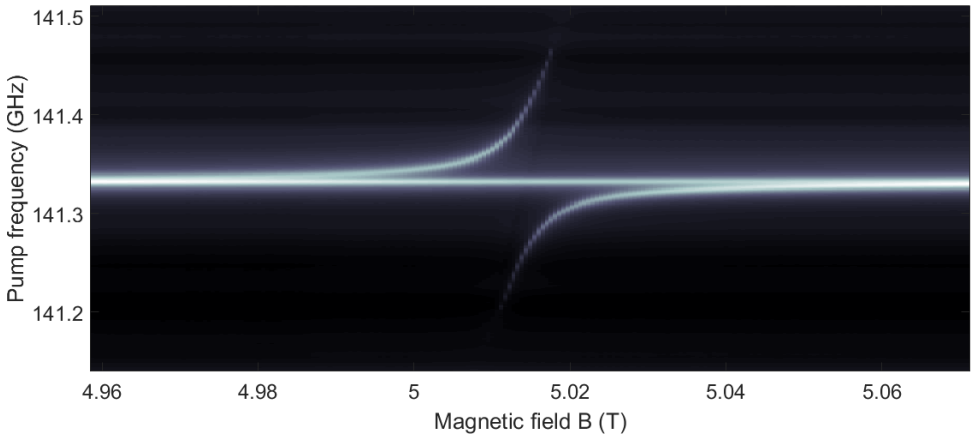
cQED with Electron Ensembles

The quantized orbital states of electrons trapped on liquid helium share many similarities with the energy structure of atomic systems, such as the Rydberg atoms. Coupling of electron ensembles on helium to a high-Q microwave resonators might present an interesting new platform for cQED-type experiments. In our experiments, we use the microwave Fabry-Perot resonators to realize strong coupling of electrons to cavity field. Another interesting direction in our research is to study coupled states of electron motion, which realize the Jaynes-Cummings model of cavity-atom interaction.

Electrons coupled to cavities

Strong coupling regime of light-matter interaction between quantum systems and photons in an optical cavity is a cornerstone of cavity Quantum Electrodynamics (cQED). Ability to coherently exchange excitations between two quantum fields has many applications in quantum technologies. Of particular recent interest is the interaction between an ensemble of two-level atoms and a cavity mode, which shows enhancement in coupling strength compared to a single atom.



In our experiments, we realize the strong coupling between an ensemble of 2D electrons on helium and a single-mode Fabry-Perot cavity resonator working in a millimeter-wave frequency range. We are interested in the study of non-linearities in this coupled system and their potential use for creation of non-classical states of light and matter.

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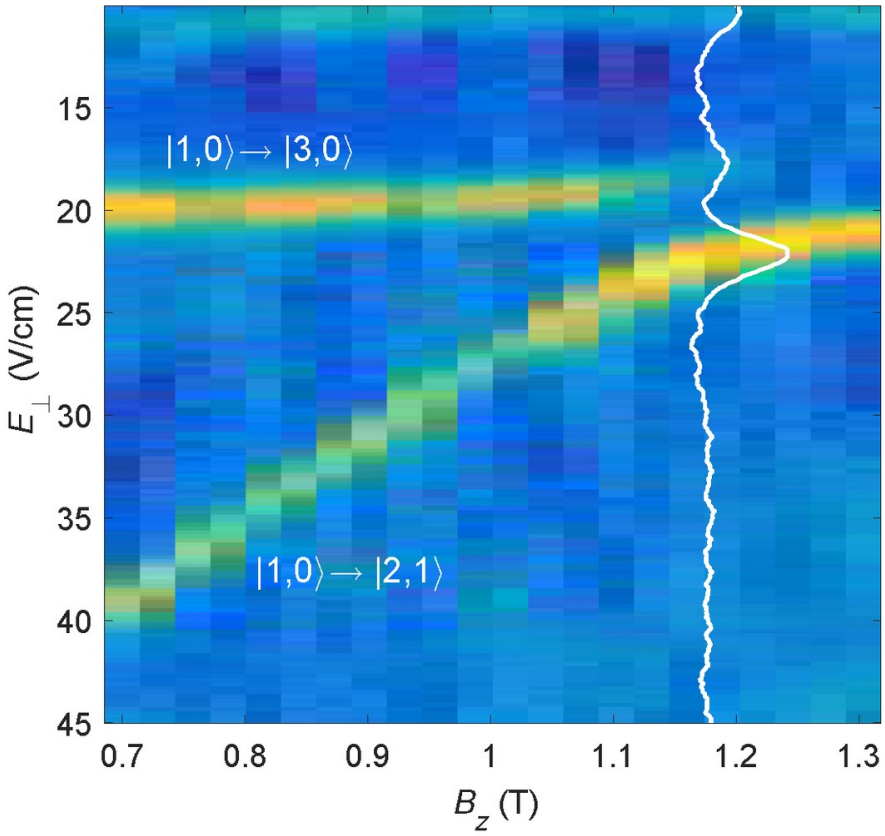
Dressed Rydberg States in Quantizing Magnetic Fields

In magnetic fields applied perpendicular to the 2D plane, quantized lateral and transverse orbital motions of an electron are essentially uncoupled. However, coupling between them can be induced by an additional component of *B*-field applied parallel to the 2D plane. The Hamiltonian of coupled system is reminiscent of the famous Jaynes-Cummings model; in our case Rydberg states and Landau states of an electron play the roles of the two-level system and the photon field, respectively.



In our experiments, we create this situation by applying a *B*-field which is tilted with respect to the surface of liquid helium and performing the Stark spectroscopy of electron's energy levels. We find a variety of phenomena reminiscent of those studied in Atomic and Molecular Optics (AMO), such as sideband transitions, avoid crossings, Lamb shift, etc. We are interested in exploiting the non-linearity introduced by this coupling and performing cQED experiments with this system.

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