Borromean three-body FRET in frozen Rydberg gases

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Cold Rydberg atoms are a promising tool for studying few-body and many-body interaction because of their strong and long-range dipole-dipole interactions. Applying an external electric field, it is possible to induce a huge dipole moment and then tune dipole-dipole interactions. A well known example are Förster resonances [1] that consists in a transfer of energy between two different two-atoms states analogous to FRET in biology [2].

We have observed 3-body Stark-tuned resonances in a cold Cs Rydberg gas for different principle quantum number n. The two processes that we have studied can be described by the following equations:

$$3 \times np \leftrightarrow (n+1)s + ns + np' \tag{1}$$

$$3 \times np' \leftrightarrow (n+1)s + ns + np \tag{2}$$

where np and np' differ respectively for $m_J = 1/2$ and $m_J = 3/2$. These new three-body FRET resonances are a general process that can be observed for all kind of atoms that present a two-body FRET resonance and with a total angular momentum $J > 1/2$.

They are by themselves the first observation of a Borromean interaction in Rydberg atoms [3]. Moreover a possible generalization to many-body Brunian interaction [4] could open the way to a new investigation on the transition from few to many body physics.

Three-body FRET resonances could find several application in quantum optics and quantum computing: they can be used to design a three-body Fredkin gate or for the realization of a 3-body entangled state. They could also provide an effective Quantum Non Demolition measure of entanglement between 2 atoms measuring the 3rd.

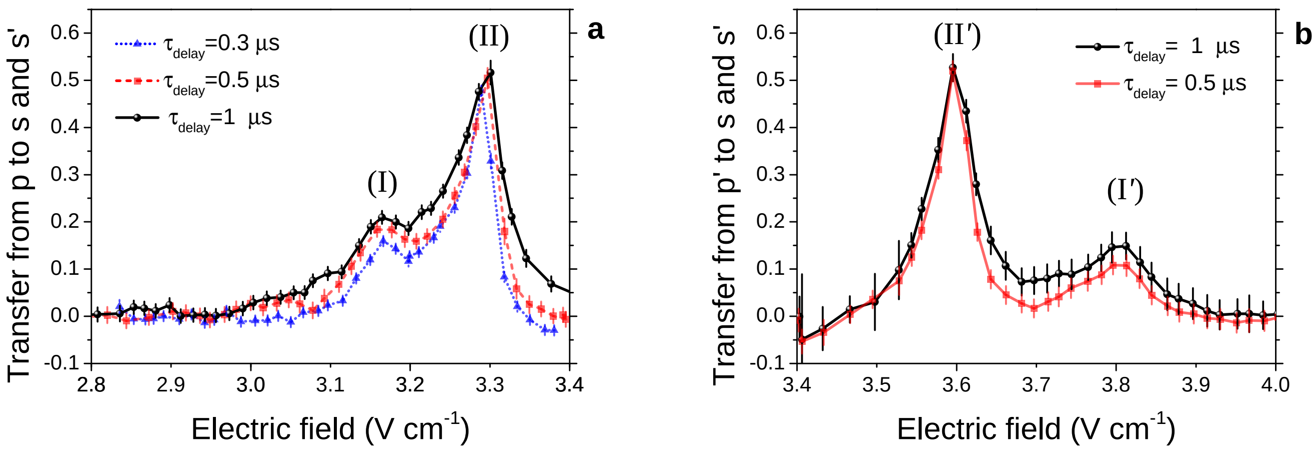

Figure 1: *Averaged transfer ratio from the initial np state (**a**) or np' state (**b**) to $ns + ns'$ states for $n = 35$ at different τ_{delay} versus the electric field. The peaks labelled with (I) and (I') correspond to 3-body resonances described respectively by eq. (1) and eq. (2). The other two peaks (II) and (II') correspond to the well known to 2-body process respectively for np and np'.*

References

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