

The background of the slide is a contour plot with a color gradient from dark purple to bright yellow-green. The plot shows several distinct peaks and valleys, with the most prominent peaks being bright yellow-green and surrounded by concentric contour lines of decreasing intensity. The overall pattern is complex and non-uniform, suggesting a high-dimensional or multi-modal data distribution.

Extended Fractional Chern Insulator Near Half Flux in Twisted Bilayer Graphene Above the Magic Angle

Aaron Sharpe

Stanford University

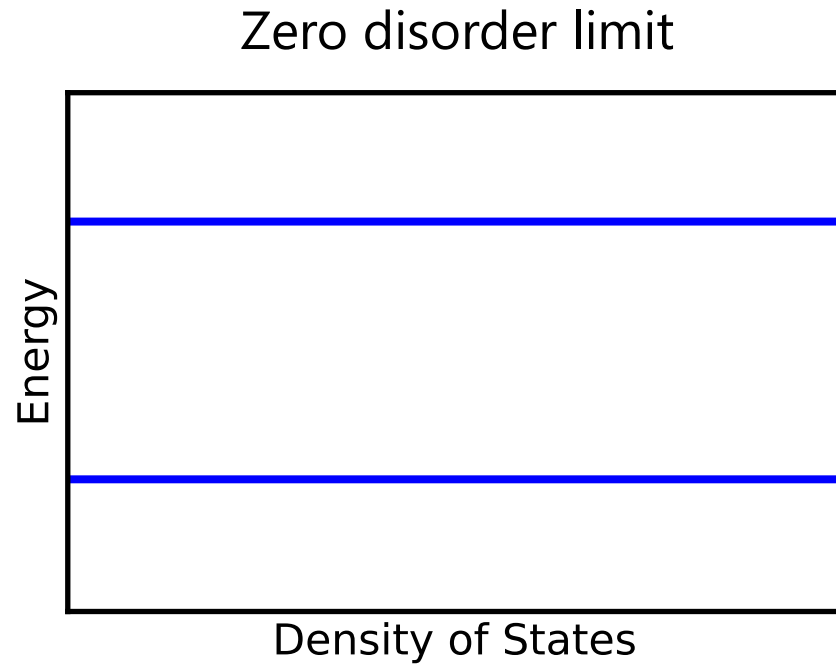
March 17th, 2025

[arXiv:2503.12819](https://arxiv.org/abs/2503.12819)

slides @ aaronsharpe.science

Landau Levels and Disorder

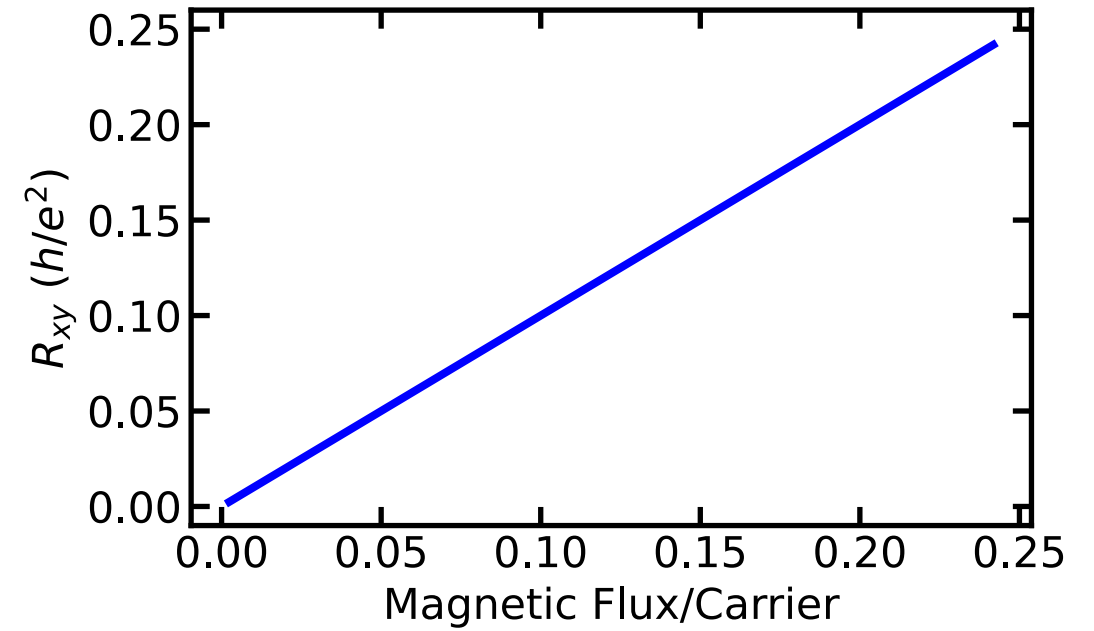
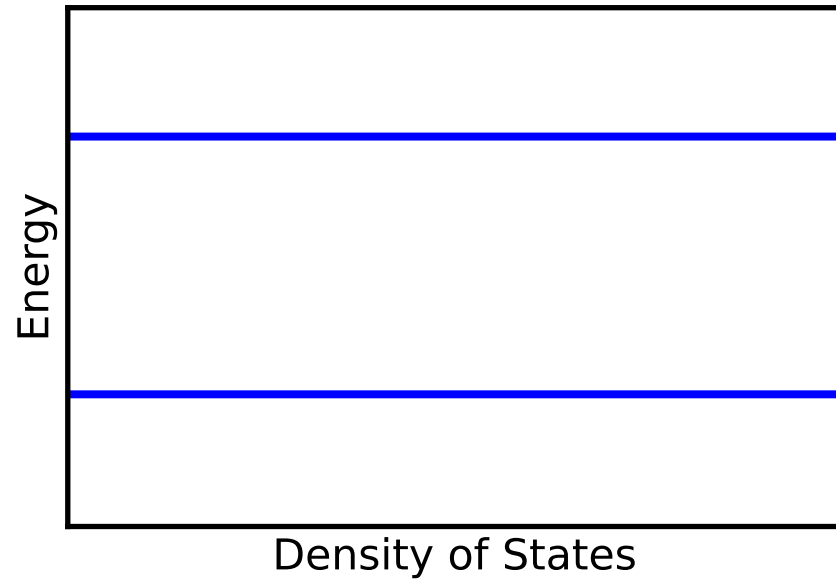
Weak disorder required to see quantized conductance



Landau Levels and Disorder

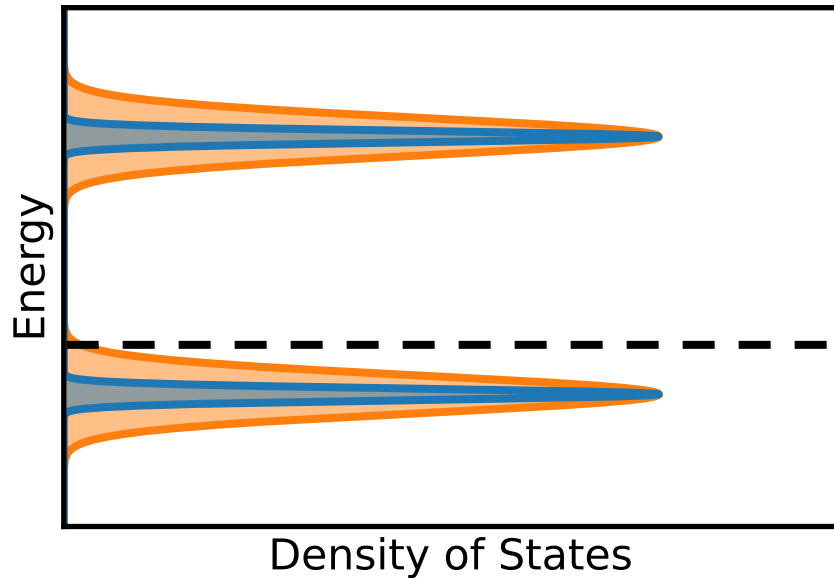
Weak disorder required to see quantized conductance

Zero disorder limit

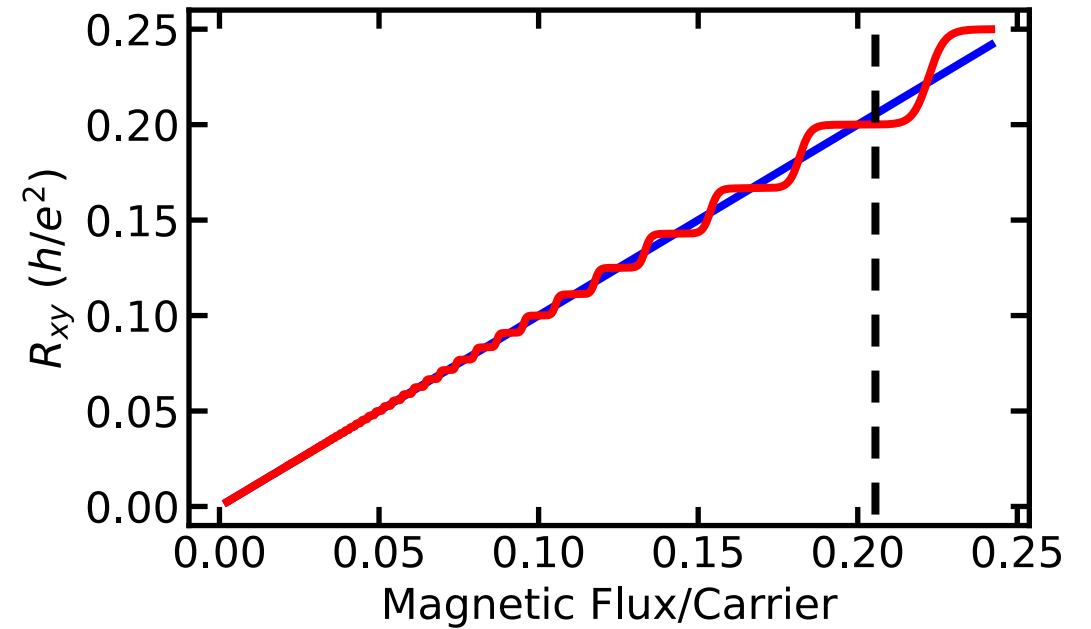


Landau Levels and Disorder

Weak disorder required to see quantized conductance



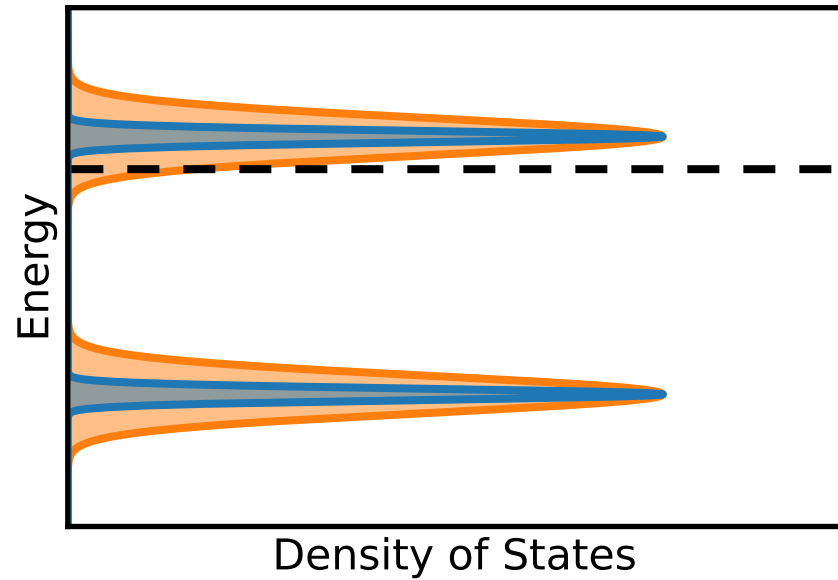
- Localized states
- Itinerant states



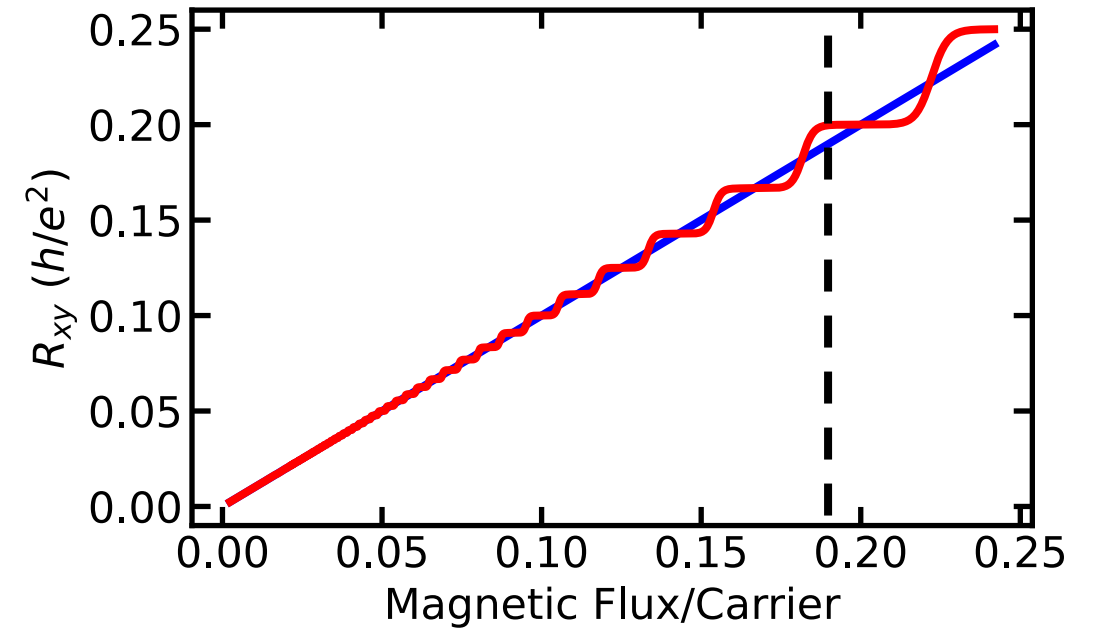
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Landau Levels and Disorder

