Fractional Quantum Anomalous Hall Effect and Chiral Superconductivity in Graphene

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Abstract

Fractional quantum Hall effect and superconductivity are two famous examples of emergent quantum phenomena driven by electron topology and correlations. They usually happen in very different materials and experimental settings. In this talk, I will discuss how they can be unified in one crystalline material, known as rhombohedral graphene. More than being hosted by the same materials, the settings challenge the conventional understandings of these phenomena: the fractional quantum Hall effect happens at zero magnetic field[1], while the superconductor behaves as a spin and orbital magnet[2]. I will also discuss the implications of these phenomena in the context of non-Abelian quasiparticles.

References

[1] Lu, Z., Han, T., Yao, Y. *et al.* Fractional quantum anomalous Hall effect in multilayer graphene. *Nature* 626, 759–764 (2024). https://doi.org/10.1038/s41586-023-07010-7
[2] Han, T., Lu, Z., Hadjri, Z. et al. Signatures of chiral superconductivity in rhombohedral graphene. Nature 643, 654–661 (2025). https://doi.org/10.1038/s41586-025-09169-7

Figures

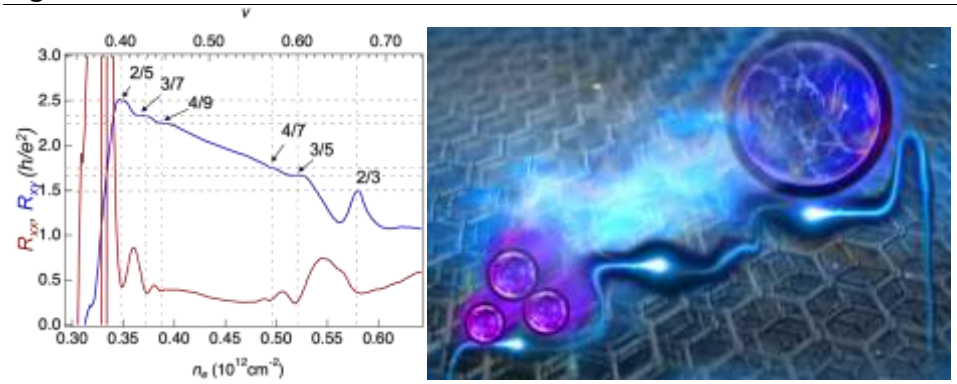

Figure 1: Left: Fractional quantum anomalous Hall Effect in pentalayer rhombohedral graphene/hBN moiré superlattice. Right: illustration of electrons breaks into fractions of themselves.

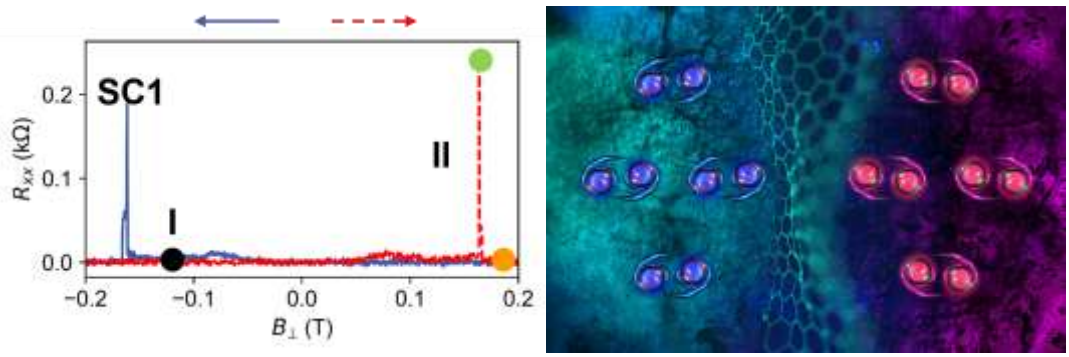

Figure 2: Left: Chiral superconductivity in rhombohedral graphene, where magnetic hysteresis of resistance is observed. Right: illustration of Cooper pairs with opposite chiralities.