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Metrology with optical lattice clocks

Arthur Schawlow, winner of the 1981 Nobel Prize in physics once recommended his students to “Never measure anything but frequency”. Indeed the SI-unit the second (defined via a 9.2 GHz hyperfine transition in Cs) is by far the most precise base-unit available today, with a relative uncertainty of just 10-16. In recent years optical frequency standards based on ultra-cold ions or atoms have surpassed the SI-standard by up to two orders of magnitude and further improvements are to be expected.

With these improved optical frequency standards, the measurement of tiny effects, such as the relativistic redshift of earths gravitational potential, are possible with unprecedented accuracy. This allows for applications not only in geodesy, but also for fundamental tests of general relativity. Another interesting field of application is the search for theories beyond the standard model of the quantum world, as drifts of the fine-structure constant or the electron-proton mass ratio are predicted by some theories. These changes alter the transition frequency of atomic levels and are therefore susceptible to detection in optical clock comparisons.

In this talk recent experiments conducted at INRIM, Italy, with an optical frequency standard based on 171Yb atoms in an optical lattice are presented.
I will discuss the optical frequency standard and some of the techniques used for the latest generation of optical clocks. Furthermore, a proof-of-principle geodetic measurement campaign conducted in 2016 will be explained.