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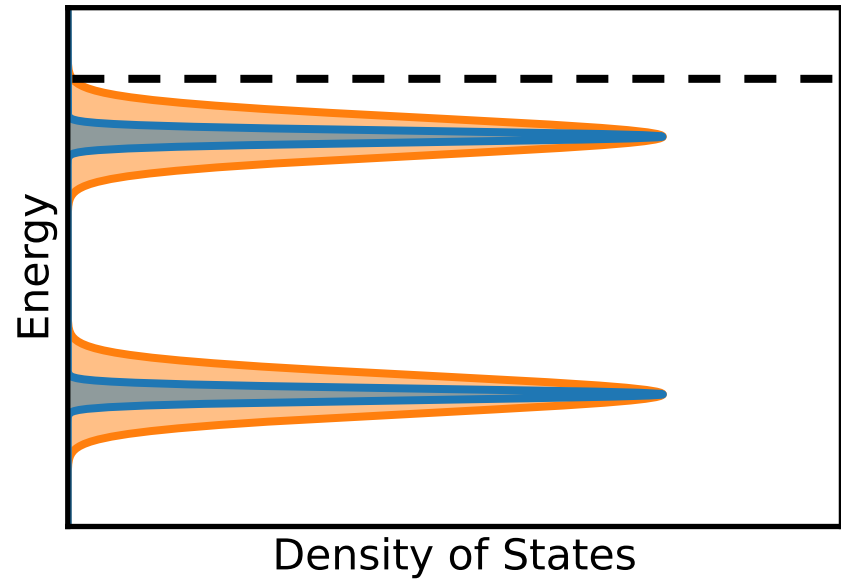
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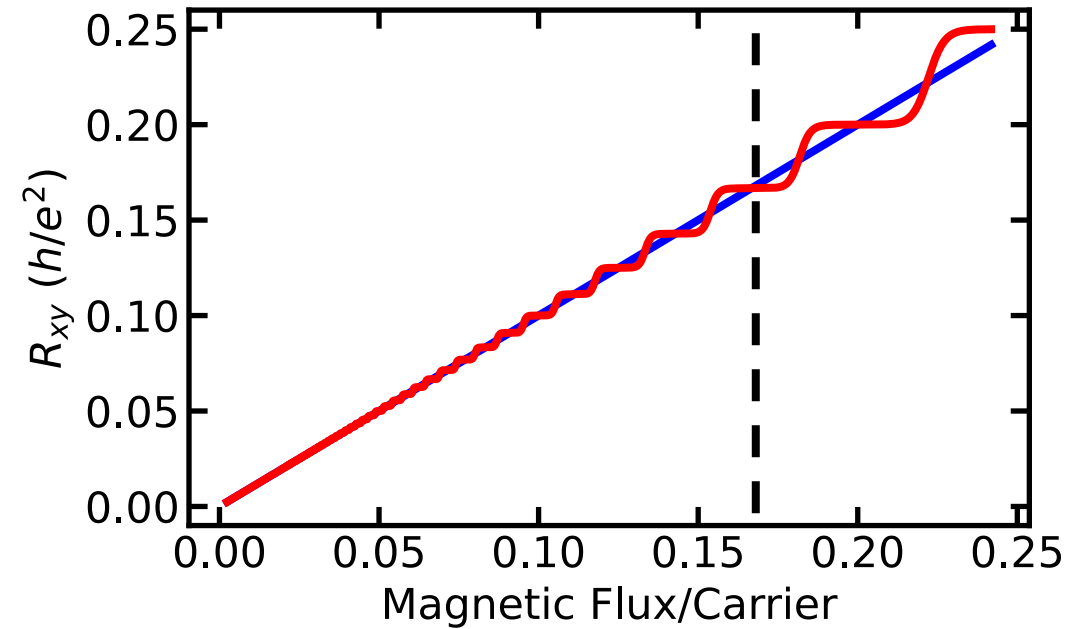
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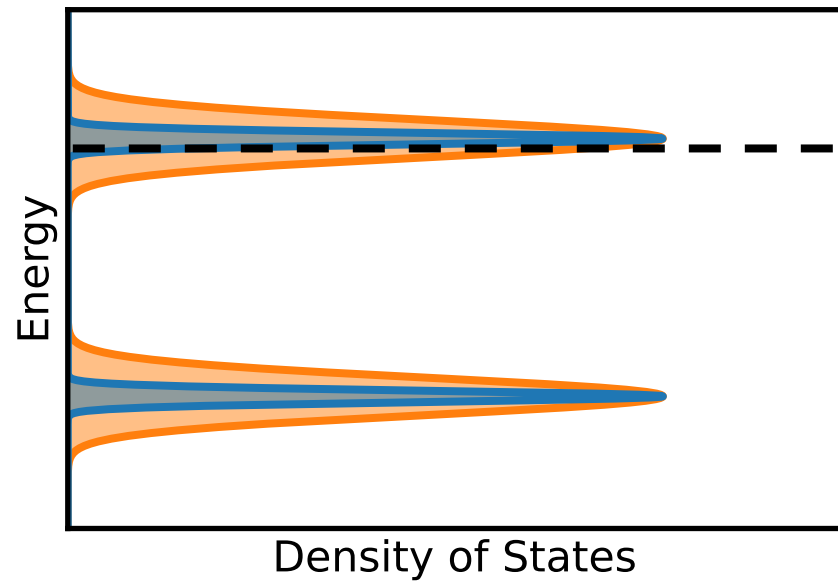
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Landau Levels and Disorder

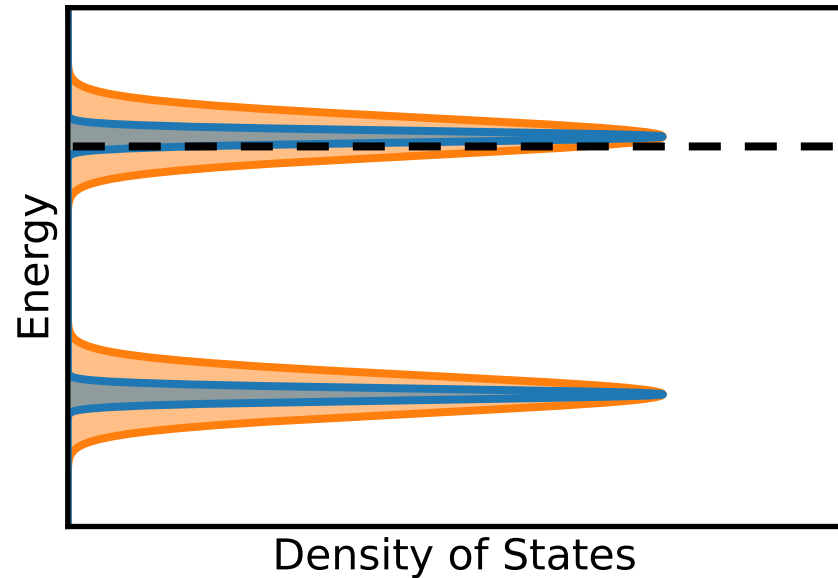
What can happen when doping into a LL?



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Landau Levels and Disorder

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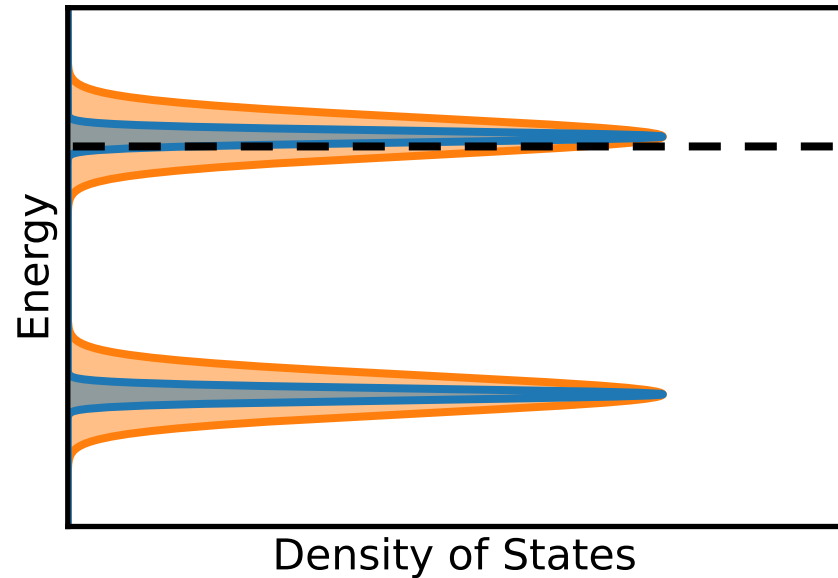
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Metallic state:

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Landau Levels and Disorder

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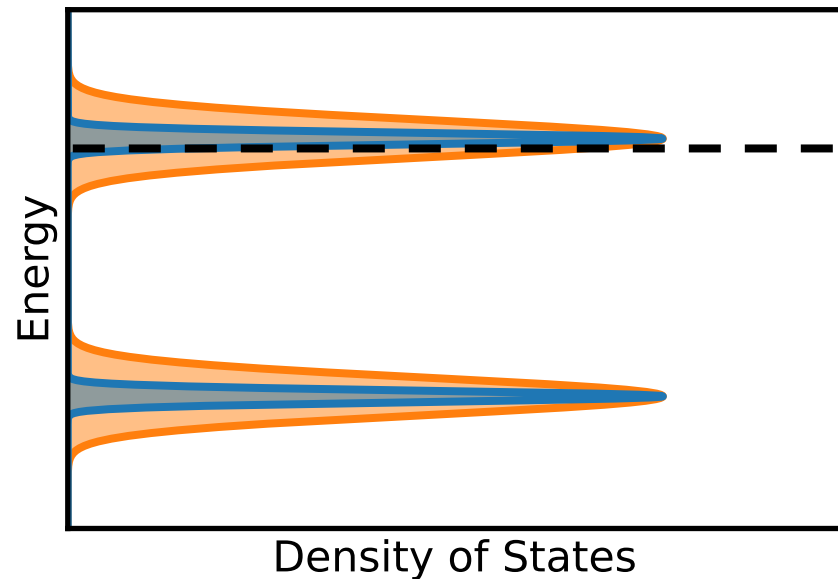
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FQH Liquid:

- Zero R_{xx} and quantized R_{xy}
- At rational filling
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Landau Levels and Disorder

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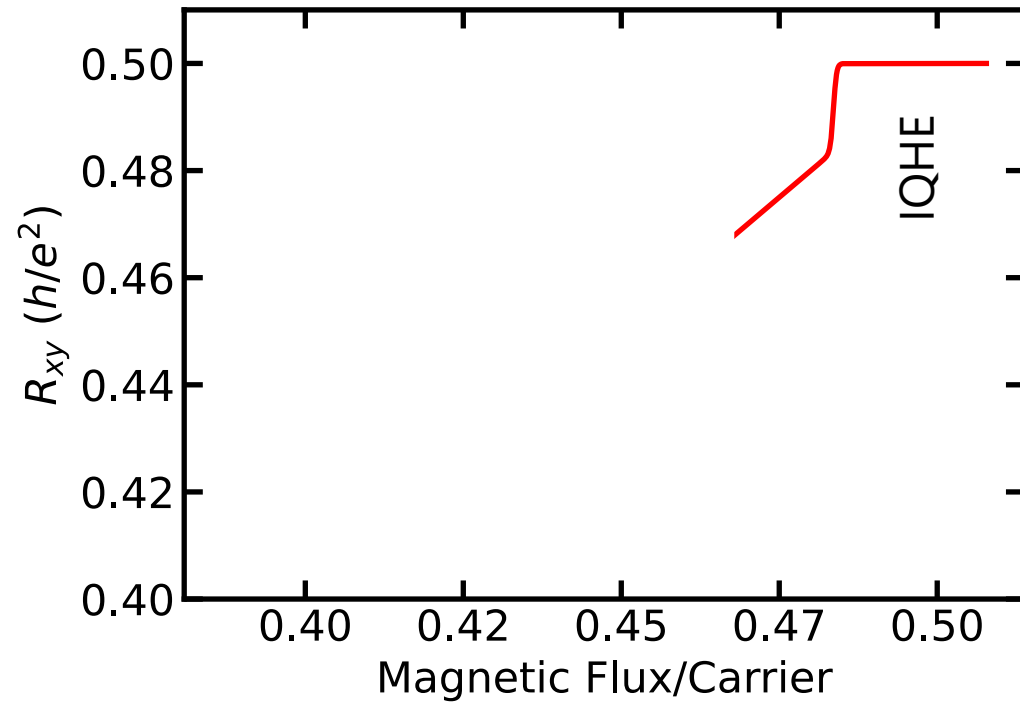
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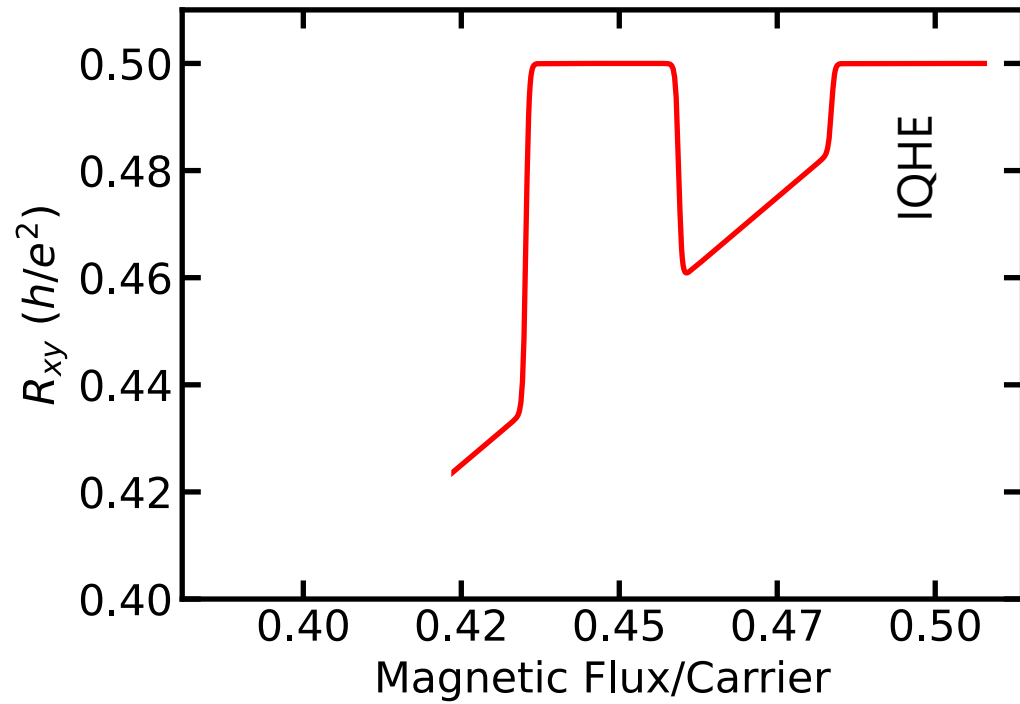
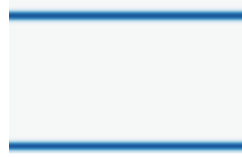
Charge ordered state:

