PHYSIKALISCHES KOLLOQUIUM

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IM GROßEN HÖRSAAL

PRECISION PHYSICS AT LOW ENERGY – THE PROTON RADIUS PUZZLE

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We have recently determined the proton charge radius by laser spectroscopy of the 2S-2P transition ("Lamb shift") in the exotic muonic hydrogen atom. In muonic hydrogen, a negative muon orbits the proton. The 200 times larger muon mass results in a 200 times smaller Bohr radius in muonic hydrogen, compared to regular, electronic hydrogen. This in turn results in a $200^3 = 10^7$ times larger overlap of the muon's wave function with the nuclear charge distribution, dramatically enhancing the effects of the finite nuclear size on the Lamb shift.

Our value of the proton rms charge radius, R_p=0.84087(39) fm, is ten times more accurate, but 7 sigma discrepant from the world average which is based on elastic electron-proton scattering and precision spectroscopy of regular (electronic) hydrogen. This so-called "proton radius puzzle" has sparked tremendous interest both in atomic and nuclear physics. Possible explanations range from experimental errors to unexpected behaviour of the proton and to physics beyond the Standard Model.

To shed new light on this discrepancy, we have measured the Lamb shift in muonic deuterium and extracted a value of the charge radius of the deuteron. Currently, we are performing an experiment to measure the Lamb shift in muonic helium ions. This will improve the accuracy of the charge radii of all helium isotopes by a factor of ten. In future, spectroscopy of of muonic lithium, beryllium and boron ions may be used for significantly improved charge radius value of the lightest isotopes.