
- Demonstration of Mg lattice clock.

The work will be done in a team comprising several Ph.D. and Master's and Bachelor students. The team is supported by an electronic engineer and a technical workshop.

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