- Wigner crystal, stripes, bubbles
- Insulator
- Reentrant quantum Hall

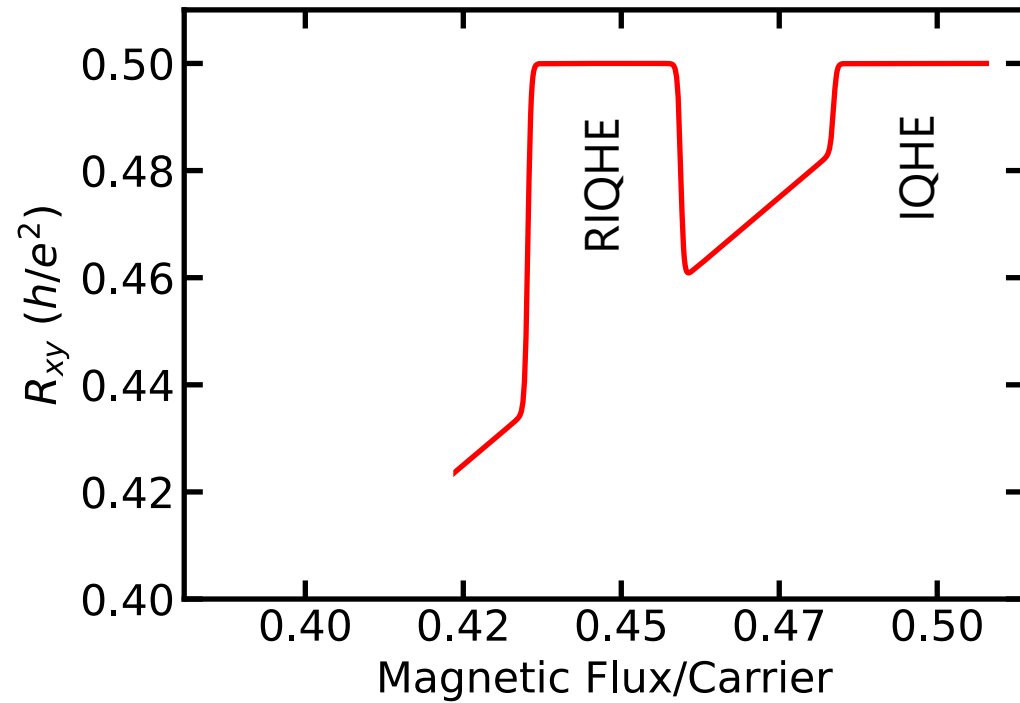
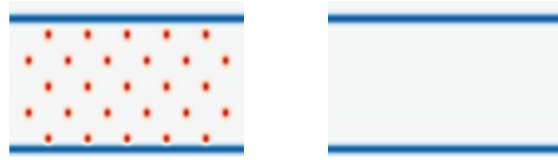
Reentrant Integer Quantum Hall (RIQHE)



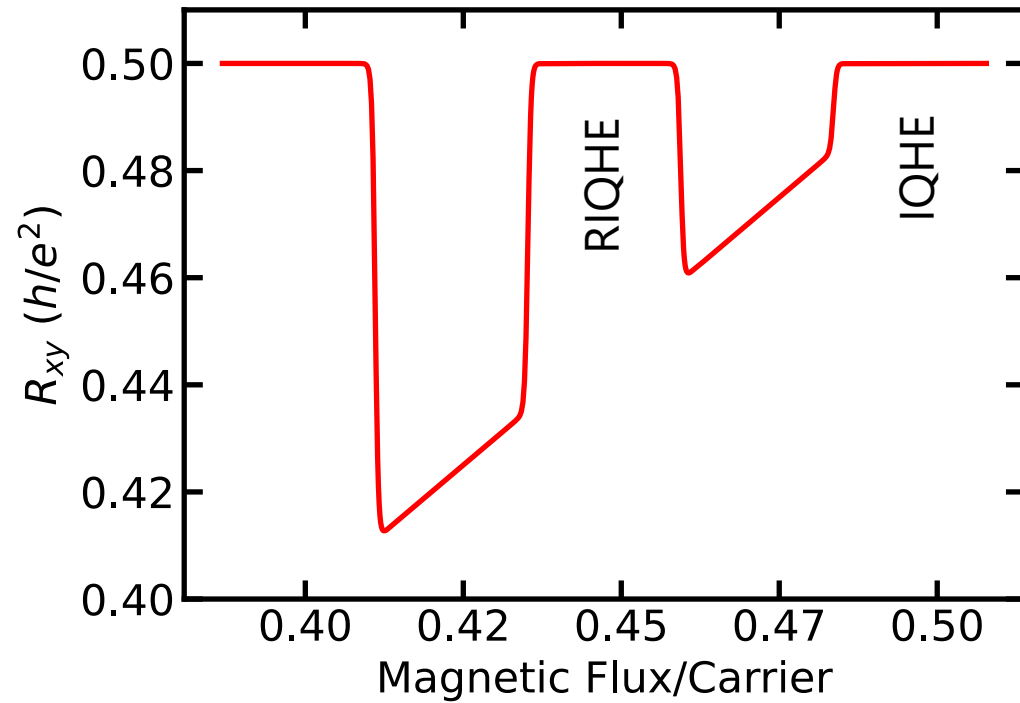
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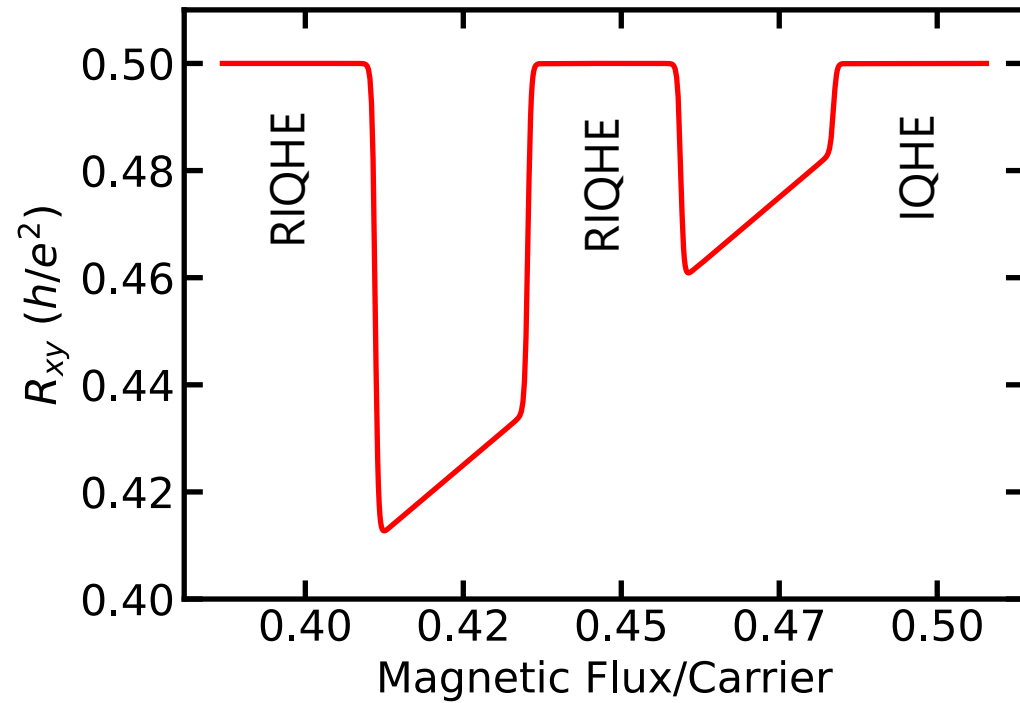
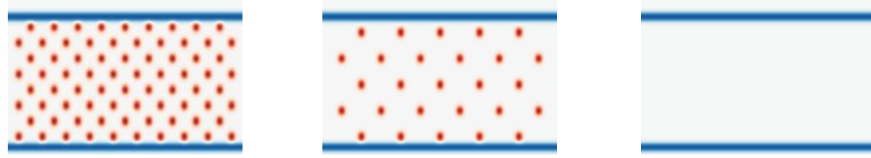
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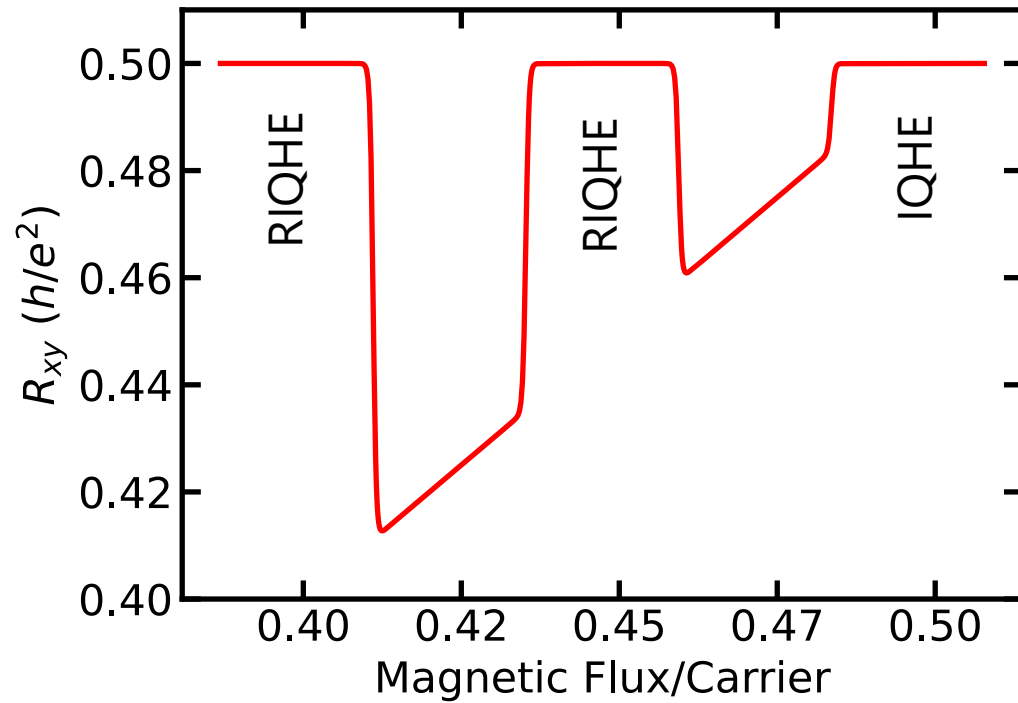
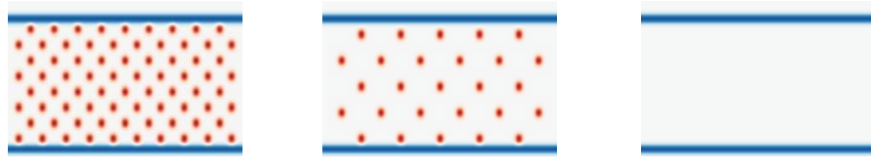
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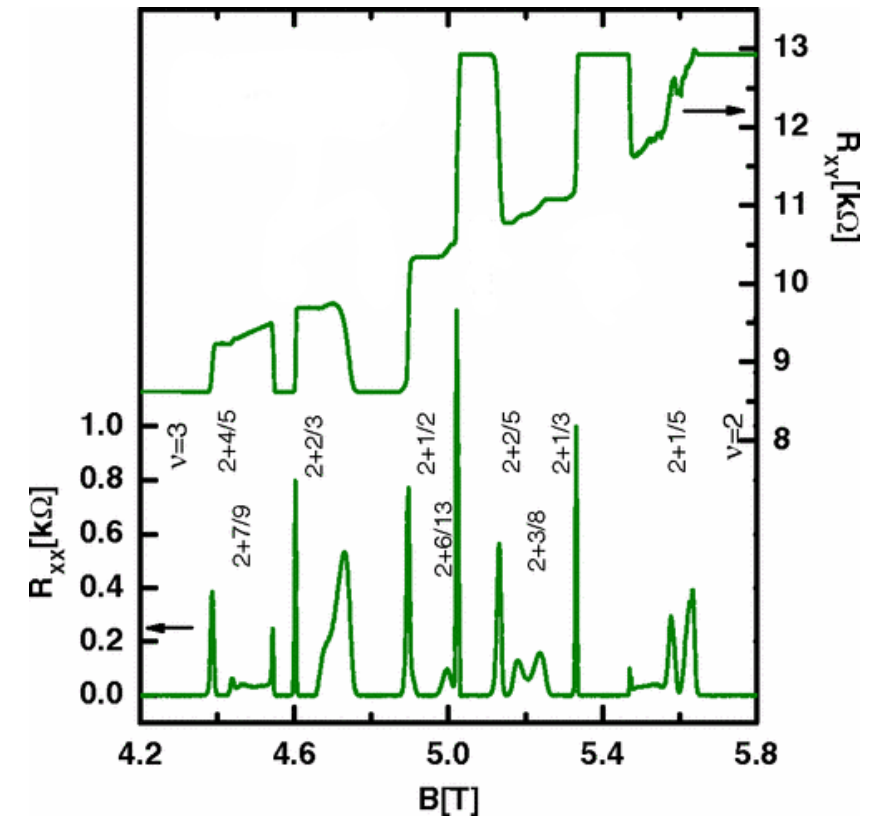
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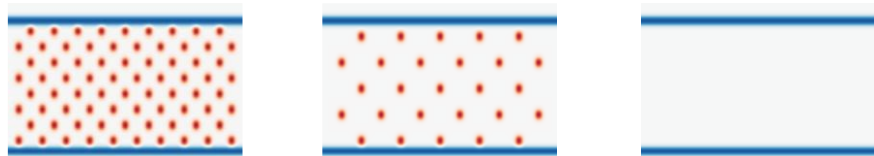
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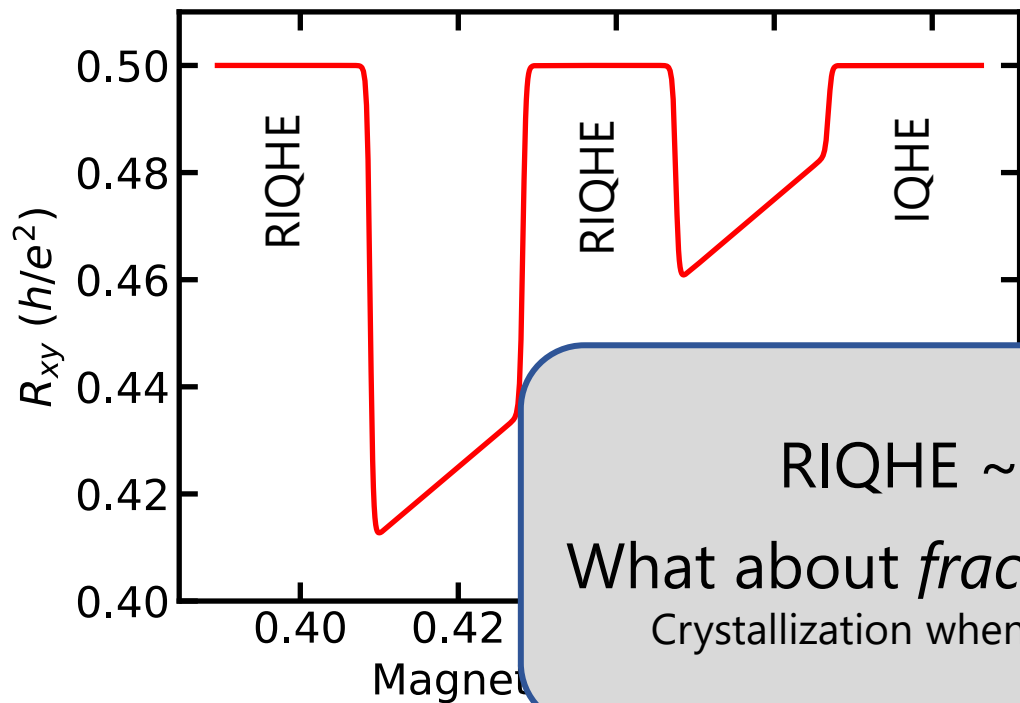
FQH and RIQHE in GaAs 2DEGS



