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Laser Spectroscopy of Hydrogen

The simple Balmer spectrum of atomic hydrogen has provided the Rosetta stone for deciphering the strange laws of quantum physics during during the early 20^{th} century. Four decades ago, Doppler-free laser spectroscopy opened a new chapter in the exploration of hydrogen. Today, precision spectroscopy of hydrogen is reaching a precision of 15 decimal digits with the help of new spectroscopic tools including the laser frequency comb technique. However, the determination of fundamental constants and experimental tests of fundamental physics laws are now hindered by our insufficient knowledge of the rms charge radius of the proton. Recently, a laser measurement of the 2S-2P Lamb shift of muonic hydrogen has yielded an independent precise new value of the proton radius which differs by five old standard deviations from the official CODATA value. This discrepancy is subject of intense current discussions. It may be caused by a mistake, or it may indicate a dent in the armor of quantum electrodynamic theory.