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Measurement of muonic hydrogen 1S hyperfine splitting at RIKEN-RAL

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All the hierarchy down to hadron, matter can be divided into constituent particles, but hadron like proton, which have finite size and consist from infinite number of quarks and gluons, cannot be subdivided. Thus, how they are formed and the internal structures are the matter of interest for long time. Recently, the proton charge radius was measured by Lamb-shift of muonic hydrogen atom. This muon measurement is 10 times more accurate than that of electron measurements, and remarkably smaller. This unacceptable discrepancy triggers a question "what about the magnetic-radii of proton?"If this discrepancy is real, we might need to modify the Standard Theorem, and the modification could affect to the magnetic radius as well. We plan a laser spectroscopy on hyperfine splitting of muonic hydrogen. The muonic hydrogen ground state is spin-singlet 1S (F = 0), in which muon and proton spins are combined in opposite direction so that it is totally un-polarized. However, we can re-polarize muonic atoms to 1S (F = 1) by irradiating circular-polarized laser having wavelength exactly at hyperfine splitting energy of the atom (laser pumping), and apply μSR technique to detect the re-polarization (probe). The hyperfine splitting energy is sensitive to the proton electro-magnetic form factor, so we can study the internal structure of the proton by using muon. Muon has 200 times better sensitivity to the proton radius than electron, because it locates much closer to the proton (atomic size is 1/207 of the ordinary hydrogen atom). Combining with muonic hydrogen Lamb-shift measurement, we can identify whether there is any further mystery exist or not in proton spatial size, radii.

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