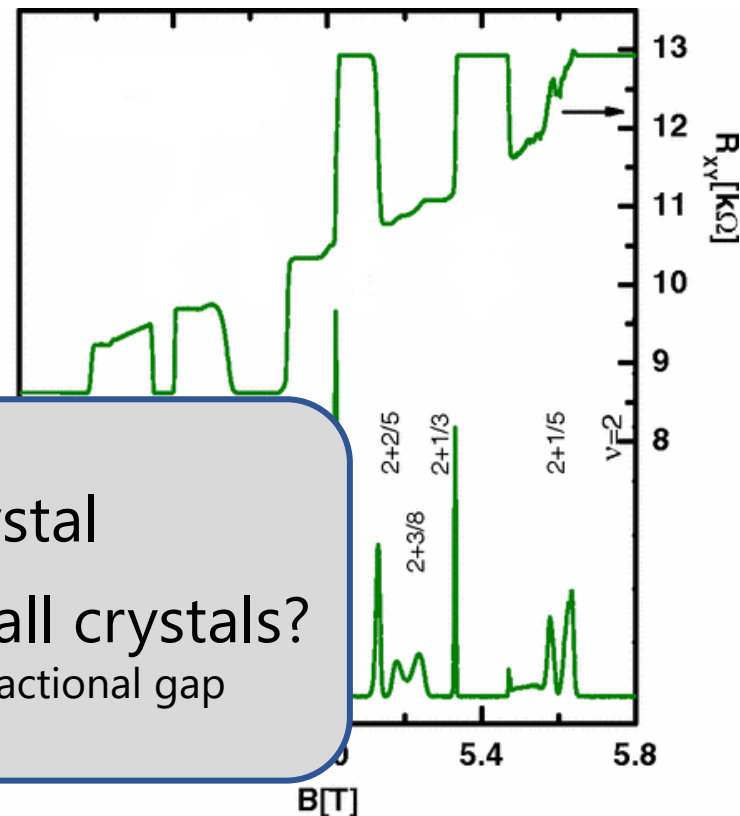
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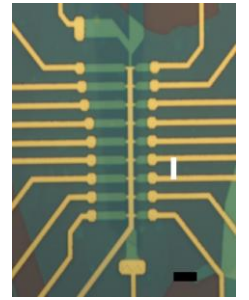
FQH and RIQHE in GaAs 2DEGS



RIQHE ~ *partial* Hall crystal
 What about *fractional partial* Hall crystals?
 Crystallization when doping relative to a fractional gap

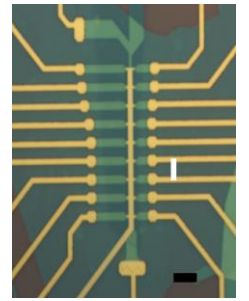


1.38° TBG: weak correlations at low fields

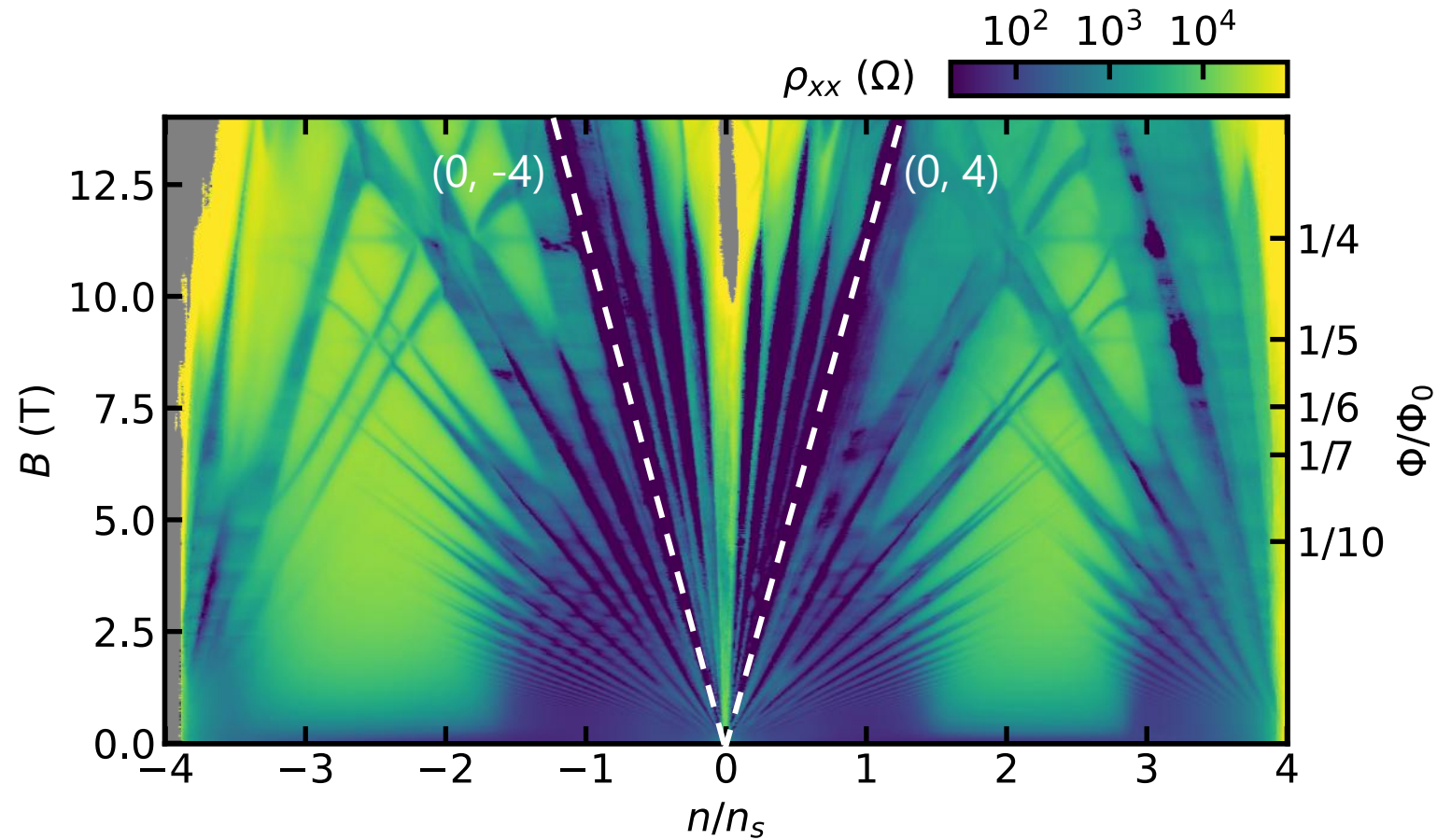


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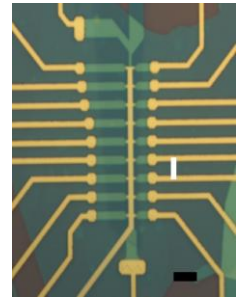
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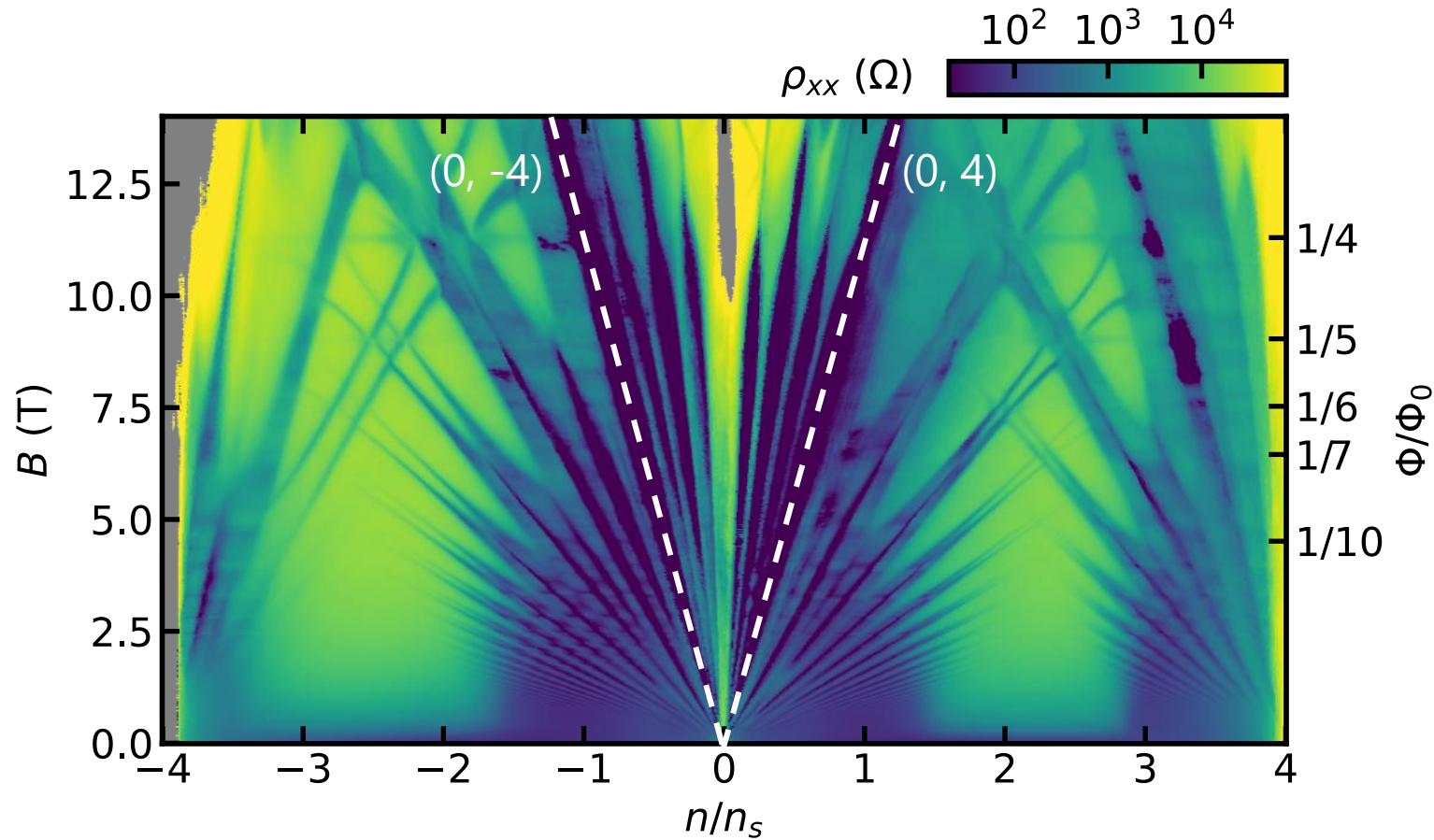
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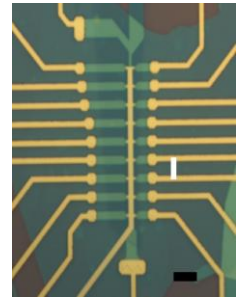
Diophantine: $n/n_s = s + t\Phi/\Phi_0$

Středa: $\sigma_{xy} = te^2/h$

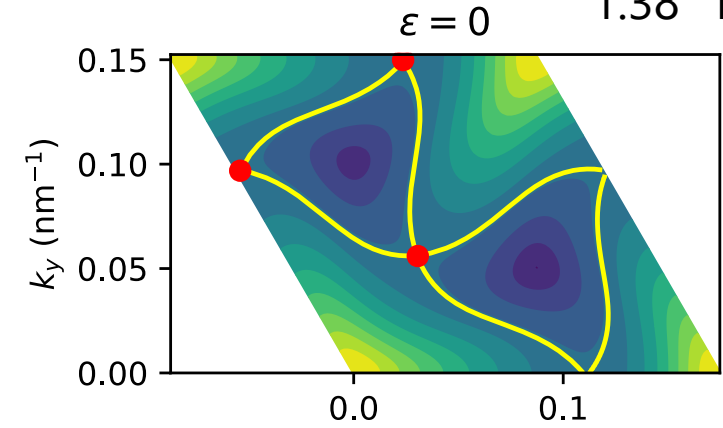
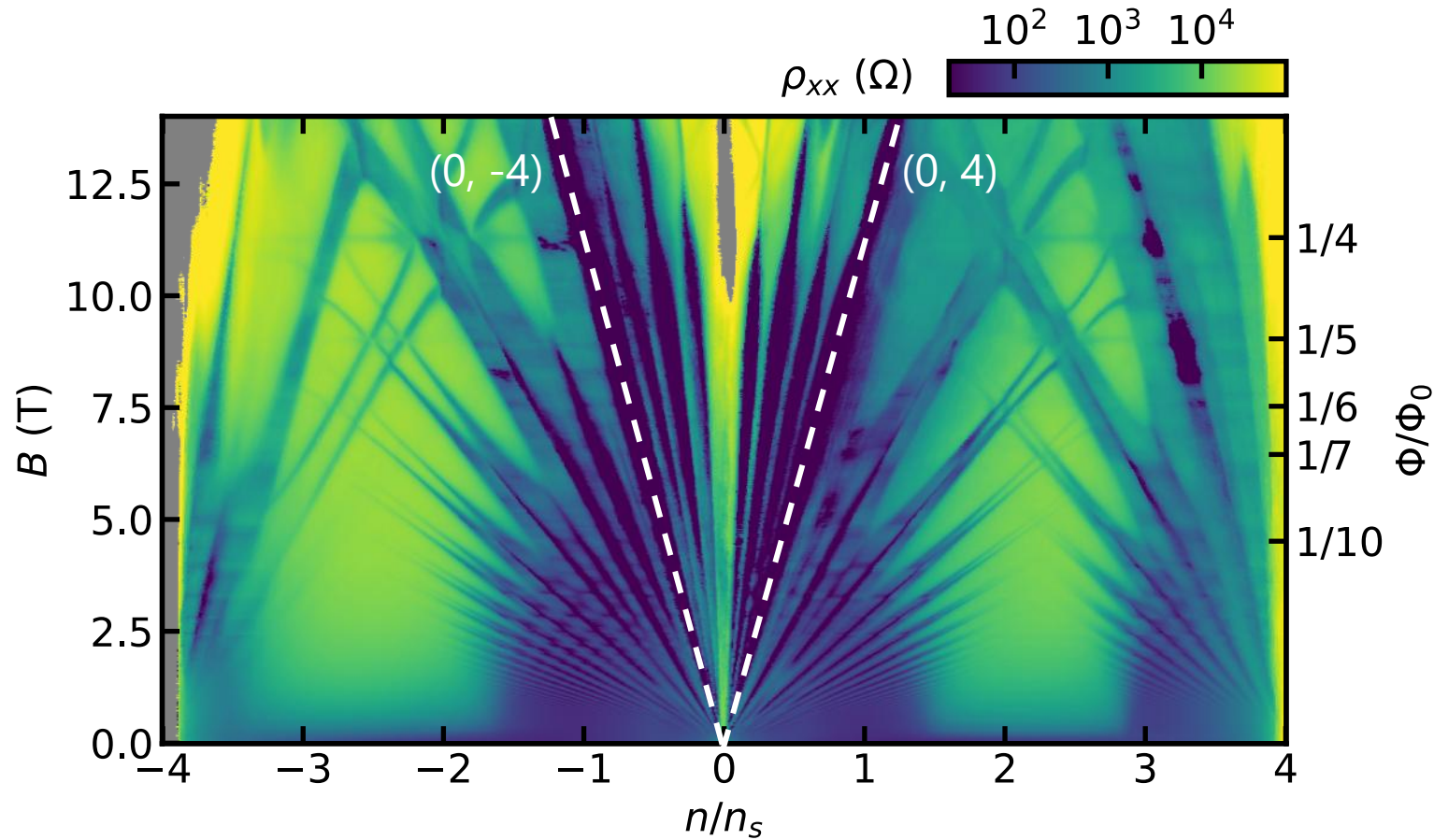
Notation: (s, t)

