Quantum Simulation with Circular Rydberg Atoms

Michel Brune
B. Ravon, P. Méhaignerie, Y. Machu, M. Favier, C. Sayrin, A. Muni, L. Lachaud, A. Couto, M. Poirier, S. Gleyzes.

Laboratoire Kastler Brossel, CNRS, Collège de France, 11 Pl. M. Berthelot, Paris, France

Michel.brune@lkb.ens.fr

Abstract

Neutral atoms in optical tweezers promoted to Rydberg states are one of the most promising platforms for quantum simulation. Due to their exceptional lifetime, circular Rydberg atoms additionally offer an unprecedented potential for being trapped for timescale ranging from tenth of ms up to minutes when implementing spontaneous emission inhibition in cryogenic environments [1]. With rubidium atoms, we recently demonstrated the preparation of up to 18 bottle beam optical tweezers for individual circular Rydberg atoms with a trapping time larger than several ms [2]. This achievement opens the route to first quantum simulations on exceptional timescale for e.g. investigation of out-of-equilibrium phenomena. We also developed a platform based on strontium, which offers a variety of possibilities for local optical manipulation of a circular atom by addressing its second valence electron with focussed lasers. We demonstrated the coherent optical manipulation of a circular state using its quadrupole coupling with the metastable 5d state of the ionic core [3,4]. We also observed laser cooling of a circular atom using the radiation pressure of a laser resonant with the ionic core [5]. In these experiments, ionic core excitation does not lead to significant autoionization of the circular state. This makes Sr circular states very promising candidates for merging quantum technology developed in the context of trapped ions with that based on the manipulation of Rydberg atoms.

References

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Figures

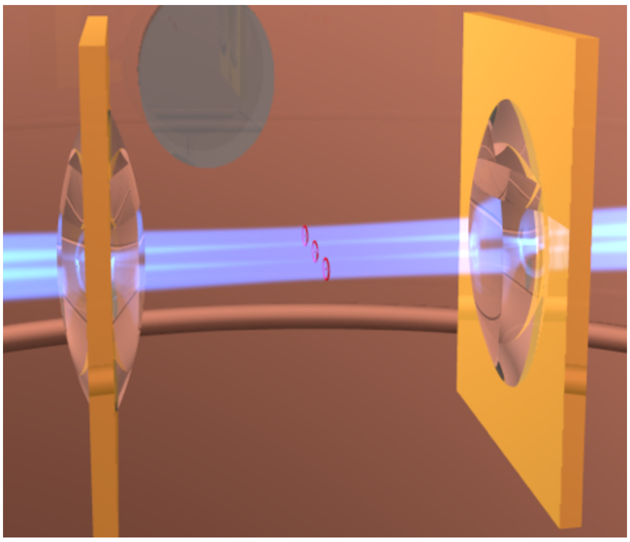

Figure 1: artist view of trapped circular Rydberg atom in a bottle beam optical tweezer.