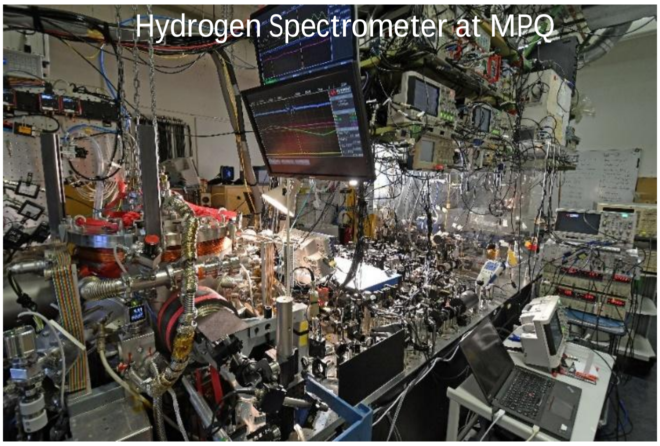
MAX-PLANCK-INSTITUT
FÜR QUANTENOPTIK

Postdoc Project
Atomic Hydrogen Lattice Clock

Hydrogen is the simplest of all atoms and allows to compute its energy levels from first principles. Our labs at MPQ operate the only cryogenic atomic hydrogen beam worldwide. It is formed with the help of a nozzle in vacuum that is held at a temperature of 5 Kelvin. This could be sufficient to cool atomic hydrogen into an optical lattice and probe the extremely sharp 1s-2s transition, just like it is done in a lattice clock. The magic wavelength for such a setting is at 515nm, a wavelength that is readily accessible with frequency doubled ytterbium lasers that can generate very large power levels.

Optical lattice clocks have become the most accurate instruments. They find applications in fundamental research such as tests of general relativity and for tightening limits on a suspected slow temporal variation of fundamental constants. Besides, it is expected that their superior accuracy will lead to a redefinition of the SI second that is still bound to a radio frequency transition. Performing laser spectroscopy on atomic hydrogen is not different from running an optical clock, except that atomic hydrogen is not easy to handle. However, defining the SI second in terms of a transition in atomic hydrogen would yield a “computable second” and remove the last remaining object (the Cs atom) from the SI system. All units would then be given by fixing the values of physical constants.

The main challenge of setting up a hydrogen lattice clock will most likely be providing sufficient cooling to load an optical trap. Several possibilities could be investigated like Doppler cooling with a VUV frequency comb at 121nm or two-photon cooling via the 1s-2s transition at 243nm. Before testing methods in the lab it would be advisable to run Monte Carlo simulations in order to identify the most promising strategy.



If you are interested to work on this problem and have some experience in this field please contact Thomas Udem: thu@mpq.mpg.de