Frequency conversion using Rydberg atoms

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In this talk, I give an overview of our recent and ongoing experiments with Rydberg atoms.

In one recent experiment [1], we demonstrate coherent and broadband conversion from microwave to optical field via six-wave mixing in Rydberg atoms. The scheme utilizes the strong coupling of microwaves to Rydberg transitions as well as coherent and efficient nonlinear process based on electromagnetically induced transparency (EIT). I will discuss our experimental results, theoretical simulations, and the perspective of using this scheme based on Rydberg atoms for transferring quantum states between optical and microwave photons.

In another experiment, we are working towards generating continuous-wave (CW) terahertz (THz) radiation by optically pumping a low lying Rydberg state (n ~10) in a heated vapour cell. A two-photon excitation creates a population inversion between the $10D_{5/2}$ and the $11P_{3/2}$ state, which combined with the large dipole moment between the two states leads to the emission of 3.28 THz radiation. I will discuss our current experimental observations and our next steps towards direct measurements of THz wave and further improving THz generation.

If time allows, I will also briefly discuss our current experimental effort in optically imaging Rydberg excitations [2].

[1] J. Han, *et.al*, Phys. Rev. Lett. **120**, 093201 (2018).
[2] G. Günter, *et.al*, Science **342**, 954 (2013).