Spatially dependent EIT from structured light

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Recent years have seen vast progress in the generation and detection of structured light, with potential applications for high capacity optical data storage and quantum technologies in high dimensions. Interaction with atomic systems offers the possibility to process and store the information contained in such light beams. We are investigating the transmission of structured light through cold rubidium atoms trapped in our dark SPOT MOT [1].

Scattering and absorption of light by atoms is usually sensitive only to the intensity profile of a light beam, essentially producing a "shadow" of the atoms in the light beam. By simultaneously driving multiple atomic transitions it is possible to modify the absorption profile of a signal laser due to the presence of a second control beam, an effect known as EIT (electro-magnetically induced transparency). Here we report our first observations of EIT with holographically shaped signal and probe light, rendering the atoms transparent to light only at certain areas, see Fig. 1. Using liquid crystal devices with spatially varying directionality, so-called qplates [2], we produce light modes that are entangled in their polarisation and spatial phase profile, proportional to $\sigma_+ \mathrm{e}^{-\mathrm{i}2\mathrm{q}\varphi} + \sigma_- \mathrm{e}^{\mathrm{i}2\mathrm{q}\varphi}$, where φ denotes the azimuthal angle of the light beam, $\sigma_\pm$ the polarisation and q the index of the qplate. This allows us to drive a Raman transition between the $m_F = \pm 1$ ground states which satisfies EIT conditions only at discrete angles φ. The spatially varying atomic dark states result in a self-modulation of the incident light beams, effectively converting optical phase information into intensity information.

Potential extensions of this work include the generalisation to arbitrary phase structures, and the storage and read-out of spatial light from the atomic sample.

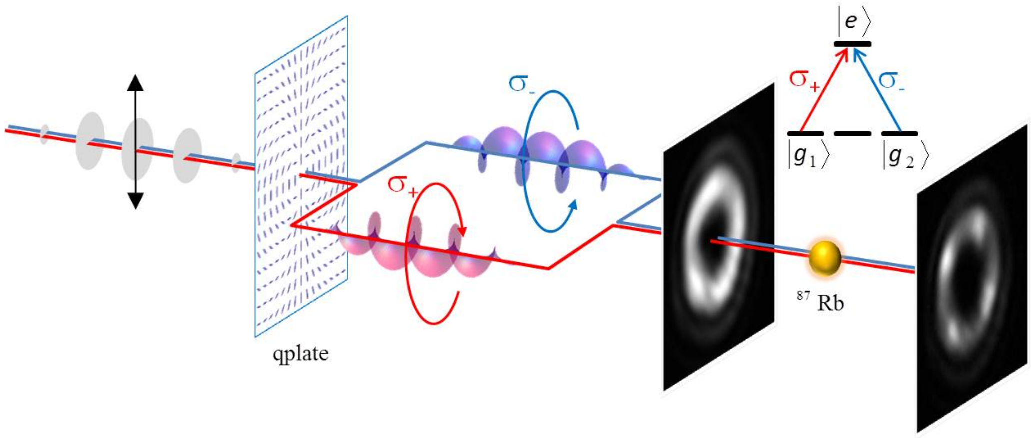

Figure 1: *Schematic of experiment: linearly polarised probe light is converted via a qplate into light entangled in polarisation and phase structure before being transmitted through cold Rb atoms. The intensity profiles before and after interaction with the atoms are shown as insets.*

References

[1] N. Radwell, G. Walker and S. Franke-Arnold, Phys. Rev. A. **88** 043409 (2013)

[2] L. Marrucci *et al.*, J. Opt. **13** 064001 (2011)