Quantum Melting of a 2D Wigner Crystal at Ultralow Temperatures

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In this talk, I will present our recent progress in performing optical spectroscopy in a dilution refrigerator at millikelvin temperatures. As an example, I will discuss the quantum melting of a two-dimensional (2D) electron Wigner crystal in monolayer $MoSe_2$ [1]. In an ideal 2D electron system, increasing carrier density drives a transition from a crystalline (Wigner) phase to a quantum liquid [2]. The long-range nature of Coulomb interactions is predicted to preclude a direct first-order transition, instead giving rise to intermediate microemulsion phases in which crystalline and liquid domains microscopically coexist [3]. Recent studies have shown that monolayer $MoSe_2$ can host Wigner crystals without the need for an external magnetic field or periodic potential [4]. Using reflectance spectroscopy and magneto-optical techniques, we probed the charge and spin order of the Wigner crystal, calibrated its electron temperature, and found compelling evidence for the emergence of a microemulsion phase [1]. Furthermore, we mapped the temperature-density phase diagram and observed signatures of the Pomeranchuk effect near the phase boundaries [1]. These findings are corroborated by recent scanning tunneling microscopy studies [5].

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