Magnetic anisotropy in twisted bilayer graphene and ABC-trilayer graphene aligned with hexagonal boron nitride

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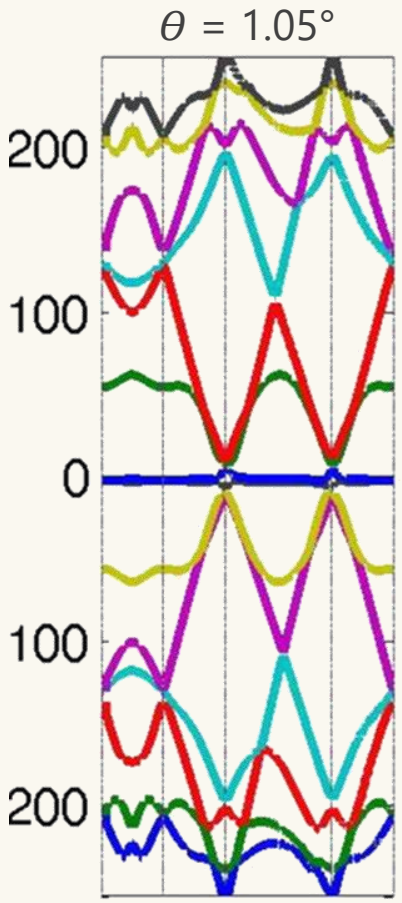
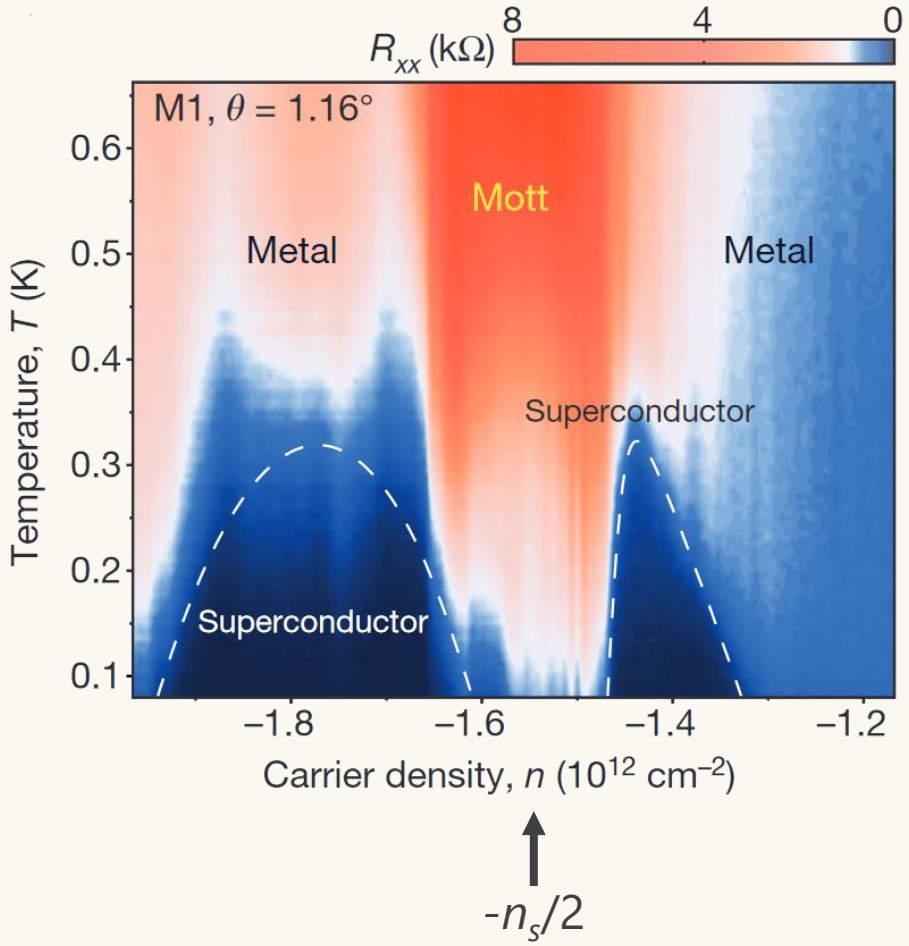
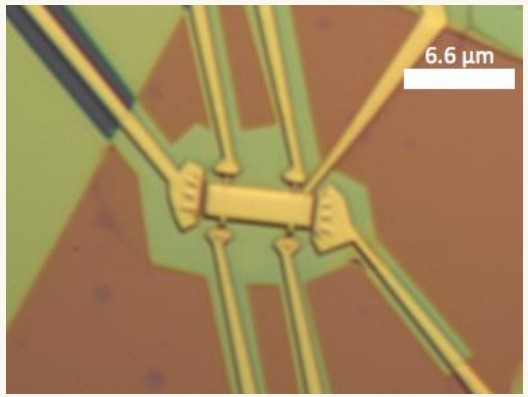
Magic Angle Twisted Bilayer Graphene

