Evidence for two-dimensional Wigner crystal formation in chemical potential measurements

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The evolution of the chemical potential of a 2-dimensional electron system was investigated within the quantized Hall regime. The measurement of this thermodynamic quantity was carried out using a closely spaced GaAs bilayer system, with top and bottom gates as well as separate contacts to each layer. Chemical potential variations in one layer were detected with high resolution by monitoring the induced resistance change in the neighboring layer [1, 2]. Apart from the well known rapid increase of the chemical potential when the lower lying Landau level became completely occupied and a higher lying Landau level got filled, two additional anomalies manifested themselves symmetrically around exact integer filling (Fig. 1 (a)). They were attributed to the formation of incompressible Wigner crystals of either quasiparticles or quasiholes [3]. Non-equilibrium dynamics was excluded as the origin of the extra jumps in the chemical potential [4].

The investigations were carried out at different densities, i.e. magnetic fields as well as temperatures. The ratio of the magnetic length l_B over the interparticle distance $l^* = 1/\sqrt{n^*}$ (n^* is the density of quasiparticles) did not vary with the B-field (Fig. 1 (b)). The anomalies vanished when the temperature exceeded around 400 mK, which is consistent with the melting behavior of a solid. More interestingly, the two anomalies got closer to the exact integer filling at higher temperatures. A linear extrapolation (Fig. 1 (c)) yields a temperature of 840 mK which marks the critical temperature for a Wigner crystal.

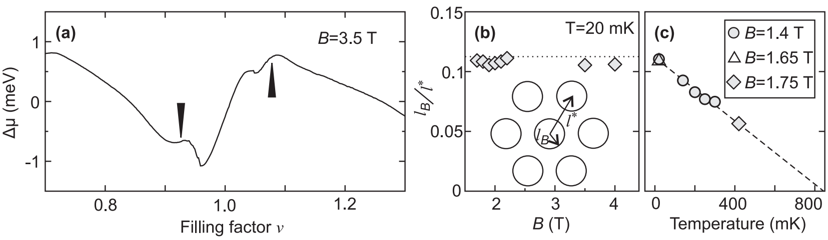

Figure 1: (a) Chemical potential measured around filling factor $\nu = 1$ at $B = 3.5$ T. Arrows mark the two anomalous features indicating the incompressible state of the Wigner crystal. (b)(c) Critical ratio l_B/l^* at which the anomalies appear plotted as a function of (b) the magnetic field B and (c) the temperature. Inset to (b) illustrates the two length scales: l_B–the magnetic length; l^*–the quasiparticle distance. Dotted line marks $l^*/l_B = 9$. Dashed line linearly extrapolates to a temperature of 840 mK at $l_B/l^* = 0$.

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