Universality of quantum phase transitions in the integer and fractional quantum Hall regimes

Aveek Bid
Simrandeep Kaur, Tanima Chanda, Kazi Rafsanjani Amin, Kenji Watanabe, Takashi Taniguchi, Unmesh Ghorai, Yuval Gefen, and G. J. Sreejith
Indian Institute of Science, Bangalore, INDIA
aveek@iisc.ac.in

Fractional quantum Hall (FQH) phases, emerging from strong electronic interactions, are characterized by anyonic quasiparticles with unique topological parameters, fractional charge, and statistics. In contrast, integer quantum Hall (IQH) effects arise from the band topology of non-interacting electrons. In this talk, I report a surprising super-universality in the critical behavior across all FQH and IQH transitions, revealing identical critical scaling exponent k = 0.41 ± 0.02, localization length exponent g = 2.4 ± 0.2 and the dynamical exponent z ≈ 1 for both. These results were experimentally obtained using ultra-high mobility trilayer graphene devices with a metallic screening layer close to the conduction channels. Previous studies on these global critical exponents were inconclusive due to significant sample-to-sample variations in measured values of k in conventional semiconductor heterostructures dominated by long-range correlated disorder. I will demonstrate that these robust scaling exponents are valid in the limit of short-range disorder correlations [1].

References

[1] Simrandeep Kaur, Tanima Chanda, Kazi Rafsanjani Amin, Kenji Watanabe, Takashi Taniguchi, Unmesh Ghorai, Yuval Gefen, G. J. Sreejith, Aveek Bid *Nat Commun* **15**, 8535 (2024), 8535

Figures

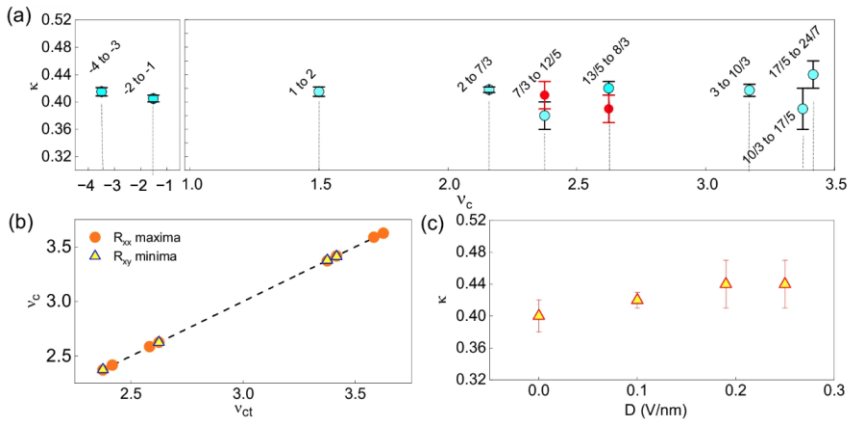

Figure 1: Plot of κ as a function of ν_c corresponding to different PT evaluated from the maxima of derivative (dRxy/dv) near the critical point. The dotted vertical lines mark the experimentally obtained ν_c. The light blue symbols are for the κ values obtained for trilayer graphene, and the red symbols are for the single-layer graphene. **b** Plot of experimentally obtained values of critical points, ν_c versus those theoretically calculated ν_{ct}14. The triangles are the values determined from crossing points of isotherms in R_{xy}, while the circles are determined from the R_{xx} maxima. The black dashed line fits the data points with slope = 1.00 ± 0.002. **c** Plot of κ versus **D** for the FQH transition from ν = 8/3 to ν = 13/5 states evaluated from the maxima of derivative (dRxy/dv) near the critical point. The error bars are determined from the least-square fits to the data.