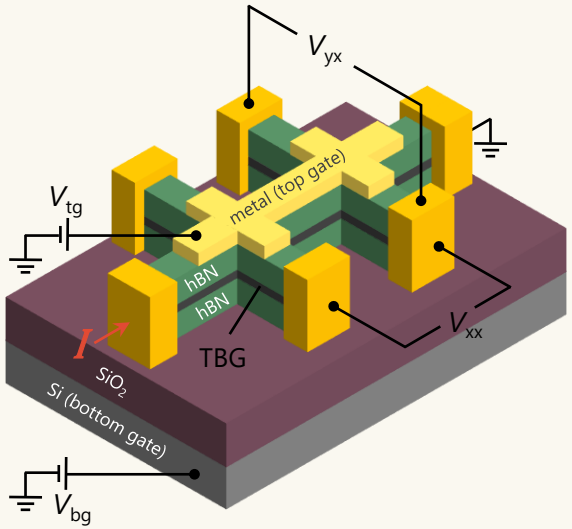


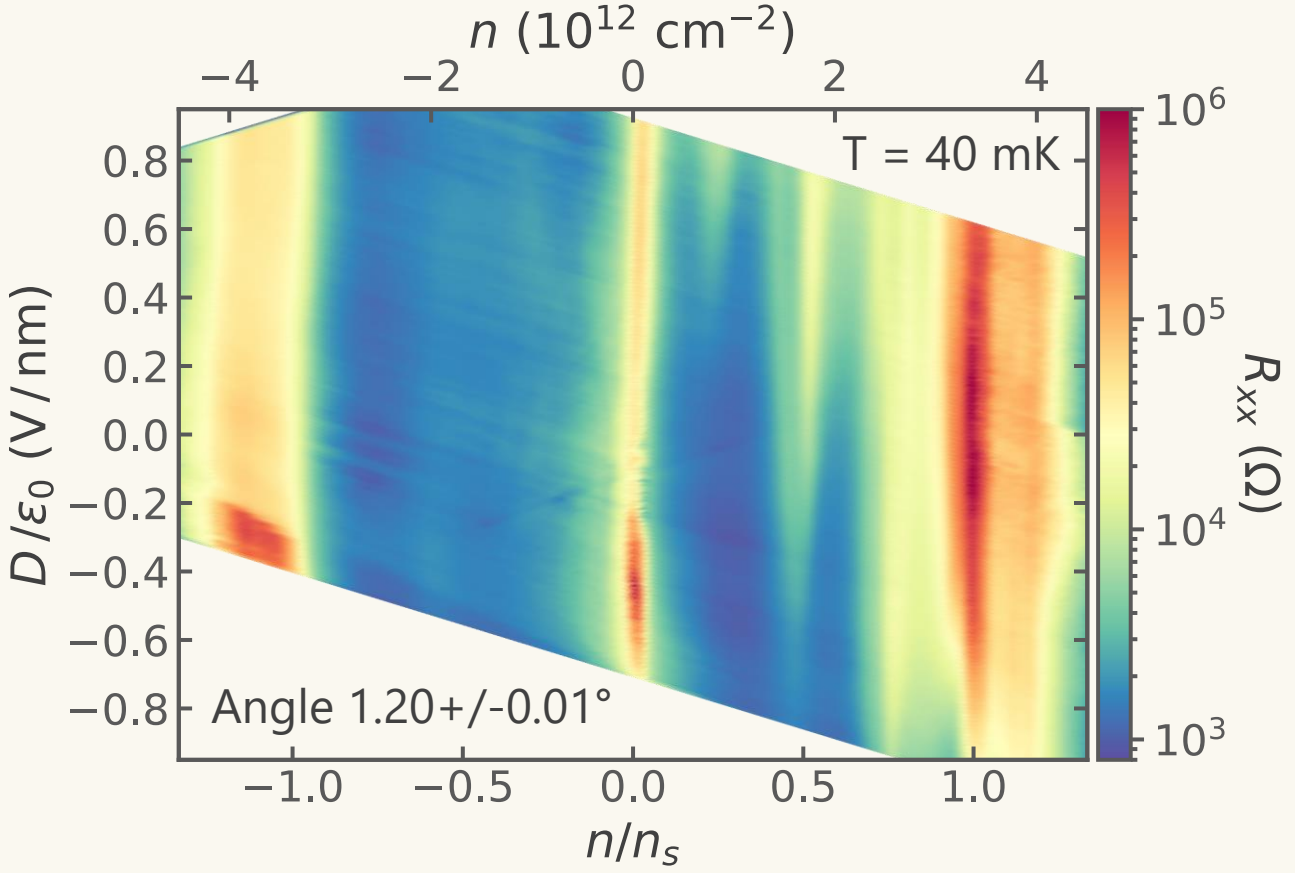


Bistritzer et al., PNAS (2011)
Cao et al., Nature (2018)

