Terahertz sensing and imaging using Rydberg atoms

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We demonstrate sensing and imaging of terahertz (THz) fields using Rydberg atoms in a thermal vapour. Rydberg atoms have a large manifold of strong electric dipole transitions spanning the microwave and THz frequency range; a fact that has been exploited to enable highly-sensitive electric field measurements [1]. We show that by using off-resonant excitation in a Raman configuration we can achieve real-time imaging of THz fields [2]. Figure 1 shows a sequence of frames from a video of a THz standing wave. In addition, we exploit a Rydberg phase transition [3] to configure the atomic vapour as a sensitive transition-edge sensor for THz radiation [4].

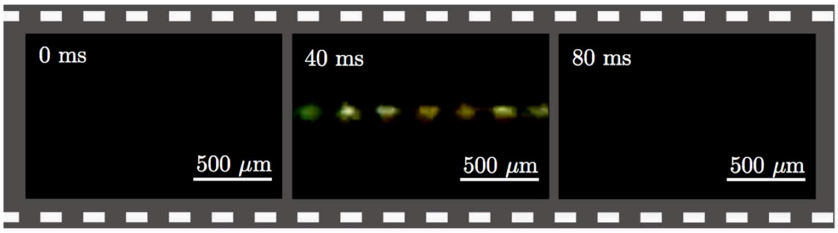

Figure 1. Frames from a video-rate movie of a terahertz standing wave inside a caesium vapour cell. The images are formed by collecting optical fluorescence that the vapour emits only in the presence of the terahertz field.

[1] H. Fan *et al.* Atom based RF electric field sensing, J. Phys. B **48**, 202001 (2015)
[2] C. G. Wade *et al.* Real-time near-field terahertz imaging with atomic optical fluorescence, Nature Photon. **11**, 40 (2017)
[3] C. Carr *et al.* Nonequilibrium phase transition in a dilute Rydberg Ensemble Phys. Rev. Lett. **111**, 113901 (2013)
[4] C. G. Wade *et al.* A terahertz-driven phase transition in a room-temperature atomic vapour arXiv:1709.00262 (2017)