Wang, Finney, Sharpe, et al. PNAS (2023)
 Finney, Sharpe, et al. PNAS (2022)

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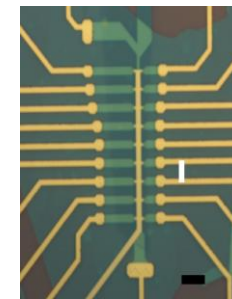
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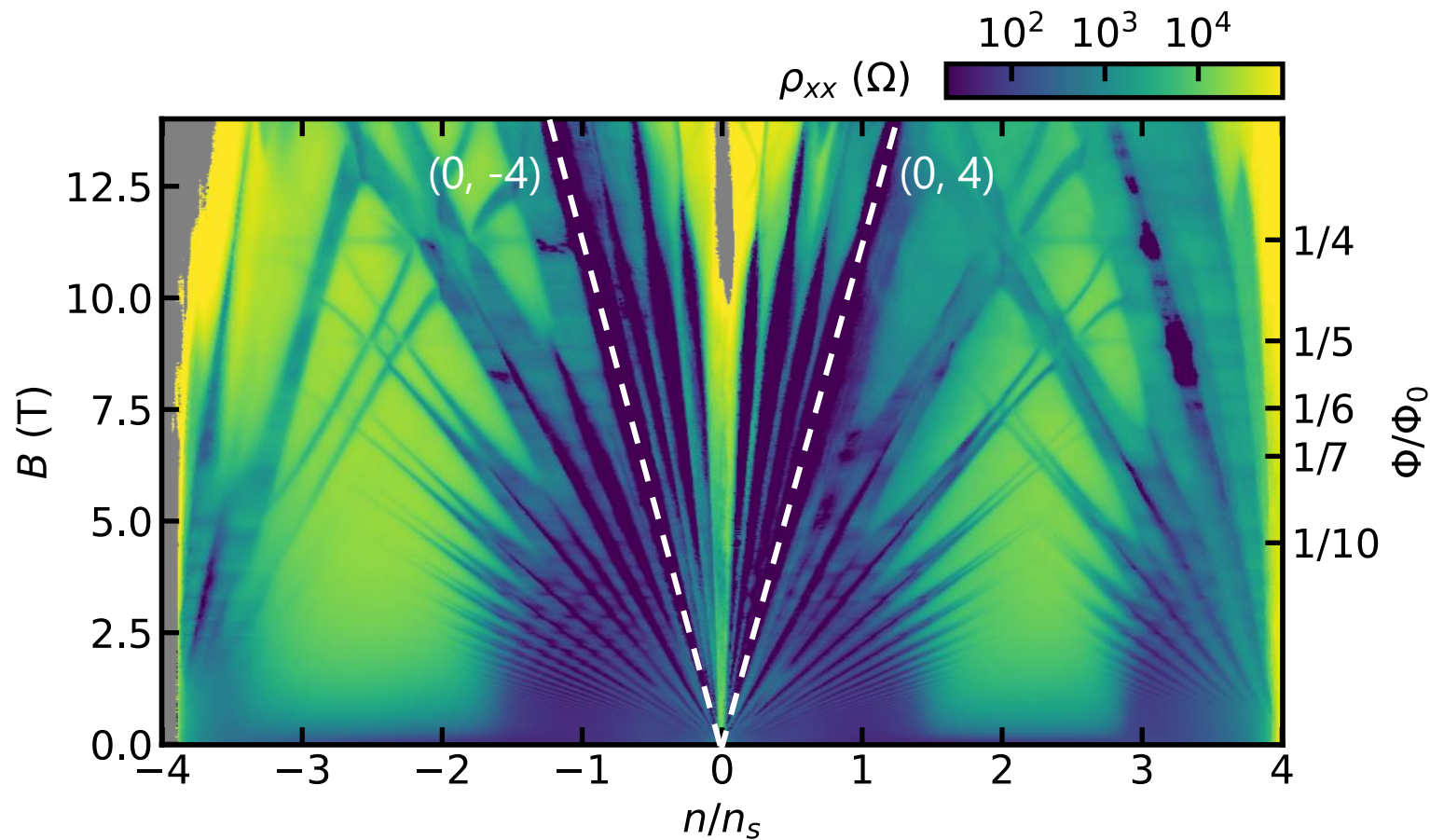
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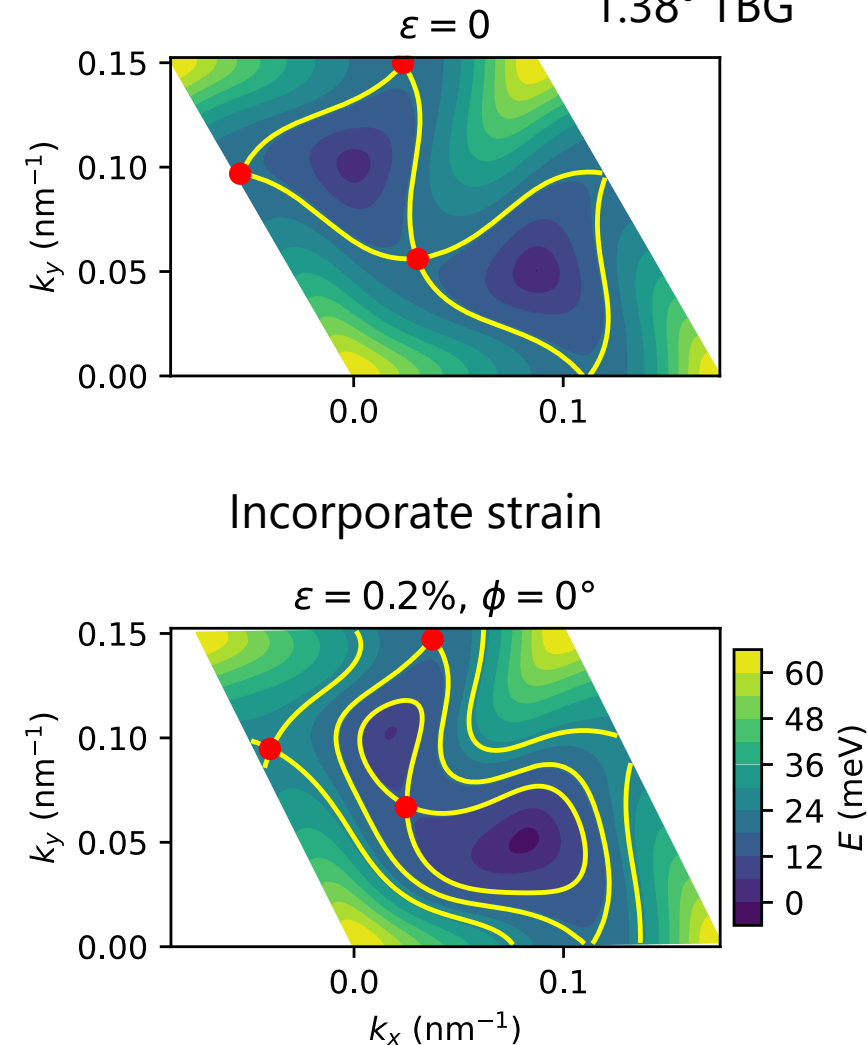
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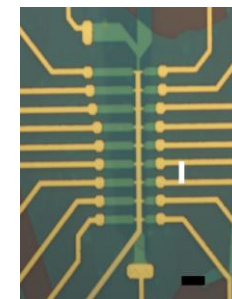
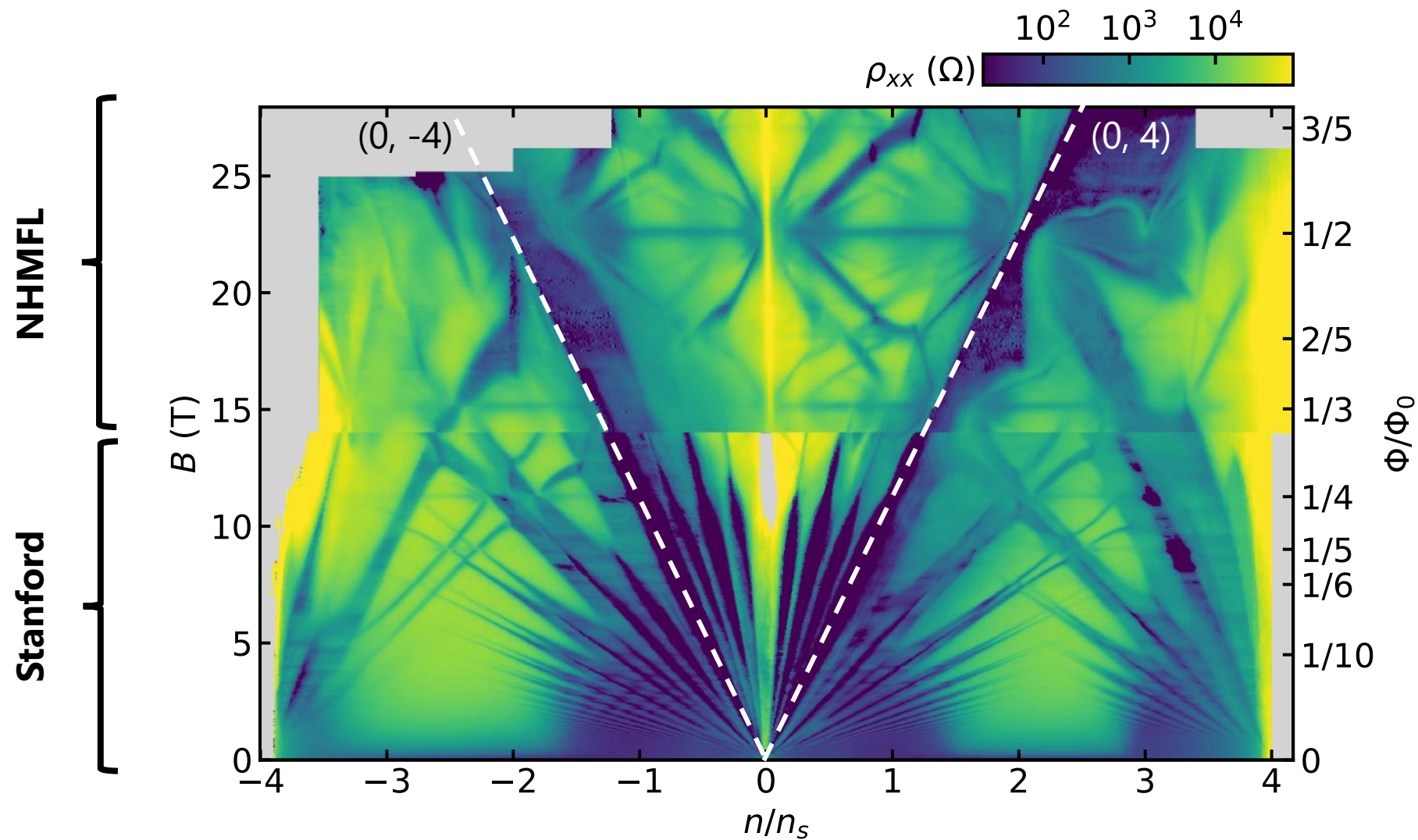


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Field induced correlation effects?

