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Precision Spectroscopy of Hydrogen and Femtosecond Laser Frequency Combs

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A femtosecond frequency comb is a simple and compact tool that allows the phase coherent connection of the radio frequency domain (below 100 GHz) with the optical domain (above 200 THz). It greatly simplified high precision optical frequency measurements and provides the long awaited clockwork mechanism for an all-optical atomic clock. We have used such a frequency comb to measure the absolute frequency of the 1S-2S two-photon transition in atomic hydrogen, i.e. comparing it with the Cs ground state hyperfine splitting. By comparing data taken in 2003 with earlier measurements in 1999 we can set an upper limit on the variation of the 1S-2S transition frequency of (-29 ± 57) Hz within 44 months. To derive limits on the drift rates of fundamental constant such as the fine structure constant, we combine these measurements with other optical frequency measurements in Hg^{+} and in Yb^{+} performed at NIST, Boulder/USA and at PTB, Braunschweig/Germany respectively. This combined method gives precise and separate restrictions for the fractional time variation of the fine structure constant and the Cs nuclear magnetic moment measured in Bohr magnetons. The latter is a measure of the drift rate of the strong interaction. We also report on efforts to convert the frequency comb technology to much shorter wavelength. Based on intra cavity high harmonic generation an XUV (up to 60 nm) frequency comb is generated with a repetition rate of more than 100 MHz useful for high resolution laser spectroscopy in this region.