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MAX PLANCK LECTURE ON NON-EQUILIBRIUM QUANTUM PHENOMENA

Polaritons and ultrasmall cavities in twisted 2D material heterostructures

Two-dimensional (2D) materials offer extraordinary potential for control of light and light-matter interactions at the atomic scale. Twisted 2D materials has recently attracted a lot of interest, due to the capability to induce moiré superlattices and discovery of electronic correlated phases [1,2]. In this talk, we present nanoscale optical techniques such as near-field optical microscopy, and reveal with nanometer spatial resolution unique observations of topological domain wall boundaries [4] and interband collective modes in charge neutral twisted-bilayer graphene near the magic angle [3]. The freedom to engineer these so-called optical and electronic quantum metamaterials [1] is expected to expose a myriad of unexpected phenomena.

We will also show record-small nanoscale polaritonic cavities [4,5], where the resonances are not associated to the eigenmodes of the cavity. Rather, they are multi-modal excitations whose reflection is greatly enhanced due to the interference of constituent modes. We demonstrate mid-IR cavities with volumes more than a billion below the free-space mode volume, while maintaining quality factors above 100.

References

[1] Song, Gabor et. al., Nature Nanotechnology (2019)
[2] Cao et al., Nature (2018)
[3] Hesp et al., Arxiv 1910.07893
[4] Hesp et al., in preparation
[5] Epstein et al., Science (2020)
[6] Herzig Sheinfux et al., in preparation

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