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Unveiling orbital angular momentum and acceleration of light beams and electron beams[1]

ADY ARIE, Tel-Aviv University

Special beams, such as the vortex beams that carry orbital angular momentum (OAM) and the Airy beam that preserves its shape while propagating along parabolic trajectory, have drawn significant attention recently both in light optics and in electron optics experiments. In order to utilize these beams, simple methods are needed that enable to easily quantify their defining properties, namely the OAM for the vortex beams and the nodal trajectory acceleration coefficient for the Airy beam. Here we demonstrate a straightforward method to determine these quantities by astigmatic Fourier transform of the beam. For electron beams in a transmission electron microscope, this transformation is easily realized using the condenser and objective stigmators, whereas for light beam this can be achieved using a cylindrical lens. In the case of Laguerre-Gauss vortex beams, it is already well known that applying the astigmatic Fourier transformation converts them to Hermite-Gauss beams. The topological charge (and hence the OAM) can be determined by simply counting the number of dark stripes of the Hermite-Gauss beam. We generated a series of electron vortex beams and managed to determine the topological charge up to a value of 10. The same concept of astigmatic transformation was then used to unveil the acceleration of an electron Airy beam. The shape of astigmatic-transformed depends only on the astigmatic measure and on the acceleration coefficient. This method was experimentally verified by generating electron Airy beams with different known acceleration parameters, enabling direct comparison to the deduced values from the astigmatic transformation measurements. The method can be extended to other types of waves. Specifically, we have recently used it to determine the acceleration of an optical Airy beams and the topological charge of so-called Airy-vortex light beam, i.e. an Airy light beam with an embedded vortex.

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