Twisted bilayer graphene aligned with hBN

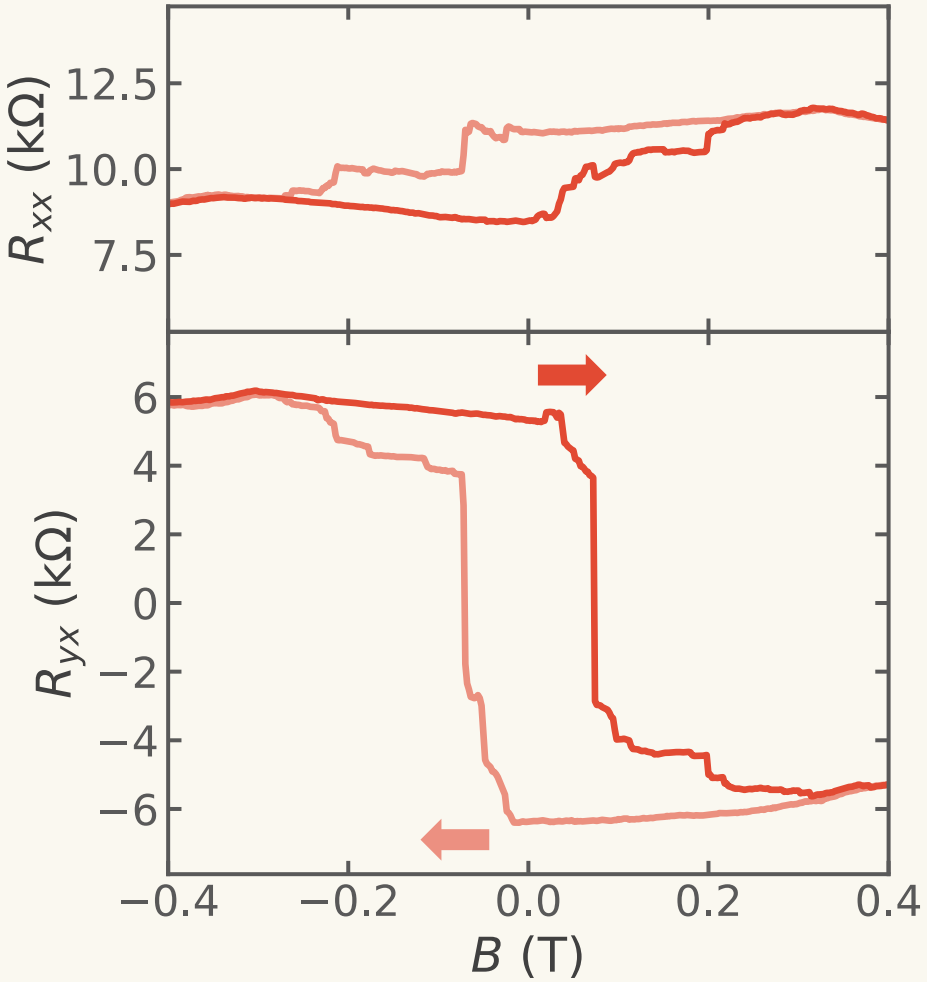


