Probing long range dipole coupling in Cold Rydberg atoms by microwave spectroscopy

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Because of their very large polarizability, Rydberg atoms have long-range interaction through dipole-dipole coupling. Rydberg excitations in a cold atomic sample are therefore expected to exhibit many-body correlations and could be used to simulate many-body Hamiltonians to understand complex and less controllable solid-states system [1, 2].

Our experiment uses a superconducting atom chip to trap and manipulate a small ^{87}Rb atom cloud in a cryogenic environment. Manipulating Rydberg atoms close to a chip is very challenging, as the Rydberg atom polarizability makes them very sensitive to stray electric field created by the surface. We had therefore to develop a new method to reduce the broadening of the Rydberg excitation line. By coating our chip with a thin layer of Rubidium, we have been able to strongly reduce electric field inhomogeneity and observe coherence time on the 60s − 61s transition in the ms range.

Then, using a cold atom cloud near Bose-Einstein condensation, we have produced samples of tens of Rydberg and used microwave spectroscopy to measure the distribution of the interaction energy of a single Rydberg atom with its neighbors. We see that if the laser frequency is detuned from the transition frequency, we can preferably excite atoms close to each other, for which the dipole-dipole interaction compensate the laser detuning. We can then monitor the motion of the atoms, by recording the energy distribution for different delay after the excitation, and observe how the Rydberg atom sample explode under the effect of the energy interaction.

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