Optical topological transition: enable canalization and control of highly confined polaritons

Jiahua Duan[1,2]
Nathaniel Capote-Robayna[3], Javier Taboada-Gutiérrez[1,2], Gonzalo Álvarez-Pérez[1,2], Iván Prieto[4], Javier Martín-Sánchez[1,2], Alexey Y. Nikitin[3,5], Kirill V Voronin[6], Valentyn S Volkov[6] and Pablo Alonso-González[1,2]

1 Department of Physics, University of Oviedo, Oviedo 33006, Spain.
2 Center of Research on Nanomaterials and Nanotechnology, CINN (CSIC-Universidad de Oviedo), El Entrego 33940, Spain.
3 Donostia International Physics Center (DIPC), Donostia/San Sebastián 20018, Spain.
4 Institute of Science and Technology Austria, am Campus 1, Klosterneuburg 3400, Austria.
5 IKERBASQUE, Basque Foundation for Science, Bilbao 48013, Spain.
6 Center for Photonics and 2D Materials, Moscow Institute of Physics and Technology, Dolgoprudny 141700, Russia.

duanjiahua@uniovi.es

Abstract

Recent discoveries have shown that when two layers of van der Waals (vdW) materials are superimposed with a relative twist angle between their respective in-plane principal axes, the electronic properties of the coupled system can be dramatically altered due to the topological transition of electronic band structure. Here, we demonstrate that a similar concept can be extended to the optics realm, particularly to propagating polaritons – hybrid light-matter interactions –. We demonstrate two types of optical topological transition: Type I (from closed to opened isofrequency curve)[1] and Type II (isofrequency curve closes at one point)[2]. These optical phenomena appear in either stacks composed of two twisted slabs of a polar vdW crystal (α-MoO_3) or heterostructures composed of in-plane anisotropic (α-MoO_3) and isotropic (4H-SiC) polaritonic crystals. Our nano-infrared images reveal that the propagation of polaritons can be strongly guided along predetermined directions (canalization regime) with no geometrical spreading (Figure 1). Moreover, the topological transition enables propagation of anisotropic polaritons along forbidden directions. These results demonstrate new degrees of freedom (twist angle or heterostructure) for controlling the propagation of polaritons at the nanoscale with potential for nano-imaging, (bio)-sensing, quantum applications and heat management.

References

[1] Duan, J. et al. Nano Letters 20 7 (2020)
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Figures

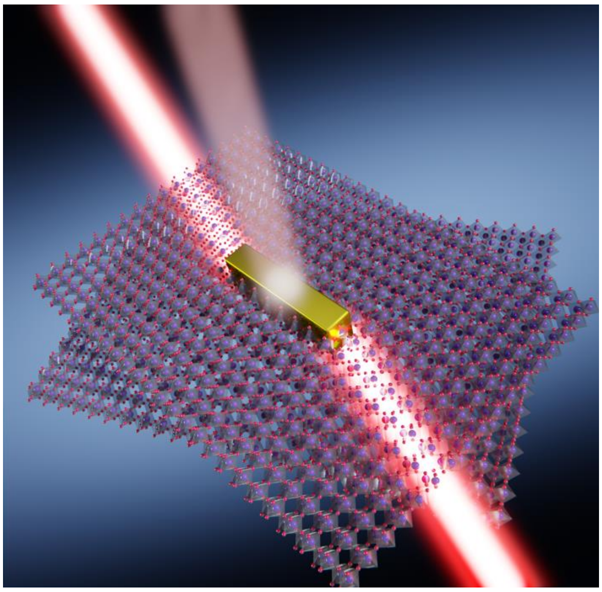

Figure 1: Canalized phonon polaritons in twisted van der Waals layers. Under a critical angle the polariton isofrequency curve undergoes a topological transition, generating the canalization of polaritons (i.e. propagation along one specific direction without diffraction).