Few-body physics with dipole-dipole interacting Rydberg atoms

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Rydberg atoms [1] are atoms in states of high principal quantum number that interact via the strong and very well controlled dipole-dipole (DD) interaction. Due to the long-range nature of the DD interaction, sizeable effects occur for large atomic separations where atoms can be resolved and addressed individually. In combination with the relatively long lifetime of Rydberg atoms, these features make Rydberg atoms ideal candidates for the investigation of few-body physics.

In my talk I will discuss several few-body phenomena in systems of two and three Rydberg atoms. First, I will show that the DD interaction between two Rydberg atoms can give rise to extremely large molecules [2]. The typical size of these macrodimers is of the order of several micrometers. Second, the DD interaction between two Rydberg atoms can induce artificial gauge fields acting on the relative motion of the atoms [3-4]. Our system exhibits two magnetic monopoles and gives rise to synthetic spin-orbit coupling induced by non-Abelian gauge fields. Third, I will show that the DD interaction can induce bound trimer states between three Rydberg atoms that are several microns apart. Since two-atom systems are unbound for the considered setup, the stable trimer configurations are a genuine three-particle effect analogous to the bond of Borromean rings.

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[3] M. Kiffner, W. Li, and D. Jaksch, Phys. Rev. Lett. 110, 170402 (2013) .

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