Probing dipole coupling in cold Rydberg atoms by microwave spectroscopy

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Due to their huge polarizability, Rydberg atoms present strong, dipole-dipole interactions. Studying many-body correlations in a dense cold cloud of Rydberg atoms may be of interest as a quantum simulator of model many-body hamiltonians of importance for understanding solid-states systems.

We study a cold 87Rb atomic sample magnetically trapped on a superconducting atom chip. Due to the large polarizability of Rydberg atoms, an essential experimental issue is the control of stray electric fields in the vicinity of the atom chip surface. This problem was solved by coating the chip surface with a thick layer of Rubidium\cite{Carla}. We observed coherence times in the ms range for the 60s to 61s microwave two-photon transition, opening interesting perspectives for the study of dipole interactions at higher density of Rydberg atoms. We then use microwave spectroscopy for measuring the interaction energy distribution of a single Rydberg atom with its neighbors\cite{Raul}. The observed energy distribution carries information on spatial correlations between Rydberg atoms prepared in the dipole blockade regime. We study the energy distribution as a function of the detuning of the excitation laser. For blue detuning, we observe that we preferentially excite atoms in the neighborhood of previously excited atoms so that interaction energy shift compensates for laser detuning. We also observe the expansion of the Rydberg atom cloud due to repulsive dipole interaction and show that the cloud rapidly goes out of the "frozen gas approximation" usually used in previous work.

We will finally discuss further development in the direction of 1D quantum simulations.