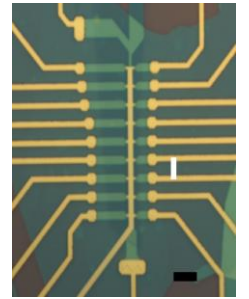


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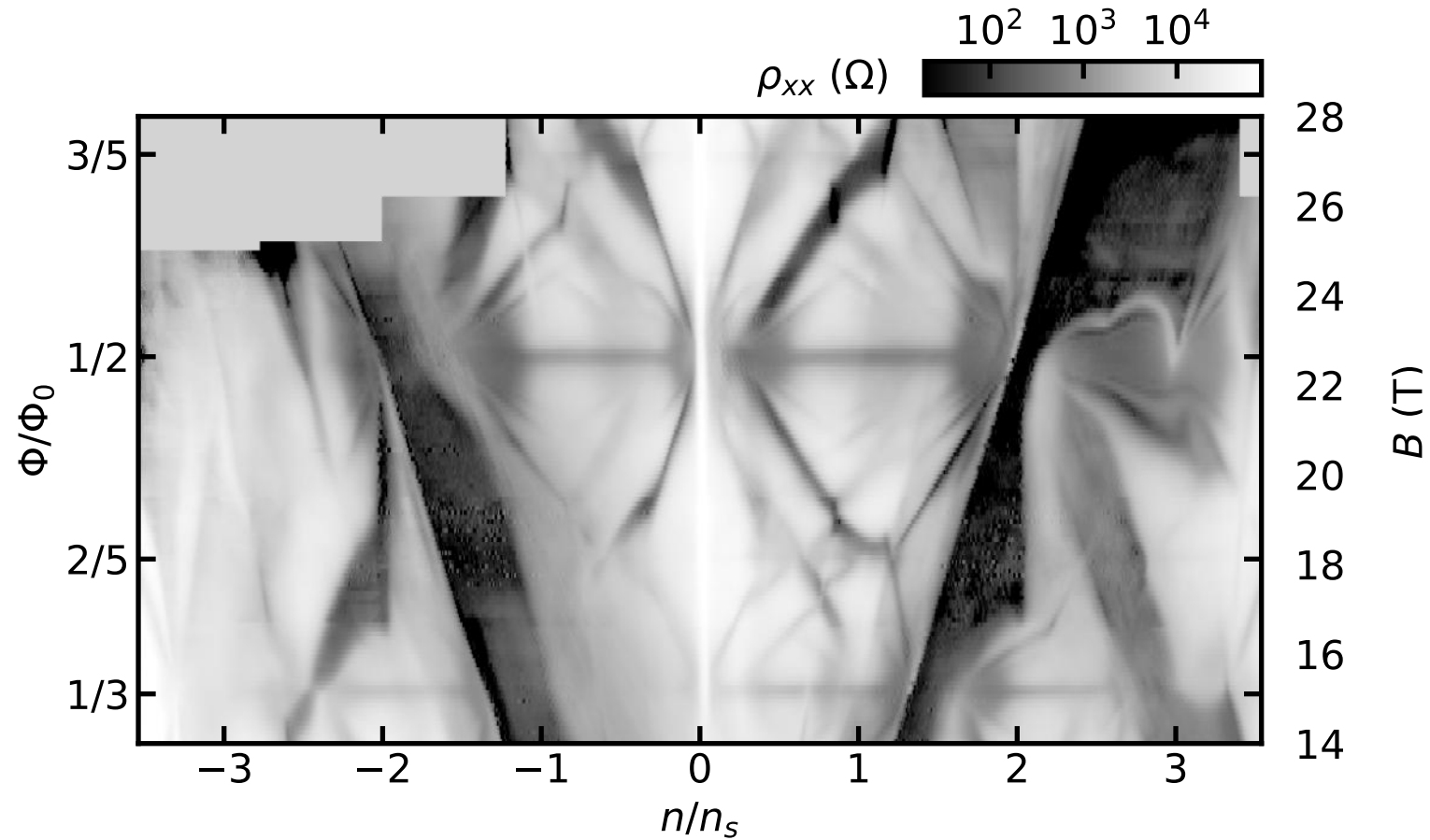
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Fractional Chern insulators



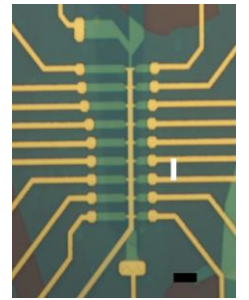
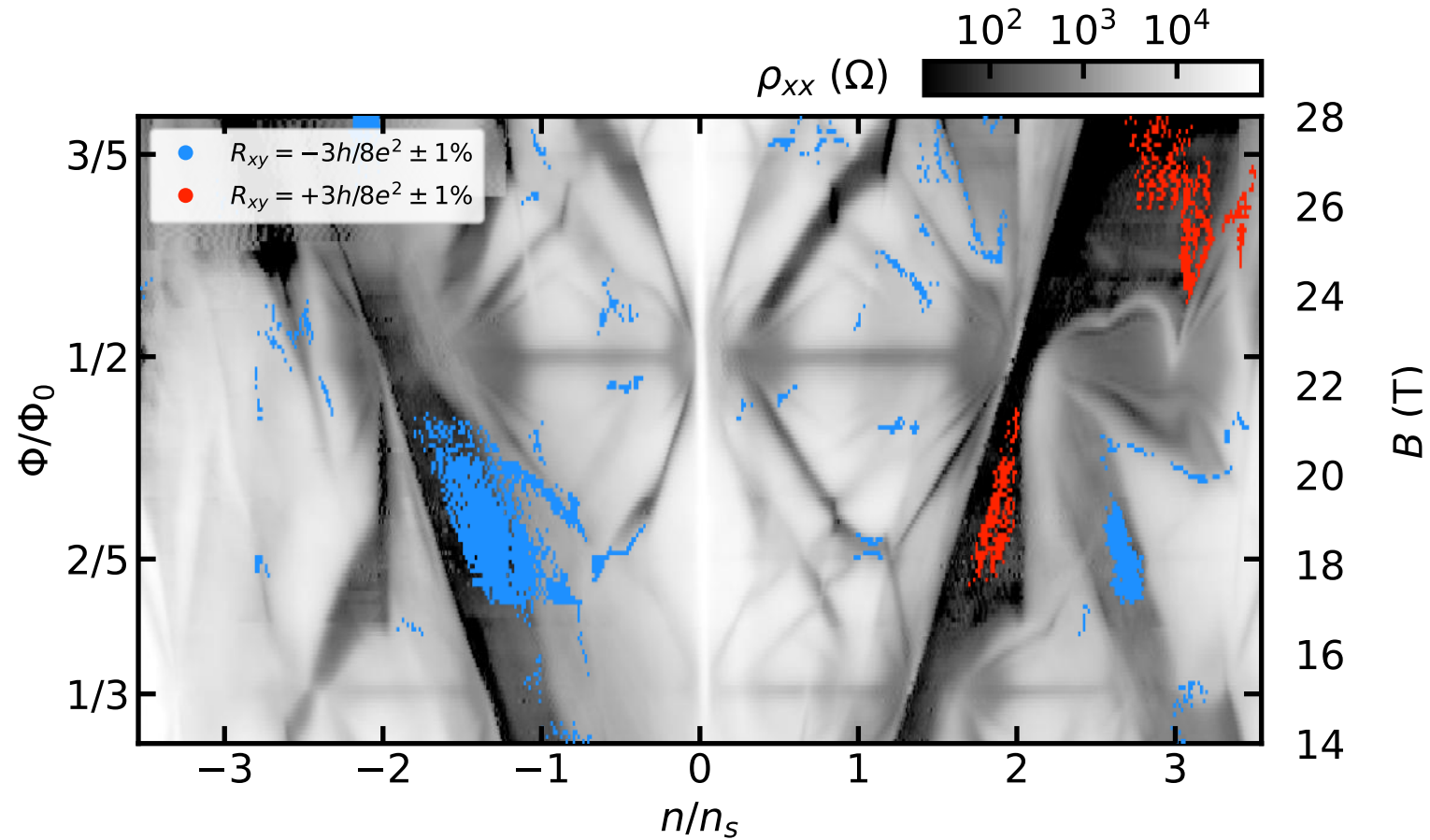
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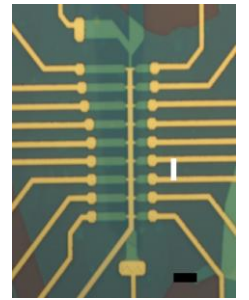
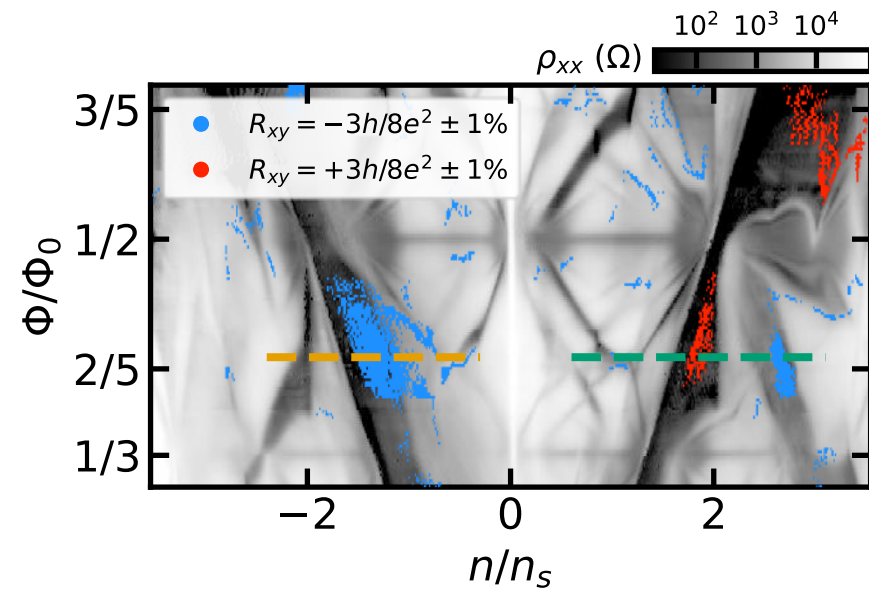
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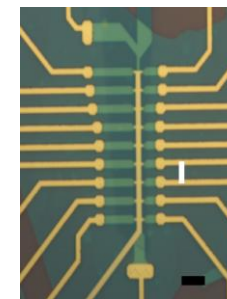
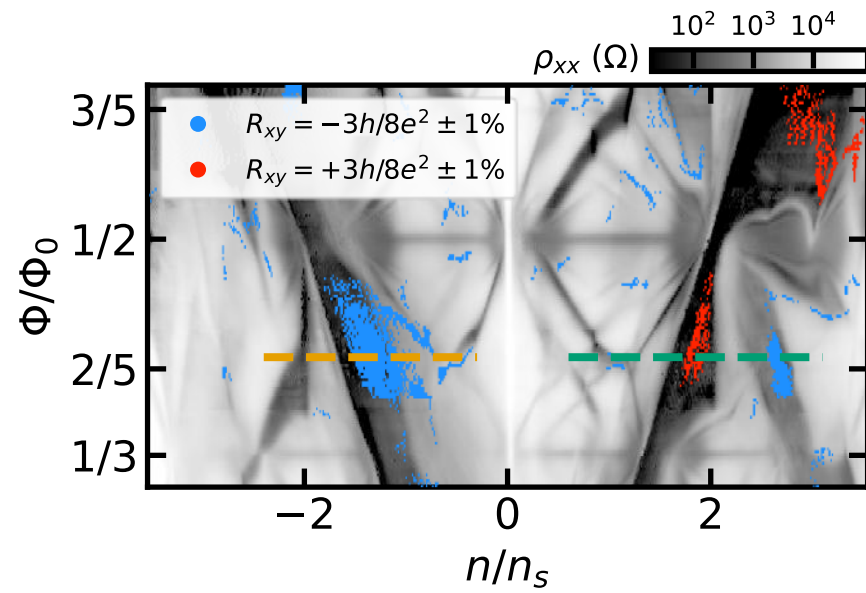
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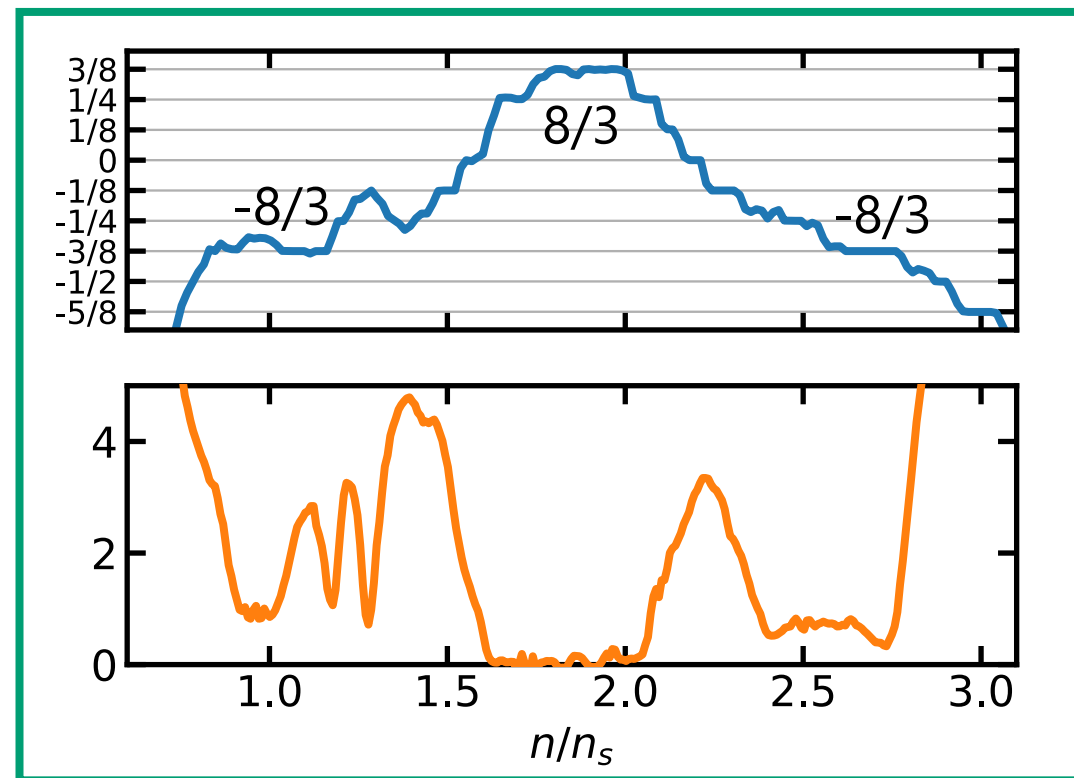
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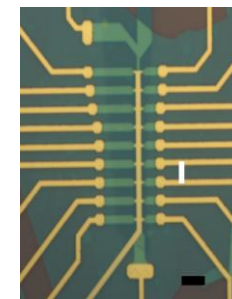
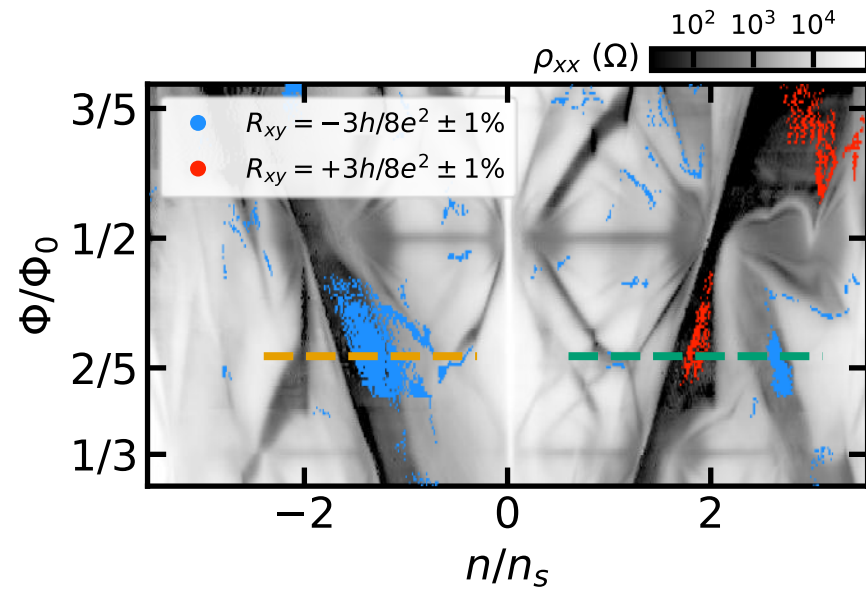


