Sensing Spatial Coherence of Light with Metasurfaces

O. Buchnev[1], T. Frank[1,2], T. Cookson[2], M. Kaczmarek[2], P. Lagoudakis[2] and V. A. Fedotov[1]

[1]Optoelectronics Research Centre and Centre for Photonic Metamaterials, University of Southampton, SO17 1BJ, UK
[2]Physics and Astronomy, University of Southampton, SO17 1BJ, UK
* O.Buchnev@soton.ac.uk

Over the last decade the concept of artificially engineered media (know as metamaterials) has revolutionized the field of optics, pushed the boundaries of microfabrication and stimulated the development of novel characterization techniques. The demonstration of anomalous reflection and refraction of light by metasurfaces opened another exciting chapter in optical engineering [1]. Metasurfaces correspond to a class of low-dimensional (planar) metamaterials and are typically formed by optically thin metal films periodically patterned on a sub-wavelength scale. Despite their vanishing thickness metasurfaces interact strongly with light, which they can transmit, absorb or reflect without diffraction, effectively acting as optical media of zero dimension in the direction of light propagation. Metasurfaces are fully compatible with the existing fabrication processes adopted by CMOS technology, and offer unmatched flexibility in the design and control of light propagation, exhibiting exotic electromagnetic phenomena and replacing conventional bulk optical components.

We report on a recent discovery that homogeneous *non-diffracting* photonic metasurfaces of a certain class are characterized by qualitatively different profiles of their transmission (and reflection) spectra in the near-IR when illuminated with, respectively, spatially coherent and incoherent light. Our systematic experimental investigation and rigorous theoretical analysis of this phenomenon (the results of which we are going to present at the conference) indicate that it is a genuine, previously unseen optical effect that has no direct analogue in natural optical materials. The mechanism underpinning the effect involves interference of light scattered non-locally via *non-dispersive* delocalised plasmon modes supported by the fabric of the metasurfaces. The strength and robust nature of the effect makes it immediately suitable for optical metrology applications. In particular, combined with a photodetector, the metasurfaces represent a very simple and compact optical device, which will enable quick quantitative assessment of light coherence. Other possible applications will rely on the discovered ability of the metasurfaces to selectively transmit or block spatially incoherent light, and may include the enhancement of optical imaging, vision, detection and communications.

[1] N. Yu, F. Capasso, “Flat optics with designer metasurfaces,” Nat. Mater. **13**, 139 (2014).