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Herbert P. Broida Prize Talk: A single Rydberg electron in a Bose-Einstein condensate: from two to few to many-body physics

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Modern quantum scattering theory was developed in the context of Rydberg spectroscopy in 1934 by Enrico Fermi. He showed that for slow electrons the scattering from polarizable atoms via a 1/rˆ4 potential is purely s-wave and can be described by a Fermi pseudopotential and a scattering length. To study this interaction Rydberg electrons are well suited as they are slow and trapped by the charged nucleus. In a high pressure discharge Amaldi and Segre, observed a line shift proportional to the scattering length [1]. At ultracold temperatures one can ask the opposite question: What does a Rydberg electron do to the neutral atom sitting in the electronic orbit? We found that one, two or many ground state atoms can be trapped in the mean-field potential created by the Rydberg electron, leading to so called ultra-long range Rydberg molecules [2]. I will explain this novel molecular binding mechanism and the properties of these exotic molecules. 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 up to several ten thousand ultracold ground state atoms can be located inside one Rydberg atom, When we excite a single Rydberg electron in a Bose-Einstein Condensate, the orbital size of which becomes comparable to the size of the BEC we observe the coupling between the electron and phonons in the BEC [3]. [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)