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Unconventional Sequence of Fractional Quantum Hall States in Graphene

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Electronic compressibility is a powerful tool for the study of correlated electron phases in two-dimensional electron systems. Using a scanning single-electron transistor, we have measured the local electronic compressibility of suspended graphene in the quantum Hall regime. The local nature of the measurement technique allows us to probe exceptionally clean regions of graphene, revealing delicate many-body effects that are obscured by disorder in global transport studies. In this talk, I will review recent measurements of the fractional quantum Hall effect (FQHE) in graphene. We observe a multitude of FQH states that follow the standard composite fermion sequence between $\nu = 0$ and 1, but only occur at even-numerator fractions between $\nu = 1$ and 2, suggesting that an underlying symmetry remains. Moreover, we observe a series of phase transitions in the FQH states between $\nu = 0$ and 1 that are marked by a decreased energy gap and a narrow region of negative compressibility that cuts across the FQH state. We use a simple model based on crossing composite fermion Landau levels with different internal degrees of freedom to reproduce much of the experimental behavior. Our results provide insight into the interplay between electron-electron interactions and the spin and valley symmetries of graphene.