MAR16-2015-000277

Abstract for an Invited Paper
for the MAR16 Meeting of
the American Physical Society

Creating High-Harmonic Beams with Controlled Orbital Angular Momentum

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A beam of light with an angle-dependent phase $\Phi = \ell\phi$, where ϕ is the azimuthal coordinate, about the beam axis carries an orbital angular momentum (OAM) of $\ell\hbar$ per photon. Such beams have been exploited to provide superresolution in visible-light microscopy. The ability to create extreme ultraviolet or soft-x-ray beams with controllable OAM would be a critical step towards extending superresolution methods to extremely small feature size. Here we show that OAM is conserved during the process of high-harmonic generation (HHG). Experimentally, we use a fundamental beam with $\ell = 1$ and interferometrically determine that the q-th harmonic has an OAM quantum number ℓ equal to its harmonic order q. We also show theoretically how to couple an arbitrary low value of the OAM quantum number ℓ to any harmonic order q in a controlled manner. Our results open a route to microscopy on the molecular, or even submolecular, scale.

Reference: G. Gariepy, J. Leach, K.T. Kim, T. J. Hammond, E. Frumker, R.W. Boyd, and P. B. Corkum, Phys. Rev. Lett. 113, 153901 (2014).