D-State Ultralong-Range Rydberg Molecules

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Ultralong-Range Molecules provide a new type of highly excited Rydberg molecules with a novel binding mechanisms different from the 'traditional' covalent or ionic binding. They combine Rydberg atoms with ground state atoms in a single molecule thereby leading to molecular properties inherited from the Rydberg component. Huge bond lengths and corresponding dipole moments belong to the peculiar features of this species. They have been observed spectroscopically approximately a decade ago and are now under intense investigation in several ultracold atom groups worldwide. Due to their small binding energies they are extremely sensitive even to weak external electric and magnetic fields, as we shall demonstrate in this presentation [1,2,3]. Bond lengths, local equilibria, orientation and aligment can be controlled using fields and vary largely with the degree of excitation of the Rydberg atom(s). We compare experimental results with theory [2] and demonstrate isotropic as well as anisotropic interaction effects with a rich structure of the resulting vibrational dynamics and states. More recently high resolution spectroscopy has even seen the spin structure of those states - and we demonstrate what is necessary in order to describe the latter and combine it with the external field effects [4]. Moving from diatomic to triatomic systems [5,6] the first evidence for three-body interactions has been demonstrated in theory and experiment opening-up the possibility of a full control of chemical reaction dynamics in these highly excited Rydberg molecules.

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