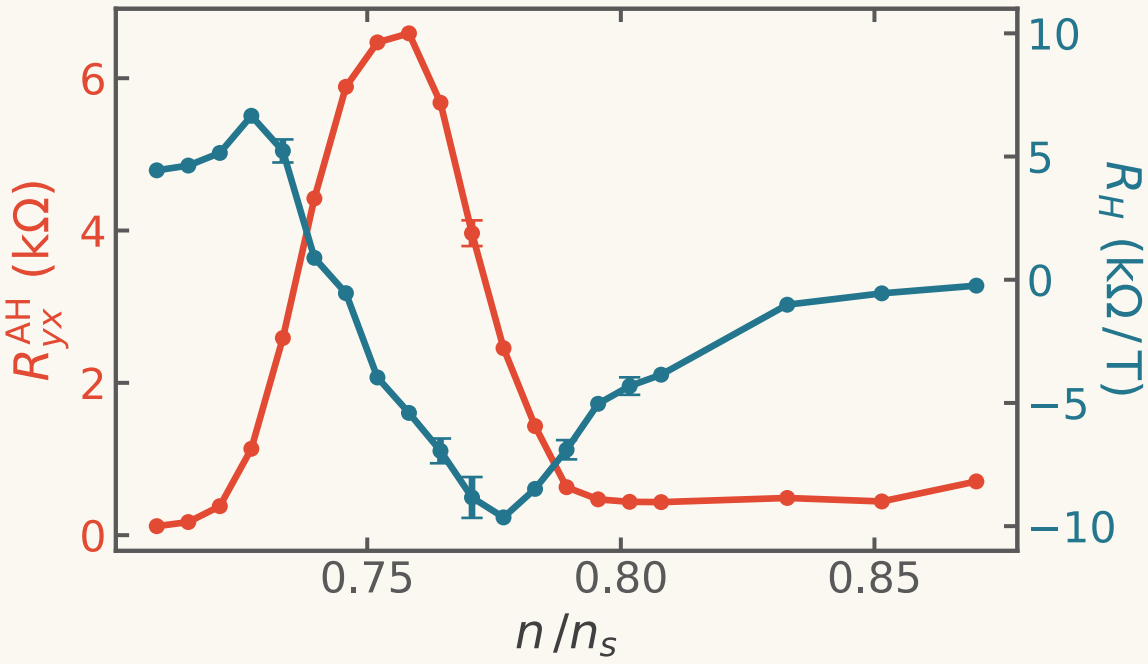




Sharpe et al., Science (2019)