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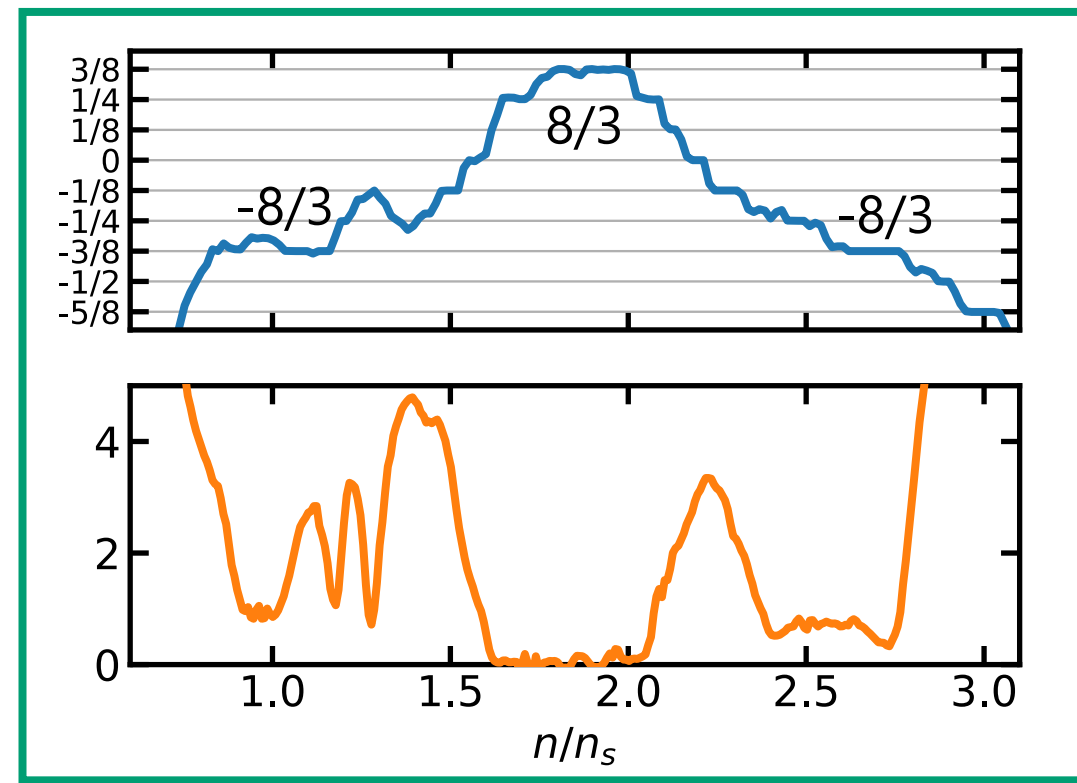
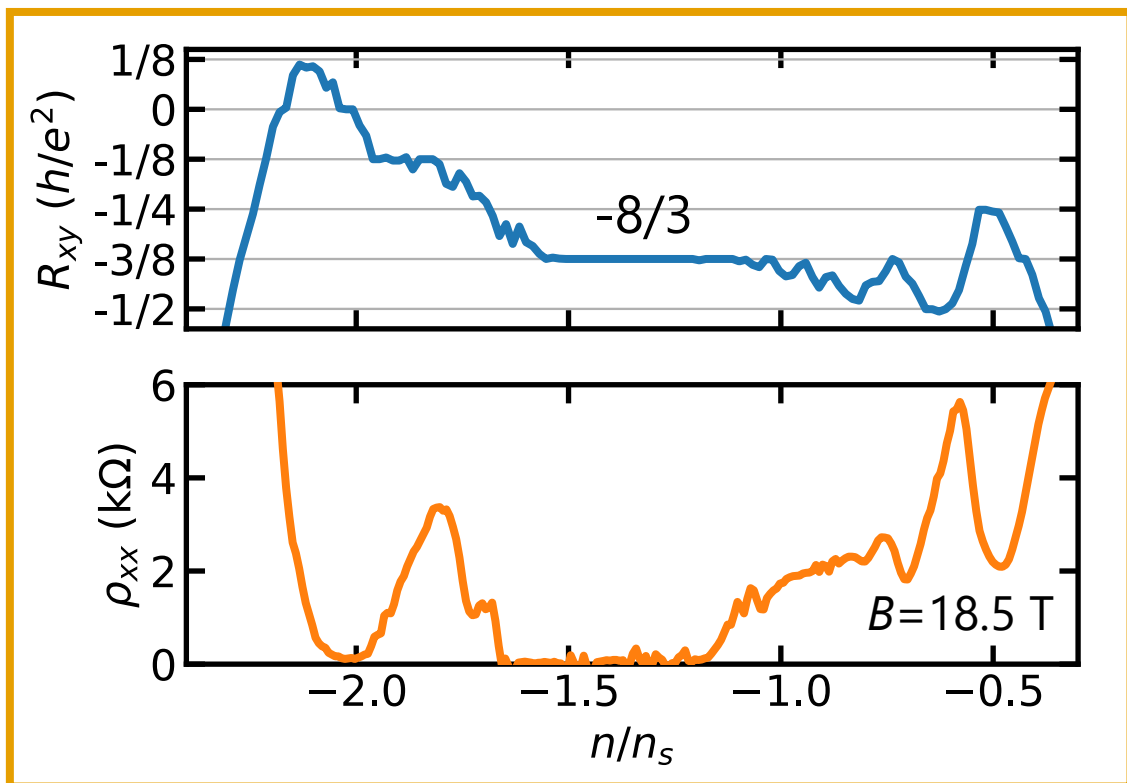


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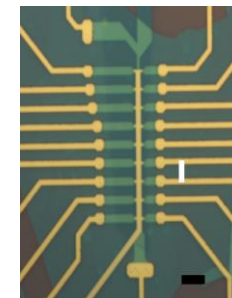




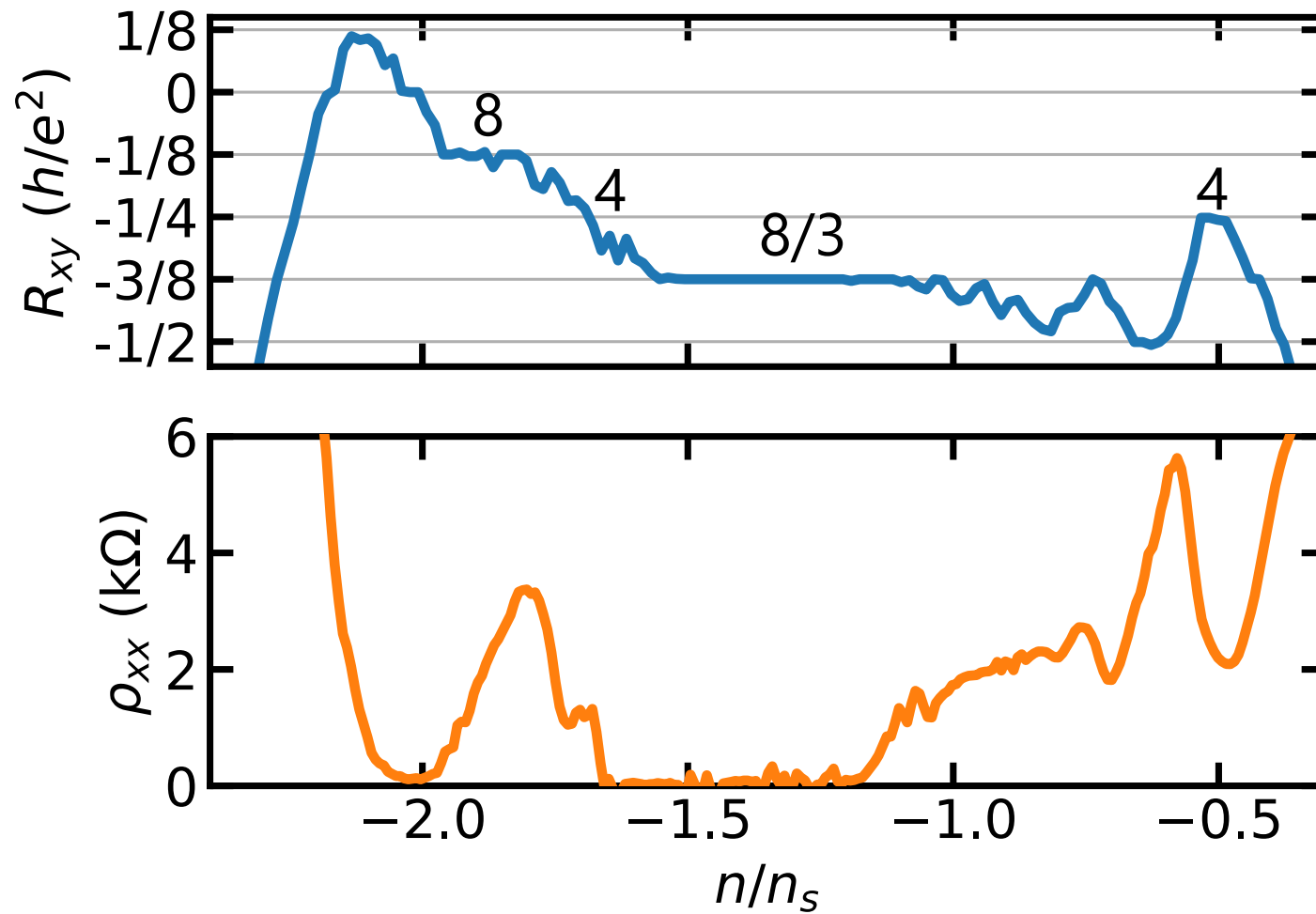
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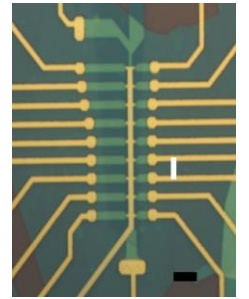
Extremely robust fractional state



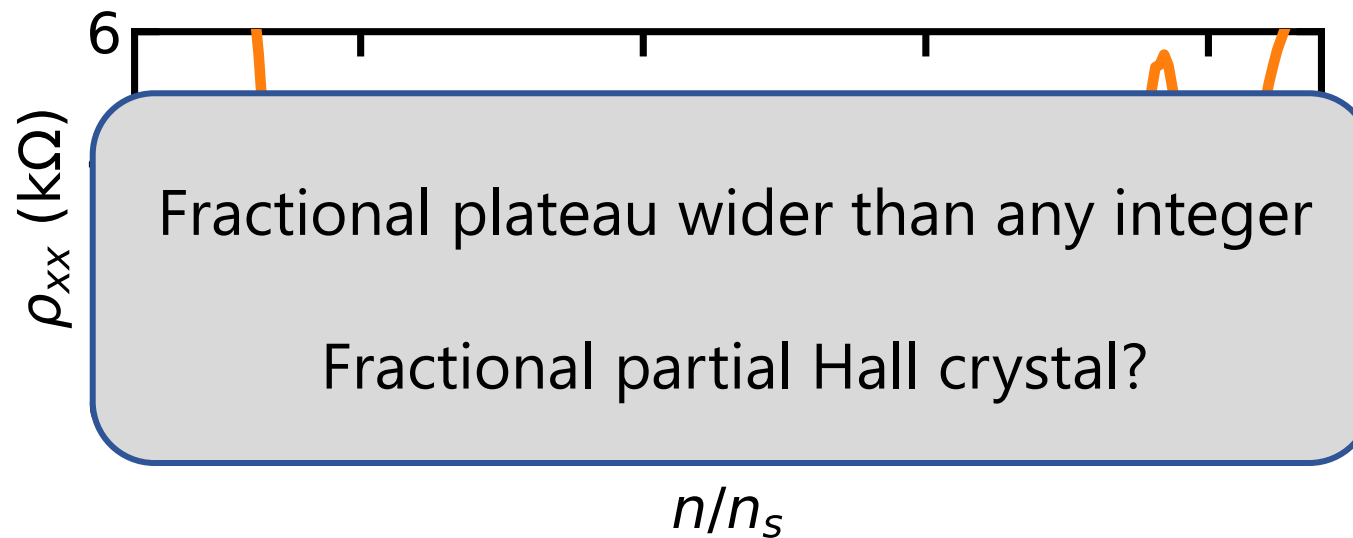
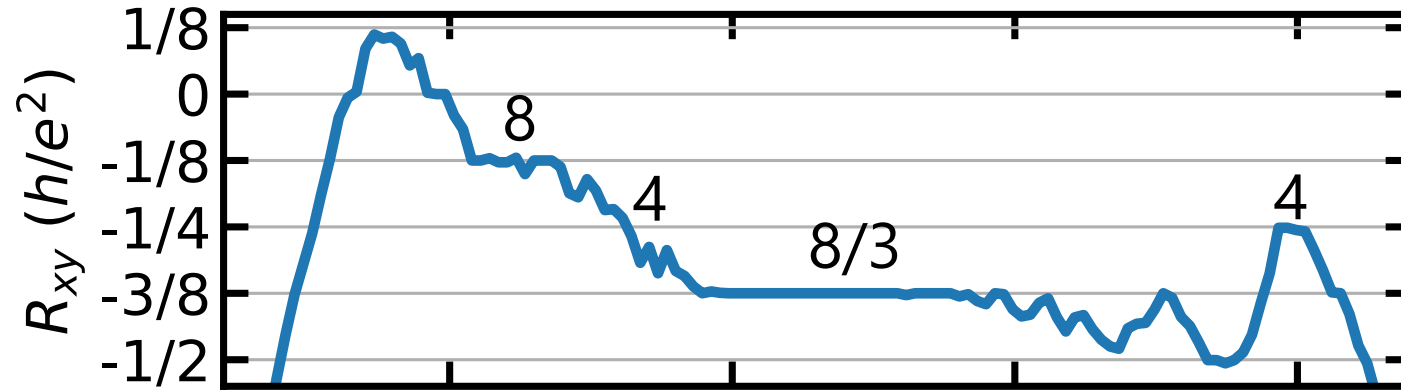
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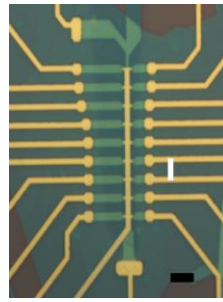
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1.38° TBG



