A Multifunctional Imaging Metalens for shaping Quantum Emission

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Abstract: We proposed a multifunctional metalens to arbitrarily structure single photon emission in hexagonal boron nitride. The metalens imprints arbitrary wavefronts onto orthogonal polarization states, manipulating directionality, polarization, and orbital angular momentum of the input source.

Quantum emission is essential for realizing quantum photonic applications such as computing, communication, and cryptography [1]. The representative example of a quantum light source at room temperature is solid-state single photon emission (SPE) observed in defects in two-dimensional (2D) hexagonal boron nitride (hBN). Recently, it is of great interest to arbitrarily modulate quantum light sources with multiple degrees of freedom, including directionality, polarization, and orbital angular momentum. However, modulating the SPE in a conventional way entails a bulky optical system such as an objective, wave plates, and diffractive optical elements, which is inappropriate in a confined on-chip quantum system. Metasurface, an array of ultra-thin subwavelength nanostructures, is capable of multiplexing multiple functionalities of bulky optical components on it. Therefore, multiplexed metasurface can dramatically reduce the volume of the optical system that engineers the quantum emission of SPE.

In this presentation, I will introduce our recent work in structuring quantum emissions using a multifunctional imaging metalens (Fig. 1.) [2]. First, a beam-splitting metalens was proposed for splitting SPE from ultra-bright defect in hBN depending on its orthogonal polarization states. Next, multiplexed metalenses were designed to imprint any arbitrary wavefront onto orthogonal polarization states, manipulating directionality, polarization, and orbital angular momentum of the output quantum source. The hybrid quantum metalens unveils the simultaneous manipulation of multiple degrees of freedom of a quantum light source, including directionality, polarisation, and orbital angular momentum The demonstrated arbitrary wavefront shaping of quantum emission in multiple degrees of freedom could unleash the full potential of solid-state SPEs for their use as high-dimensional quantum sources for advanced quantum photonic applications.

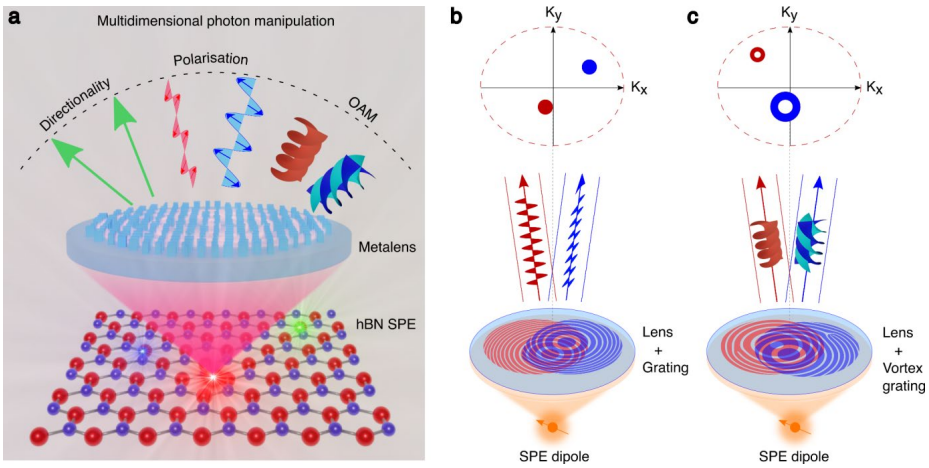

Fig. 1 Schematics of multidimensional manipulation of hBN quantum emission using a multifunctional metalens. (a) Directional photon splitting, polarization control and subsequent orbital angular momentum encoding. The green arrows stand for the directionality control of SPE emission collected by the metalens. Two sine waves indicate the split of SPE emission into two orthogonally polarised streams. The two helical beams indicate a further dressing by OAM. (b, c) Enlarged views of each encoding concept where grating and vortex grating are adapted to structure the photons in extra dimensions. In addition, the directionality of orthogonal linear polarisations is well inherited and projected as the red and blue spots in the momentum (k) space.

References

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