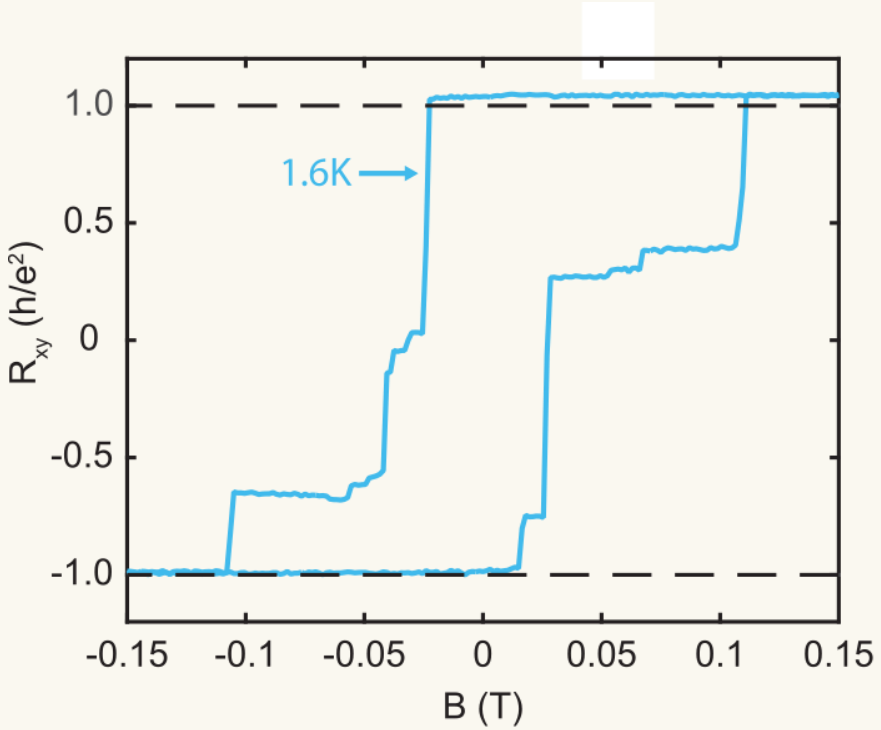
Emergent Ferromagnetism at ¾ Filling

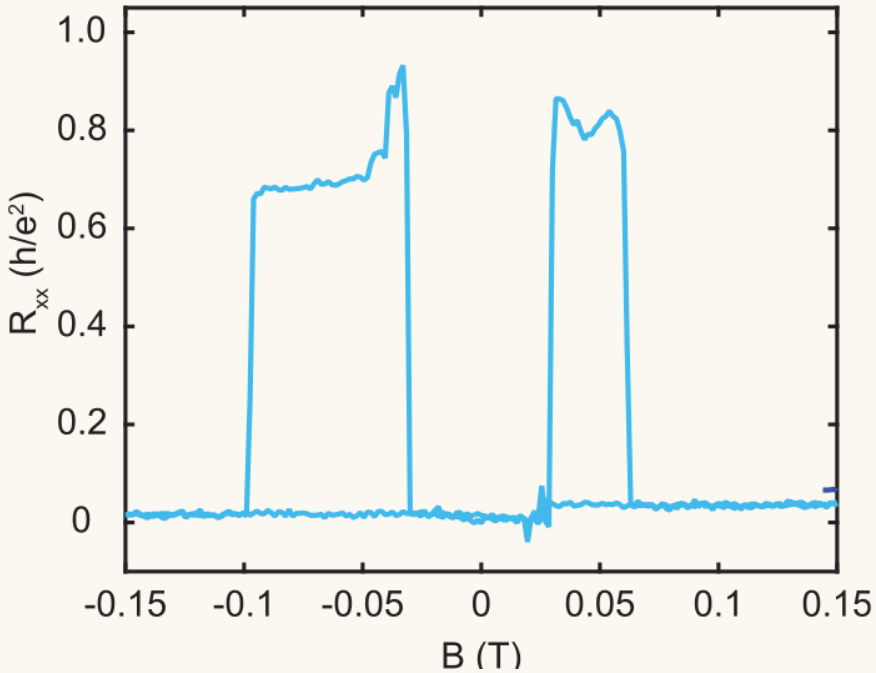


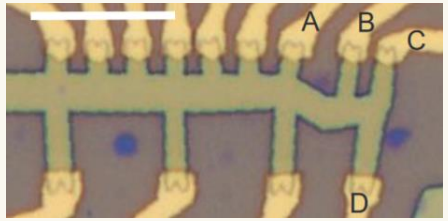


Sharpe et al., Science (2019)

