JOURNAL CLUB

Making a better atomic clock: Using femtosecond light pulses to precisely measure optical frequencies

by

Kurt Vogel
Time and Frequency Division,
National Institute of Standards and Technology, Boulder, CO

ABSTRACT

Frequencies of atomic transitions are currently among the most precisely measured quantities, with the best measurements known to less than few parts in 10^{14}. In particular, measurements of optical frequencies (wavelength<1 micron), such as the Hydrogen 1S-2S transition, have led to improved values for some fundamental constants, and are important for precisely testing QED theory. At NIST, our mission is to develop better frequency standards for the time-keeping community, and we are currently exploring the use of very narrow optical transitions of laser-cooled atoms and ions as the basis for the next-generation atomic clocks. Optical-based frequency standards promise to have a much better frequency stability and reproducibility than the current primary Cs microwave standard, which defines the unit of the time, the second. A particular disadvantage of these optical references is that their large frequencies (>300-THz) make them extremely difficult to measure, and this inaccessibility has been the major stumbling block to the development of an "optical clock." In this talk I will present recent work that uses of a femtosecond mode-locked laser to measure optical frequencies to a very high precision, with the eventual hope of achieving a fractional uncertainty of less than 10^{-15}. Using a microstructure optical fiber to expand the frequency-domain comb output of the pulsed laser, we generate a stable comb of reference frequencies that span from about 500-nm to 1100-nm, thus providing a "frequency ruler" for comparing optical frequencies in this spectral region. This technique greatly simplifies the measurement of optical frequencies and opens the door to the development of an atomic clock with an unprecedented stability and reproducibility.

Friday, September 22
Globe Room, Elvey Bldg
3:45 pm