

Hubert M James Memorial Lecture- Professor Theodor W. Hänsch



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October 31st, 2013

4:00 pm – 5:00 pm

PHYS 112

**Refreshments served at 3:30 p.m.
in Physics room 242*

Passion for Precision

Some of the most fundamental insights in physics have been gained by very precise measurements. The simple Balmer spectrum of atomic hydrogen provided the Rosetta stone for deciphering the strange laws of quantum physics during the early 20th century. Seemingly tiny discrepancies between theory and experiment repeatedly led to important conceptual breakthroughs. Four decades ago, Doppler-free laser spectroscopy has opened a new chapter in the exploration of hydrogen. Today, spectroscopy of the 1S-2S two-photon transition in atomic hydrogen has reached a precision of 15 decimal digits with the help of new spectroscopic tools including the laser frequency comb technique. The 1S-2S transition frequency can now be compared directly to the atomic clocks of the German national metrology institute PTB through a 920-km-length optical fiber link that has been tested to a relative accuracy of 19 decimal digits. Future advances might permit a redefinition of the second in terms of the simple hydrogen atom. Spectroscopy of antihydrogen may reveal conceivable differences between matter and antimatter. However, the determination of fundamental constants and tests of fundamental physics laws are now hindered by our insufficient knowledge of the charge radius of the proton. This charge radius can be determined by precise spectroscopy of auxiliary transitions to higher lying states. Such experiments have gained much in relevance since recent laser measurements of the 2S-2P Lamb shift in muonic hydrogen have created the “proton size puzzle”. The rms proton charge radius as determined with muonic hydrogen has an uncertainty of less than one per mille, but it is about 4% smaller than the CODATA accepted value. This discrepancy may be due to some mistake, or it may hint at a dent in the armor of quantum electrodynamic theory.