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AVVISO DI SEMINARIO

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il Dr. ***Igor RYABTSEV***

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terrà un seminario sul tema:

Controlling many-body Förster resonances between cold Rydberg atoms by a time-varying electric field

Long-range interactions between cold Rydberg atoms are being investigated for neutral-atom quantum computing, quantum simulations, phase transitions in cold Rydberg gases and other applications [1]. Fine tuning of the interaction strength can be implemented using Förster resonances between Rydberg atoms controlled by an electric field. In our experiments with cold Rb Rydberg atoms in a MOT we have found that the transients at the edges of the controlling electric pulses strongly affect the line shapes of the Förster resonances, since the resonance occurs on a time scale of ~100 ns being comparable with the duration of the transients. For example, a short-term ringing at certain frequency causes additional radio-frequency (rf) assisted Förster resonances, while non-sharp edges lead to an asymmetry. An intentional application of the radio-frequency field induces transitions between collective states whose line shape depends on the interaction strengths and time. In this report we present the experimental and theoretical analysis of the line shapes of the Förster resonances for a few cold Rb Rydberg atoms in a time-varying electric field [2,3]. In particular, we studied the rf-assisted Förster resonances between N=2-5 cold Rb Rydberg atoms. We have shown that they can be induced both for the ”accessible” Förster resonances which can be tuned by the dc field alone and for those which cannot be tuned and are ”inaccessible”. The van der Waals interaction of almost arbitrary high Rydberg states can thus be tuned to resonant dipole-dipole interaction. This can be especially useful for improving the fidelity of quantum gates and simulations implemented with Rydberg atoms [1,4].
Some exotic quantum simulations demand to control the interactions of simultaneously three atoms. Three-body Förster resonances at long-range interactions of Rydberg atoms were first predicted and observed in Cs Rydberg atoms [5]. In these resonances, one of the atoms carries away an energy excess preventing the two-body resonance, leading thus to a Borromean type of Förster energy transfer. The experiment in [5] was done with an ensemble of ~105 Cs atoms in an interaction volume of ~200 μm in size. Therefore, the three-body Förster resonance was in fact observed as the average signal for the large number of atoms N>>1. In this report we present the first experimental observation of the three-body Förster resonance for a few Rb Rydberg atoms with n=36, 37 [6]. In our experiment, N=2-5 Rydberg atoms in the initial nP3/2 Rydberg state interact in a single volume of ~20 μm in size. Förster resonance spectra are post-selected over the number of the detected Rydberg atoms N=1-5 and then additionally processed to extract the true multi-atom spectra taking into account finite detection efficiency of 70%. We have found clear evidence that there is no signature of the three-body Förster resonances for exactly two interacting Rydberg atoms, while it is present for the larger number of atoms. As the observed three-body resonance appears at the different dc electric field with respect to the two-body resonance, it represents an effective three-body operator, which can be used to directly control the three-body interactions in quantum simulations with Rydberg atoms.

[1] I.I.Ryabtsev et al., Physics − Uspekhi 59, 196 (2016).
[2] D.B.Tretyakov et al., Phys. Rev. A 90, 041403(R) (2014).
[3] E.A.Yakshina et al., Phys. Rev. A 94, 043417 (2016).
[4] I.I.Beterov et al., Phys. Rev. A 94, 062307 (2016).
[5] R.Faoro et al., Nature Comm. 6, 8173 (2015).
[6] D.B.Tretyakov et al., arXiv:1707.01636.