A single charge in a Bose-Einstein condensate: from two to few to many-body physics

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Electrons attract polarizable atoms via a 1/r^4 potential. For slow electrons the scattering from that potential is purely s-wave and can be described by a Fermi pseudopotential. To study this interaction Rydberg electrons are well suited as they are slow and trapped by the charged nucleus. In the environment of a high pressure discharge Amaldi and Segre, already in 1934 observed a lineshift proportional to the scattering length [1].

At ultracold temperatures and Rydberg states with medium size principle quantum numbers *n*, one or two ground state atoms can be trapped in the meanfield potential created by the Rydberg electron, leading to so called ultra-long range Rydberg molecules [2].

At higher Rydberg states the spatial extent of the Rydberg electron orbit is increasing. For principal quantum numbers *n* in the range of 100-200 and typical BEC densities, up to several ten thousand ground state atoms are located inside one Rydberg atom, We excite a single Rydberg electron in the BEC, the orbital size of which becomes comparable to the size of the BEC. We study the coupling between the electron and phonons in the BEC [3].

We also observe evidence for ultracold collisions involving a single ion which is shielded by a Rydberg electron. Reactive processes due to few-body Langevin dynamics are mostly l-changing and lead to molecule formation.

As an outlook, the trapping of a full condensate inside a Rydberg atom of high principal quantum number, the imaging of the Rydberg electron's wave function by its impact onto the surrounding ultracold cloud as well as the observation of polaron formation seem to be within reach [4].

[1] E. Amaldi and E. Segre, Nature **133**, 141 (1934)

[2] C. H. Greene, et al., PRL **85,** 2458 (2000); V. Bendkowsky et al., Nature **458**, 1005 (2009)

[3] J . B. Balewski, et al., Nature **502**, 664 (2013)

[4] T. Karpiuk, et al., arXiv:1402.6875