University of Crete
Department of Physics

Physics Colloquium

Thursday, 27 October 2022 | 17:00 – 18:00, Seminar Room 3rd Floor

Artificial and natural 2D materials for photonics

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ABSTRACT

Metasurfaces, artificial ultrathin materials composed of subwavelength resonant building blocks (meta- atoms), promise to replace bulky conventional diffractive and dispersive optical components, offering significant technological advantages (size & weight reduction, planar fabrication) and the ability to tailor their response at will by engineering the underlying meta-atoms. However, due to the inherent resonant nature, their response is typically narrowband limiting their practical potential. I will discuss how metasurfaces with multiresonant unit cells can overcome this limitation and be made to exhibit arbitrarily broadband (achromatic) response. This will be demonstrated by examples of broadband pulse delay without distortion [1] and achromatic wavefront manipulation (beam steering) [2]. The proposed concept has been experimentally verified in GHz frequencies by a subwavelength multiresonant unit cell comprising five meta-atoms [3].

Natural 2D photonic materials are being investigated for a broad range of photonic and optoelectronic applications. Graphene, the most prominent representative, exhibits strong third-order nonlinearity in THz and optical frequencies. I will discuss graphene-enhanced components for nonlinear applications, focusing on optical bistability [4] (memory functionality), four-wave mixing [5] and third-harmonic generation [6] (frequency generation) and saturable absorption [6] (switching/routing). In addition, I will highlight the modifications to traditional theoretical frameworks required for studying nonlinear components incorporating 2D materials.

[1] ACS Photonics 5, 1101 (2018); https://pubs.acs.org/doi/abs/10.1021/acsphotonics.7b01415
[2] Advanced Optical Materials 8, 2000942 (2020); https://doi.org/10.1002/adom.202000942
[3] ACS Photonics 8, 1649 (2021); https://doi.org/10.1021/acsphotonics.1c00025
[4] Journal of Applied Physics 122, 233101 (2017); https://doi.org/10.1063/1.5005610
[5] Physical Review B 98, 235421 (2018); https://doi.org/10.1103/PhysRevB.98.235421
[6] Optics Express 30, 460 (2022); https://doi.org/10.1364/OE.445751
[7] Journal of Applied Physics 131, 053104 (2022); https://doi.org/10.1063/5.0076959