Vector beams, high harmonic generation and THz solenoidal magnetic fields

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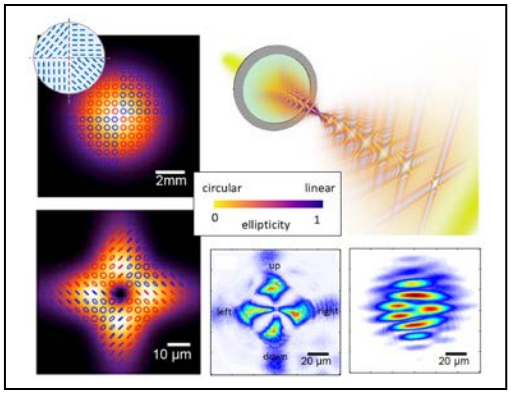
In the visible and infrared it is possible to transform a Gaussian beam into vortex beams – beams with orbital angular momentum. Such vortex beams are important for advanced microscopy and for quantum optics. But is orbital angular momentum conserved during high-harmonic generation? We show the conservation of orbital angular momentum and show how it leads to a method for coupling a controlled orbital angular momentum on any harmonic. Our results open a pathway for attosecond science with similarly structured light.



Besides shaping the wave fronts, a Gaussian beam can also be transformed into beams with complex polarization states – so called vector beams. We use an 800 nm, 2 mJ pulse, 35 fs pulse and a Q-plate (illustrated in the inset) to produce a vector beam with each quadrant circularly polarized, with adjacent quadrants delayed in phase by $\pi/2$ and with different handedness for adjacent quadrants (encoded in red and blue in the figure). As such a vector beam propagates, it transforms into a beam with linearly polarized segments as illustrated (bottom left) and measured (bottom, middle). We transform this beam via high-harmonic generation to photon energy of 40 eV creating a new vector beam with linearly polarized segments and also with adjacent quadrants phase delayed by $\pi n/2$ where n is the harmonic order. This beam likewise transforms as it propagates into a beam with circularly polarized segments as illustrated in the 3-dimensional figure.

I conclude by discussing how, when vector beams are combined with coherent control, we can produce high-intensity, THz, solenoidal magnetic fields.