Phase Diagram of a Classical Quasi-One-Dimensional Electron System

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Surface-state electrons (SSE) on a liquid helium substrate form a model two-dimensional (2D) electron system. Because the Coulomb interaction between electrons is essentially unscreened, the electrons form a triangular lattice, the Wigner crystal, at low temperatures. Here we investigate the Wigner crystallisation of SSE confined in a 10 μm-wide microchannel filled with superfluid ^{4}He. Electrodes at the microchannel edges and under the helium surface are used to control the parabolic confinement potential and the electron density, respectively. The SSE resistivity increases when the electrons form a Wigner crystal, due to the depression of the helium surface beneath each electron. By measuring the SSE current along the microchannel we are therefore able to study Wigner melting in a quasi-one-dimensional (Q1D) geometry. We find that the melting of the Q1D system depends not only on the electron density, as in the 2D case, but also on the confinement energy; for sufficiently strong confinement at a given temperature, the system is crystalline for all densities. Furthermore, the Wigner transition depends on the commensurability of the electron lattice with the confinement potential. This leads to striking oscillations in the current as the electron density changes, when the system is close to melting. The number of electron rows formed in the microchannel can therefore be determined, from more than 30 rows, down to a single electron chain[1].

1. H. Ikegami, H Akimoto, D.G. Rees and K. Kono. "Evidence for Reentrant Melting in a Quasi-One-Dimensional Wigner Crystal". Phys. Rev. Lett. **109**, 236802 (2012).

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