qcmd - Seminar

mpsd

Dear All,

We are pleased to announce the visit of Giacomo Scalari from the ETH Zürich to MPSD.

Giacomo will give a presentation on his work titled

''Landau polaritons and cavity-driven attractive interactions in single and bilayer graphene''

at a seminar on Wednesday, March 4, at 14:00 CET in MPSD 900 EG 136.

Abstract

Landau polaritons and cavity-driven attractive interactionsin single and bilayer graphene

Strong light-matter coupling has been recently successfully explored in the GHz and THz range with on-chip platforms, where metallic resonators with small cavity volumes are combined with high electron density materials to exploit the collective enhancement of the coupling Ω. New and intriguing quantum optical phenomena have been predicted in the ultrastrong coupling regime, when the coupling strength Ω becomes comparable to the unperturbed frequency of the system ω [1][2]. The use of extremely small cavity volumes ($V/\lambda 3 \simeq 10{-}6$), attainable with circuit-like resonators, has allowed the study of ultrastrong light-matter coupling at THz frequencies[3][4][5] While sub-wavelength localization of terahertz fields can be efficiently achieved using micro-structured metallic resonators, conventional approaches rely on metamaterials of repeating resonators placed atop the material of interest.[3] [6] This method is incompatible with exfoliated 2D materials, which are usually limited to in-plane dimensions of just a few microns, and with the study of few-electron systems requiring an active mode surface of a few micrometer squared.

We will discuss experimental results where a single strongly subwavelength resonator is coupled to a single graphene flake and, in a second experiment, to a dual-gated Bernal stacked bilayer graphene.

In the first experiment, we use the Landau polariton platform that has been extensively exploited to investigate the physics of ultrastrong light-matter coupling both in optical and transport experiments [3][7]. We employ a system of immersion lenses [8] to spectroscopically investigate a graphene flake encapsulated in hexagonal Boron Nitride

and embedded in single resonator operating at 1.2 THz. The resonator features an electrical gate in order to modulate the graphene's electron density ρ2deg and, as a consequence, the Rabi frequency Ω. The normalized coupling ratio Ω/ ω scales with the expected fourth root of the density reaching a maximum value of 0.3, well within the ultrastrong coupling range.

In the second experiment, we couple a Bernal stacked bilayer graphene (BLG) to a bow-tie antenna resonator, operating at 2.3 THz. The presence of a dual gate system allows to independently tune the carrier density and the displacement field, with which we tune the BLG gap in the range 0-6 THz [9]. The immersion lens assembly allows the measurement of the field-tunable bandgap of bilayer graphene as a function of the displacement field. With such a setting we demonstrate that terahertz cavity photons can mediate attractive interactions in a tunable van der Waals material and reorganize a continuum of electron–hole transitions into an exciton-like state [10] [11]. Spectral measurements in the 1- 6 THz range reveals an anticrossing behavior of such an exciton-like state, and the estimated coupling strength, $\eta = \Omega/\omega \approx 0.43$, which places our system well into the ultrastrong coupling regime.

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