Many-body states and topological properties of low-dimensional quantum materials

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Understanding of the interaction-induced many-body states and topology of quantum matter have been at the heart of the study of modern condensed matter physics ever since its development. In low-dimensional mesoscopic systems, measurements of transport properties allow us to acquire details of the physics of condensed matter systems. Two-dimensional (2D) cleavable materials, known as van der Waals materials, have a defect-free crystalline structure that is suitable for use in high-quality quantum devices. It is even possible to obtain a single layer of these materials and build heterostructures exhibiting interesting many-body interaction-induced quantum phenomena.

In this talk, at first, I will introduce the field from my own perspective, explain what makes these 2D crystals so special and how they can be exploited to unveil the new mesoscopic quantum transport phenomena. I will then discuss some of my recent contributions to the field for the investigation on many-body states and topologically non-trivial properties in different 2D materials. I will begin by introducing the Hall micromagnetometry technique to quantitatively estimate extremely small magnetic field arising from ferromagnetic 2D material, $CrBr_3$. The observed ferromagnetic behaviour, that remains down to monolayer, is markedly different from that given by the simple 2D Ising model normally expected to describe 2D easy-axis ferromagnetism [1]. I will also show quantum transport properties of 2D triangular mesh of 1D conductive wires in marginally twisted bilayer graphene. Topologically protected 1D transport channels exhibits giant Aharonov-Bohm oscillations that reach in amplitude up to 50 % of resistivity and persist to temperatures above 100 K [2]. At last, I will present electron hydrodynamics study in graphene, as a recently-discovered approach to measure the strength of electron-electron interactions, that provides a guidance for future attempts to achieve proximity screening of many-body phenomena in 2D systems [3]. I am going to conclude this talk by discussing some of the possible future researches on low dimensional quantum materials.

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