Real-time phase imaging via nanophotonic devices

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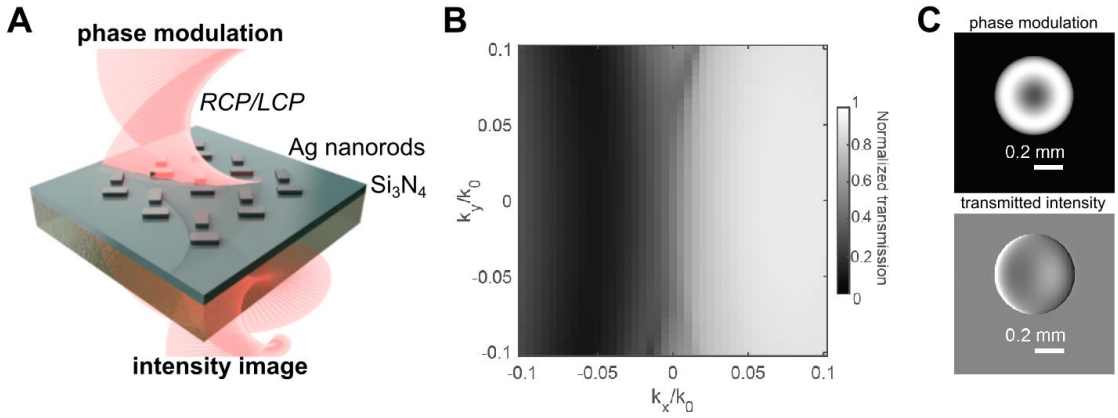
The visualisation and quantification of the phase of an optical field is of fundamental importance to fields including biological imaging and wavefront sensing. Common all-optical methods such as differential interference contrast microscopy (DIC) or Zernike phase-contrast are widely used for the investigation of biological cells. The rise of meta-optical devices for all-optical image processing [1] suggests intriguing possibilities for ultra-compact alternatives to conventional phase-imaging technology. Here we discuss thin-film and metasurface devices that can generate phase-contrast in real-time without computational post-processing [2,3]. These involve resonant waveguide gratings, metasurfaces exploiting photonic spin-orbit coupling and metal-insulator-metal (MIM) absorbers.



***A**-Visualising optical phase via transmission through metasurface **B**- Asymmetric optical transfer function of device **C**- Simulated phase imaging of model of a red blood cell using meta-optical device with circularly polarized light*

We will present results demonstrating a metasurface with an asymmetric optical transfer function that permits discrimination between positive and negative phase gradients in an optical field and enables the generation of pseudo-3D intensity images similar to those obtained in differential interference contrast (DIC). Furthermore, we will discuss and demonstrate the application of meta-optical devices to phase imaging of biological cells and discuss their potential for integration into photodetectors.

[1] L. Wesemann, T.J. Davis and A. Roberts, "Meta-optical and thin film devices for all-optical information processing," Appl Phys Rev 8, 031309 (2021).

[2] L. Wesemann, J. Rickett, J. Song, J. Lou, E.L. Hinde, T.J. Davis and A. Roberts, "Nanophotonics enhanced coverslip for phase imaging in biology," Light Sci Appl 10, 741 (2021).

[3] L. Wesemann, J. Rickett, T.J. Davis, and A. Roberts, "Real-Time Phase Imaging with an Asymmetric Transfer Function Metasurface," ACS Photonics 9(5), 1803-1807. (2022).