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SPP 1929 – Seminar

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Universität Ulm
Raum 45.2.304
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Circular-State Rydberg Atoms and the Proton Radius Puzzle

The Rydberg constant is of interest due to its relation to other fundamental constants and its role in calculations of atomic energy levels. Its current relative uncertainty stands at 5.9x10^-12 [1]. However, a large discrepancy involving the proton radius and the Rydberg constant has emerged in muonic hydrogen and deuterium ("proton radius puzzle" [2]). One concern expressed by the leading author of [2] is that "physicists have misgauged the Rydberg constant" [3]. A validation of the Rydberg constant using an independent method is therefore of high value. The work reported here aims at measuring the Rydberg constant and other atomic constants, such as polarizabilities, using long-lived circular Rydberg atoms, which are insensitive to critical systematics that limit the accuracy in spectroscopy of low-lying atomic states (nuclear penetration and QED shifts).

The large Rydberg-atom size enables a new method of atom trapping and spectroscopy that exploits the "A-square term" of the atom-field interaction. The method requires a light field that is spatially modulated within the atomic volume, and that is amplitude-modulated in time, at a frequency near that of the probed Rydberg transition. Rydberg atoms in electro-optically modulated standing-wave light fields (amplitude-modulated optical lattices) are ideal for this. The experimental approach and possible implementations in a microgravity experiment will be discussed. A careful study of the systematics expected in the measurement will be presented. A new high-precision measurement of the rubidium g-level quantum defects is reported. Results are compared with another recent measurement [4].

[1] http://physics.nist.gov/cuu/Constants/
[2] For recent work, see http://science.sciencemag.org/content/353/6300/669
[3] https://www.quantamagazine.org/20160811
[4] J. Lee, J. Nunkaew, and T. Gallagher, Physical Review **A 94**, 022505 (2016)].