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Anomalous structure in the single particle spectrum of the fractional quantum Hall effect[1]

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Using a pulsed tunneling technique known as "Time Domain Capacitance Spectroscopy," we obtain high fidelity and high resolution measurements of the single particle spectrum of the two-dimensional electronic system (2DES) in the fractional quantum Hall regime. The method produces spectra with precisely calibrated energy and density axes and with no observable heating of the 2DES for tunneling energies as high as 30 meV. In spectra taken as a function of both energy and density, we observe prominent, fan-like, structure emanating from filling factors $\nu = 1$ and $\nu = 1/2$ which appears only when the 2DES is cooled to very low temperatures. The same structure appears in spectra from different samples, but it is most pronounced in the samples with the lowest disorder and appears only in high magnetic fields. Some of the feature's energies agree qualitatively and quantitatively with what might be expected for composite fermions, which have proven effective for interpreting other experiments in this regime. At the same time, a simple model with electrons localized on ordered lattice sites (a Coulomb glass) and including exchange also generates structures that are, in some ways, similar to those observed in the experiment. However, both models predict additional structure that is not observed in the experiment, and neither is expected to be applicable across the entire range of filling fractions where we observe structure. Further work is needed to clarify which, if either, of these two models is correct at any given density, as well as to understand any possible equivalence of the two models. The dramatic and unexpected structures revealed by this measurement suggest more surprises are to come with higher resolutions and lower temperatures.

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