A computable Hydrogen optical lattice Clock

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Defining the values of physical constants is the best method to set up a system of units. With this method the definition gets separated from the realization. Therefore, progress in technology that allow new methods for realization of the unit does not require a new definition. The 2018 definition of the value of Planck constant is an example where two methods for realization currently yield comparable accuracies. Another advantage of fixing the values of constants, is that different realization can operate on vastly different scales. Whereas with the kg artifact it was very difficult to bridge the gap to particle masses, one can readily realize masses at the photon energy scale with the new definition.

With the reform of the SI system in 2018, all but one of the units are now based on defined constants. The only remaining (natural) object is the cesium atom that is used to define **and** realize the SI second. It is interesting to note that one can remove the last object from the system of units, that then seem to have no relation to the real physical world. However, this is not so because the realization of the units still requires physical objects. The definition simply does no longer say which.

Any atomic or molecular transition frequency can be expressed through the Rydberg constant multiplied with a dimensionless number obtained from theory. Defining the value of the Rydberg constant would remove the last object from the SI. While for hydrogen-like systems this theory expression is known with the best accuracy, the cesium ground state hyperfine splitting cannot be computed from first principles with sufficient accuracy. What is a sufficient accuracy of course depends on the demands. The best optical lattice clocks are now sensitive to variations of the gravitational redshift within the atomic cloud. Going below this level essentially means to measure elevation not time. In future the hydrogen like systems may also reach this level if experimental techniques are improved. To use it for a new definition of the SI second also requires progress of the underlying theory.

Here we are proposing a new spectrometer that may reach this level with atomic hydrogen. We want to set up an optical lattice clock for atomic hydrogen that is not more complex than a usual optical atomic clocks. It is based on a magic wavelength optical dipole trap, similar to the current most accurate optical clocks. The trap can be loaded without Doppler cooling which avoids an extremely difficult 121nm cooling laser. The 1S−2S transition with a natural linewidth of 1.3Hz would be the clock transition driven in a Doppler-free manner. Hence, only moderate temperature and no Doppler cooling are required. Even without operating it as a clock, such a setup can be used to improve hydrogen spectroscopic data to test QED. In the long run other hydrogen like systems like He^+ could be envisioned for realizing a new SI second.