Experimental platform for interfacing Rydberg atoms with a high overtone bulk acoustic wave resonator

Darius Hoyer,[1,*] Julia Gamper,[1] Valerie Leu,[1]
Wolfgang Alt,[1] and Sebastian Hofferberth[1]

[1] *Institute of Applied Physics, University of Bonn, Wegelerstr. 8, 53115 Bonn, Germany*

We are developing a hybrid quantum optics setup that couples Rydberg atoms to an electromechanical resonator. Owing to their large electric dipole moments and widely tunable transition frequency, Rydberg atoms exhibit strong and controllable coupling to electric fields across the microwave regime. This tunability makes them promising candidates for interfacing atomic systems with solid-state devices whose excitations lie in the microwave domain. In particular, the electromechanical resonator we use is a high overtone bulk acoustic wave resonator (HBAR) consisting of a high Q-substrate and a piezoelectric layer.

Our goal is to use this coupling together with engineered dissipation to cool one vibrational mode of the electromechanical resonator to its quantum mechanical ground state. For this, the experiment employs a two-chamber design. Rubidium atoms are first trapped and cooled in a magneto-optical trap and are then magnetically transported to a cryogenic science chamber. There, an atom chip enables trapping of the atoms in proximity to the HBAR using a superconducting on-chip Z-wire trap. By exciting the atoms to a Rydberg state, the atomic transition can be Stark tuned into resonance with the electric field associated with the HBAR mode. The Rydberg atoms are then detected by electromagnetically induced transparency (EIT) or by ionizing the Rydberg atoms.

We present progress in constructing this hybrid quantum system, representing a step towards interfacing Rydberg atoms with superconducting platforms using the electromechanical resonator as a transducer.

* dhoyer@uni-bonn.de; https://www.iap.uni-bonn.de/nqo/en