Confinement effect on electron transport of Wigner solid on liquid He

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Electrons trapped on the ultra-clean surface of liquid helium form a model 2D system. The additional restriction of electron motion in the plane parallel to the helium surface allows transport in quasi-one-dimensional geometries to be investigated.

Here we present a detailed study of electron transport in a microchannel 100 μm long and 10 μm wide, formed by gate electrodes. Varying the gate electrode voltage allows the effective width and depth of the electrostatic potential (and correspondingly the electron surface density) within the microchannel to be controlled. In our measurements, three transport regimes were identified; first, the zero current regime, when the channel is closed; second, a high current regime, when the electrons are in a liquid-like state; and third, a low current regime, when the electrons form a quasi-one-dimensional Wigner crystal. The evolution of these regimes with changing temperature was investigated, in the range 0.6-1.2 K. Close to the phase boundary between the electron liquid and Wigner crystal regimes, a unique oscillatory behaviour was observed in the electron current. This was attributed to the reentrant melting of the electron system which occurred as the number of electron rows changed. Our results were compared to a theoretical model developed with the aid of a finite-element analysis of the device.