ICFO

PhD THESIS DEFENSE: Optoelectronic studies of correlated 2d materials

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September 02, 2024

11:00

ICFO Auditorium and Online (Teams)

The study of strongly-correlated matter in two-dimensional materials has emerged as a exciting prospect for the exploration of condensed matter physics, as well as the design of novel device platforms. Moire engineering, where the 2D layers feature an interlayer twist angle of 1.1º between the graphene layers generates a moire superlattice potential. A fla electronic band appears at the Fermi level, in which a variety of interaction-driven many-body quantum phases can emerge. Another avenue to study strong electroni correlations in two dimensions is the exfoliation of intrinsically correlated bulk crystals int the atomic limit

The optoelectronics study of strongly-correlated systems in 2D heterostructures stands ou as a powerful probe, as it can provide insight into both the electronic transport propertie and the fundamental light-matter interaction in these systems. In this thesis, we study tw strongly correlated 2D materials: MATBG and the cuprate superconducto Bi2Sr2CaCu208-delta (BSCCO-2212). We leverage different optoelectronic techniques t study the fundamental properties of the correlated electrons in the MATBG flat bands and th potential of two-dimensional BSCCO-2212 layers for applications in quantum sensing

First, we investigate the electronic spectrum of the MATBG flat bands through the study o their thermoelectric transport. We use an optical excitation to induce a thermal gradient which in turn generates a charge current. We report anomalous thermoelectricity whic provides strong evidence for the coexistence of localized and de-localized electronic state in the strongly-interacting flat bands

Next, we study the dynamics of hot carrier cooling in the MATBG flat bands using frequency-resolved photomixing technique. Strikingly, we find that hot carriers ca efficiently relax their energy down to cryogenic temperatures; in contrast to the case o bilayer graphene samples. We propose a novel Umklapp electron-photon scatterin mechanism for hot carriers in MATBG, enabled by the moire superlattice potential

Lastly, we explore the development of superconducting photodetectors with high-T_c base on ultrathin BSCCO-2212 flakes. We fabricate high quality samples that exhibit remarkabl performance at telecom wavelengths. We observe fast and sensitive bolometric response a T = 77 K in free-space and waveguide-coupled devices, as well as single-photon sensitivity a T = 20 K through a non-bolometric, avalanche detection mechanism

Monday September 02, 11:00 h. ICFO Auditorium and Online (Teams)
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Hosted by: Prof. Dr. Dmitri K. Efetov