Transverse Spin and Orbital Angular Momentum of Light

Andrea Aiello

Max Planck Institute for the Science of Light, Erlangen, Germany

A circularly polarized electromagnetic plane wave carries an electric field that rotates clockwise or counterclockwise around the propagation direction of the wave. According to the handedness of this rotation, its longitudinal spin angular momentum density is either parallel or antiparallel to the propagation of light. However, there are also light waves that are not simply plane and carry an electric field that rotates around an axis perpendicular to the propagation direction, thus yielding transverse spin angular momentum density. Electric field configurations of this kind have been suggestively dubbed photonic wheels [1-2]. It has been recently shown that photonic wheels are commonplace in optics as they occur in electromagnetic fields confined by waveguides, in strongly focused beams, in plasmonic and evanescent waves [3].

Such fields enable numerous applications, for example in nano-optics, topological photonics, biosensing and near-field microscopy, including 3D control over single atoms, molecules and nanostructures, and the development of chiral nanophotonic interfaces and plasmonic devices [4]. Theoretical and experimental investigations of these fields often pose formidable computational and measurement challenges due to the intrinsic three-dimensional vector nature of light at nanoscale with complex spatial variations. In this talk, I will report on the recent developments of optics with light carrying transverse angular momenta, presenting both the underlying principles and the latest achievements, and highlighting the new capabilities and future applications emerging from this still young yet advanced field of research [5].

![Fig. 1 from [5]. Snapshots of amplitude (hues) and polarization (arrows) distributions of the electric field of a suitably tailored Bessel beam propagating along the z-axis. The field rotates in the plane of the figure (meridional plane) counterclockwise around the x-axis. This rotation is the hallmark of a photonic wheel.](image)