From the Lamb dip to the proton radius puzzle

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The discovery of the Lamb dip in the early days of the laser inspired Doppler-free saturation spectroscopy of atomic and molecular gases. Since the first Doppler-free laser spectroscopy of the Hydrogen Balmer-alpha line in 1972, the accuracy of laser-spectroscopic measurements in atomic hydrogen has advanced by 8 orders of magnitude, approaching the limit set by the definition of the unit of time. Spectroscopic measurements of hydrogen resonances permit tests of quantum electrodynamic theory, they yield values of the Rydberg constant and the proton charge radius, and they provide a reference for laser spectroscopy of antihydrogen and of other hydrogen-like exotic atoms, notably muonic hydrogen and muonic deuterium. The rms proton charge radius as derived from laser measurements of the 2s-2p Lamb shift in muonic hydrogen some years ago is about 4% smaller than that obtained from hydrogen spectroscopy or electron scattering experiments. This "proton size puzzle" has not yet been resolved. Current experiments in our laboratory aim to confirm or resolve this puzzle.