Controlling the optical vortex beam emission from a photonic chip

Xu Fang
School of Electronics and Computer Science, University of Southampton, Southampton SO17 1BJ, UK
Corresponding author: x.fang@soton.ac.uk

We propose and numerical demonstrate several methods for generating optical vortex beams from planar, photonic chip-based devices. The creation of high-value topological charges and incident direction-based tuning are observed in methods that utilize integrated metasurfaces.

Optical vortex beams carry orbital angular momentum, which can be exploited as an extra degree of freedom for applications such as communications, computing, imaging and microfluidic particle manipulation. For many of these applications, the creation of such vortex beams from an integrated photonic chip is highly desired, as it offers benefits such as a small form factor and the possibility of device mass production. At the University of Southampton, my team has explored a few methods in this research direction. We started with using microring resonators, where nonlinear optical effects [1] and coherent tuning [2] are utilize to control the vortex emission. More recently, we have explored using integrated metasurfaces for this purpose. By proposing an amplitude gradient design concept, we have numerically demonstrated the generation of vortex beams that carry a large topological charge [3], which is usually a challenging task for planar vortex beam emission. By breaking conjugate symmetry in light emission, we have demonstrated the generation of two independent sets of vortex beams from a single device, which is achieved by using direction-based tuning [4]. These works suggest a huge application potential for chip-based optical vortex beam generation.

References

[1] Integrated vortex beam emitter in the THz frequency range: design and simulation. *APL Photonics*, 5, 076102 (2020).
[2] Coherent generation of arbitrary first-order Poincaré sphere beams on a Si chip. *Optics Express*, 30, 7342-7355 (2022).
[3] Amplitude gradient-based metasurfaces for off-chip THz wavefront shaping. *Photonics Research*, 11, 1542-1552 (2023).
[4] Asymmetric vortex beam emission in a metasurface-integrated microring with broken conjugate symmetry. *Optics Express* 31, 42549-42561 (2023).