Summary



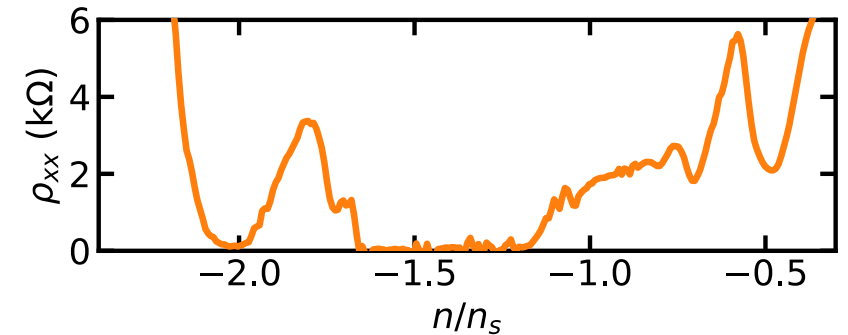
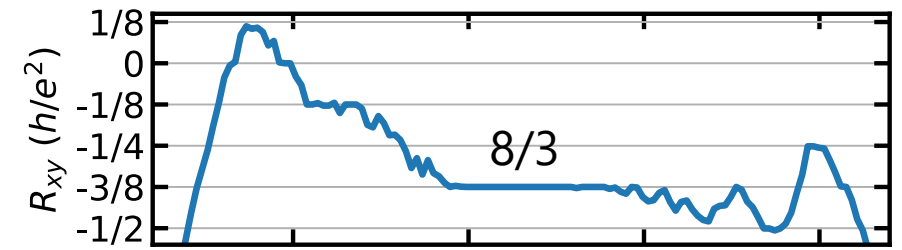
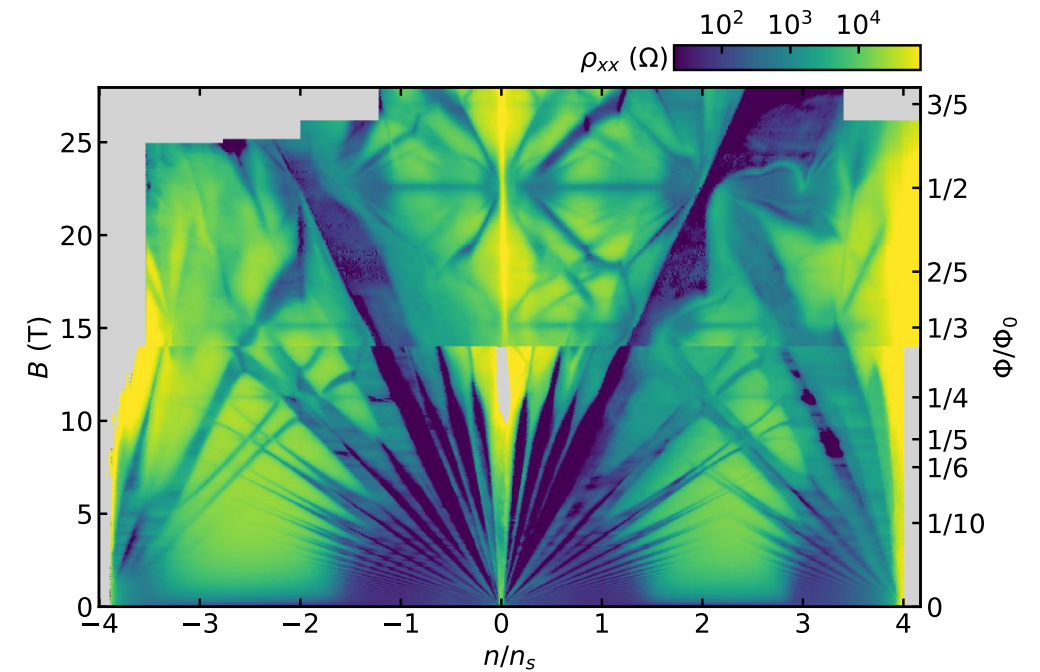
1.38° TBG

We still have much to learn about TBG!

Extended fractional Chern insulator near half flux!

Likely not extended because of **disorder**
More robustly quantized than any integer state

Fractional partial Hall crystal?



Acknowledgments



Joe Finney



Xiaoyu Wang



Jian Kang



David Goldhaber-Gordon



Marc Kastner



Oskar Vafek

Thanks

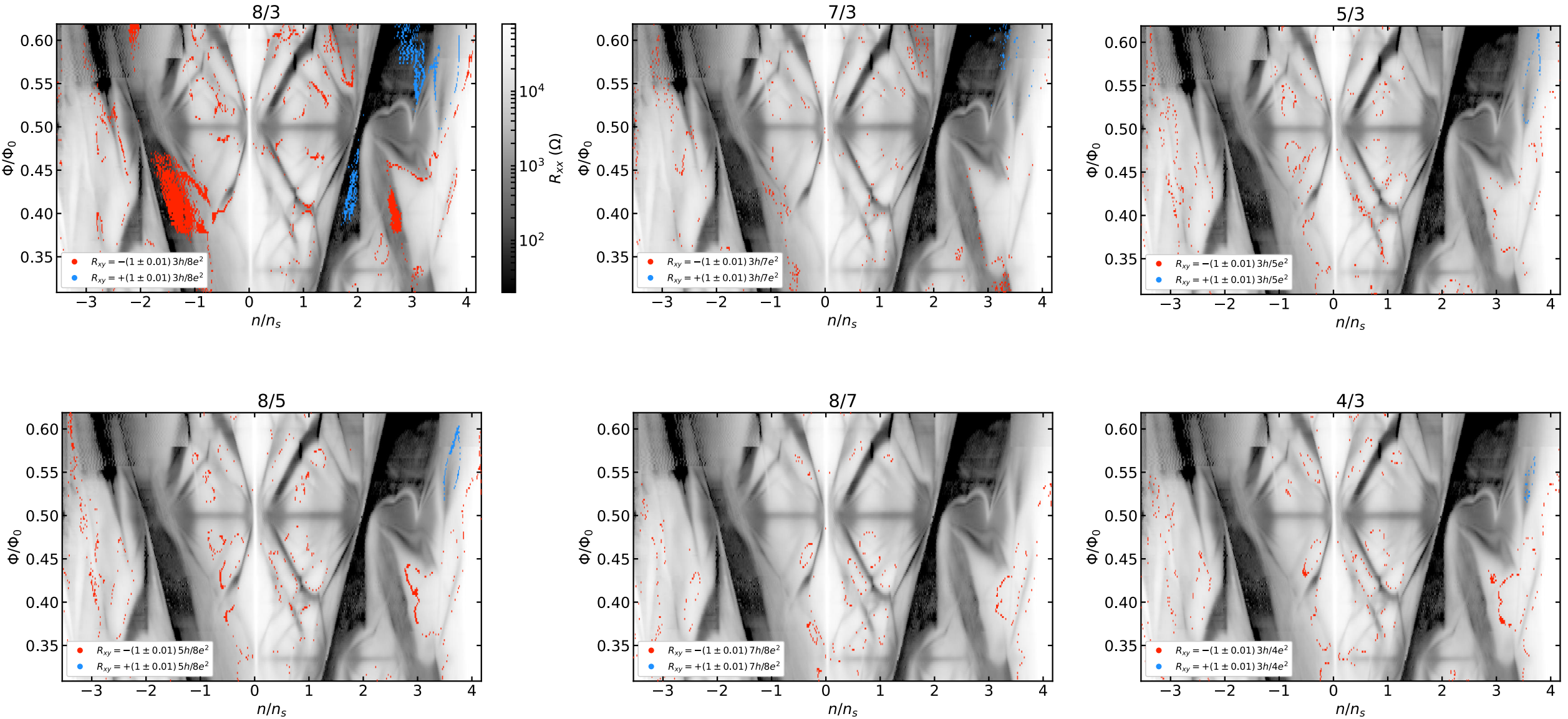
Linsey Rodenbach, Connie Hsueh

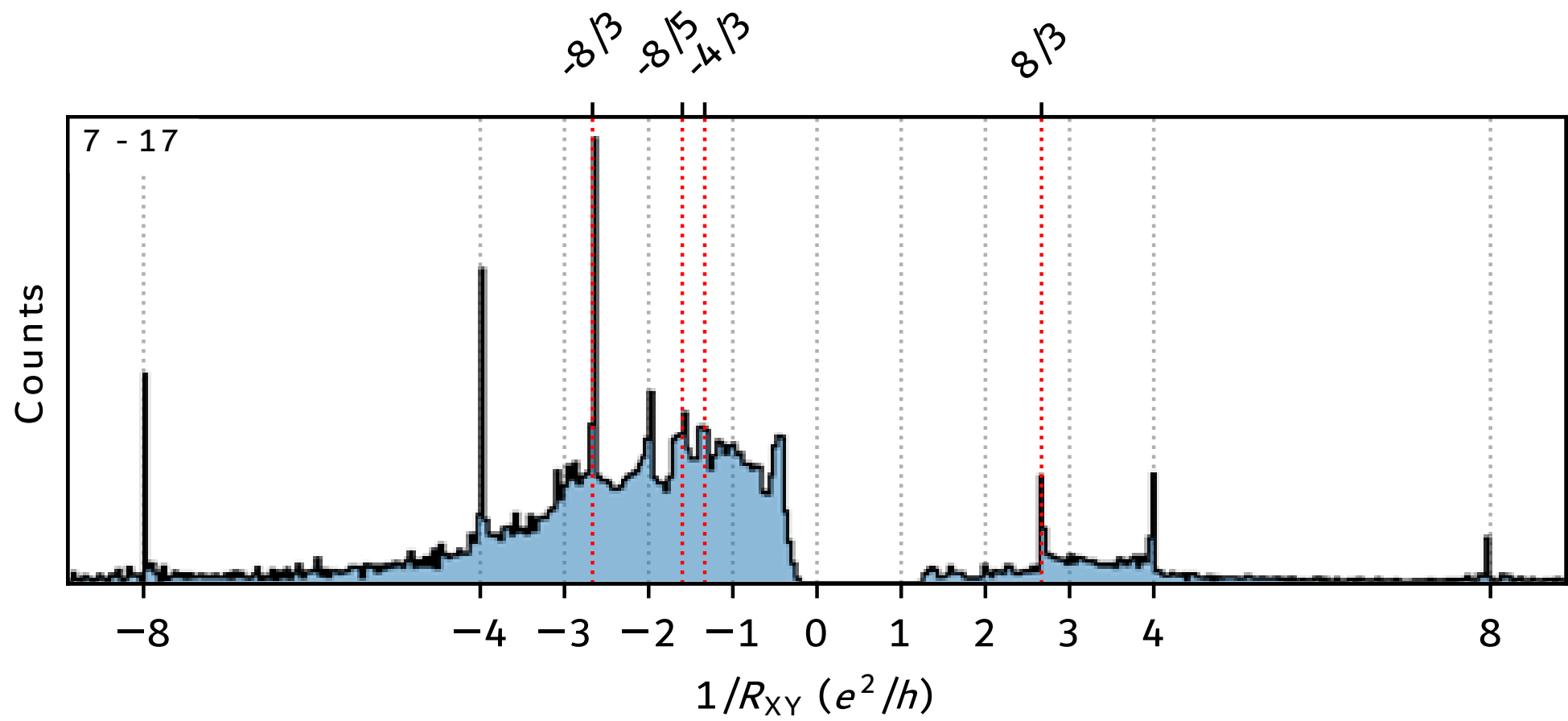
Takashi Taniguchi and Kenji Watanabe

National High Magnetic Field Lab

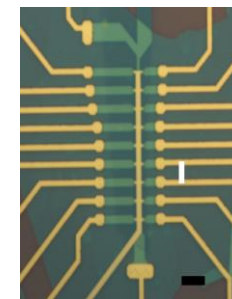
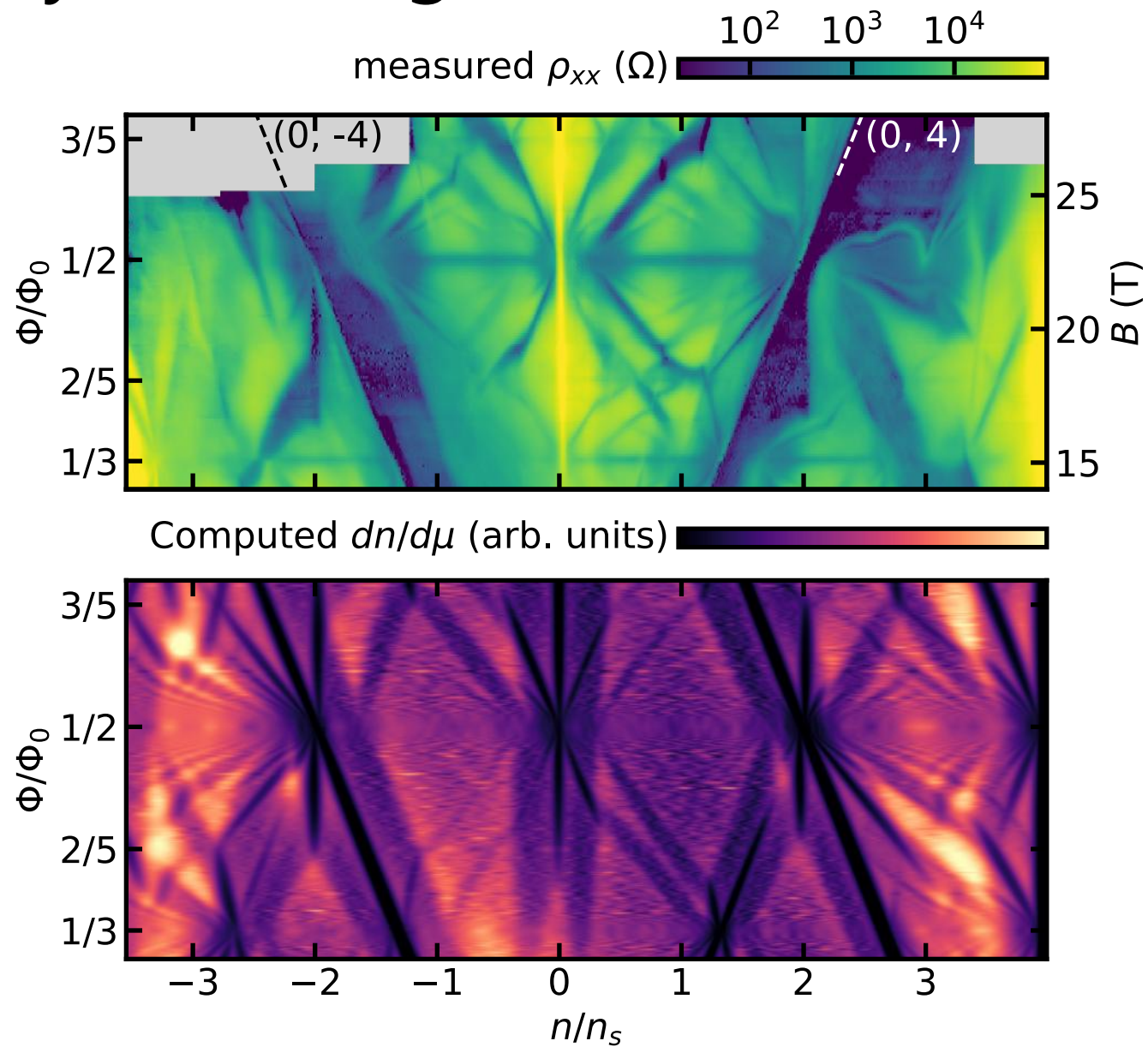
Wonderful discussions with:

Steve Kivelson, Julian May-Mann, Trithep Devakul,
Yves Kwan, Tomohiro Soejima, Patrick Ledwith,
Ben Feldman, Matt Yankowitz, Jonah Herzon-Arbeitman,
Nisarga Paul, Sayak Bhattacharjee





Correlated physics at high field



1.38° TBG