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Invited talk

Polarisation textures of light and atoms

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Polarisation - while invisible to the eye - has been recognized as an important feature of light since the days of Ptolemy. Over the last decades we have gained significant control in shaping light, allowing us to design phase and polarisation structures in 2D and 3D, to explore the associated topologies, and their interaction with matter. Optical $\sigma_\pm$ transitions, excited by the right and left circular polarisation components of polarisation structured light, in conjunction with an external magnetic fields, can form an atomic state interferometer, rendering atomic interaction sensitive to the polarisation profile and allowing us to imprint optical polarisation textures onto atomic spin structures. Unlike optical polarisations, atomic spin alignments react to external fields and forces, promising applications in magnetometry, [1] and vice versa allowing us to sense properties of the structured light via atomic absorption patterns.[2]

Structured light, when strongly focused, is shaped into highly confined vectorial electromagnetic field distributions, generally including a polarisation component along the optical axis. Manipulating and detecting such 3D light fields is challenging, as conventional optical elements and detectors do not interact with the axial polarisation component. Electric dipole transitions (specifically π transitions), however, are sensitive to the illustrious axial polarisation component. Working in the hyperfine Paschen-Back regime, where the electric dipole transitions are spectrally resolved, we demonstrate direct evidence of the axial polarisation component of strongly focused radial light. By measuring the spatially resolved absorption pattern at the π transition we retrieve the predicted distribution of the axially polarised light component, which corresponds to areas of radial polarisation in the input light (see Fig. 1).

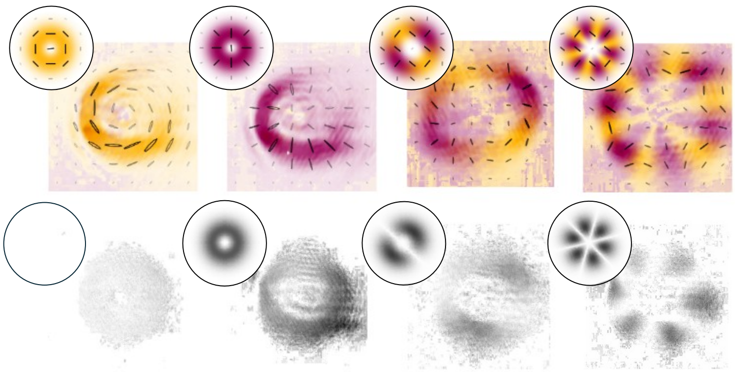

Figure 1: Visualizing the axial component of various strongly focused (NA = 0.4) vector light beams (top row) via atomic optical densities at the π transition (bottom row). Radial polarisation components (which yield axial polarization when focused) are shown in purple, and azimuthal components in yellow. The disk insets show the corresponding theoretical predictions.

[1]F. Castellucci, T. W. Clark, A. Selyem, Jinwen Wang, and S. Franke-Arnold, Phys. Rev. Lett. **127** (2021)
[2]Jinwen Wang et al, Phys. Rev. Lett. **132**, 193803 (2024)