Universität Münster

Aktuelle Fragen der Nanophysik

Montag, 15.04.2024 um 15:15 Uhr
R87, Wilhelm-Klemm-Str. 10

Correlated insulating states in a Coulomb-coupled moiré structure

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The Hubbard model of interacting particles on a lattice provides a theoretical foundation to understand correlated physics in crystals, predicting ubiquitous phases such as the Mott insulator and superfluidity, depending on the bosonic or fermionic statistics of the constituent particles. To date, the Hubbard model has been primarily realized physically in cold atom optical lattices, which allow for microscopic control and readout of the resulting correlated states at the cost of technical complexity[1]. Over the last few years, charges in moiré superlattice structures made from 2D semiconductors have been demonstrated as an alternative, hosting robust correlations at experimentally accessible temperatures[2-4]. In this talk, I will present evidence for a wide range of correlated charge insulators in trilayer structures. These structures consist of a moiré heterobilayer (HBL) of monolayers of WSe_2 and WS_2 which is Coulomb-coupled to a moiré-free monolayer (free layer, FL) of WSe_2[5]. In this context, both charged and neutral excitons in the FL can serve as proximity sensors for correlated insulators in the FL. Following this, I will discuss the emergence of a spatial indirect excitonic insulator when electrons doped in the FL bind to holes doped into the electron Mott insulator of the HBL. Such a state offers the chance to study a mixed boson/fermion system with a continuously tunable bosonic fraction, which is predicted to either form dipolar crystal phases[6] or a superfluid/condensate[7-8] at sufficiently high densities and low temperatures, depending on localization and dipole-dipole interaction strength.

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