Observation of Rydberg blockade due to the charge-dipole interaction between an atom and a polar molecule

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We envision a hybrid quantum network of individually trapped polar molecules interfaced with Rydberg atoms. The nodes of the network are single molecules, where information is stored. The links are Rydberg atoms which mediate strong, long-range interactions between nodes. This hybrid network leverages the long-lived internal states of molecules and the strong interactions provided by Rydberg atoms. We report progress towards this goal where we have observed Rydberg blockade of a Rb atom due to the charge-dipole interaction with a ground state RbCs molecule.

We produce single RbCs molecules in optical tweezers with single-site control and imaging. We demonstrate a magic-trapping technique that supports second-scale rotational coherence times in the molecules. Alongside the molecules, excess Rb atoms are prepared in the motional ground state and excited to Rydberg states with a two-photon excitation scheme. The atom and molecule are held in species-specific tweezers which allows them to be brought to a separation of 310(40) nm without significant collisional loss. The effect of the polar molecule is to perturb the Rydberg state energy to be off resonance with the two-photon excitation causing blockade.

Finally, we present experiments to engineer resonant dipole-dipole interactions between the Rydberg atom and polar molecule.

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