Quantum Anomalous Hall in TBG

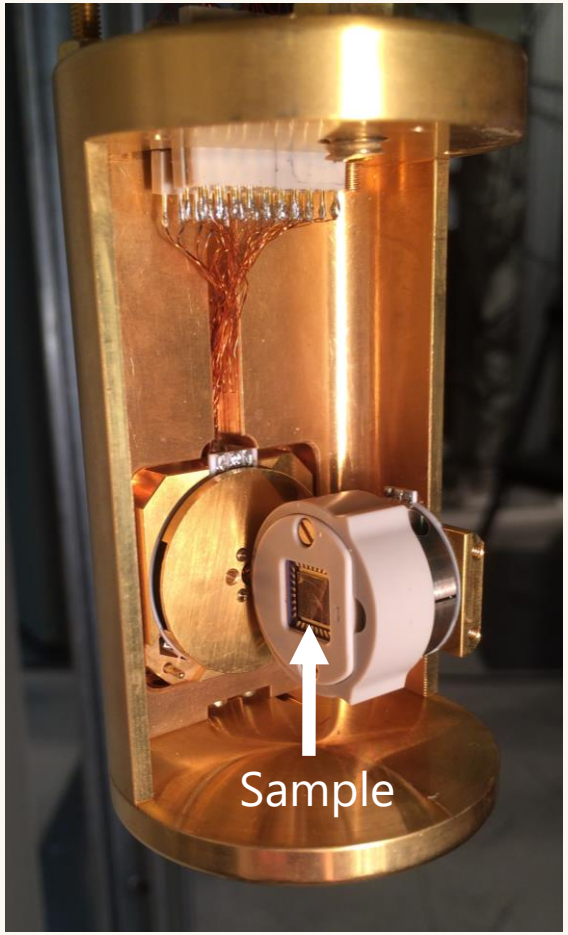


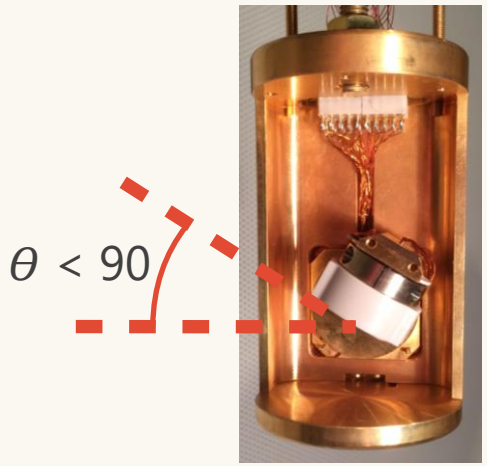


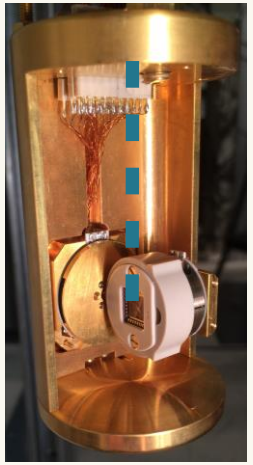


Serlin et al., Science (2019)

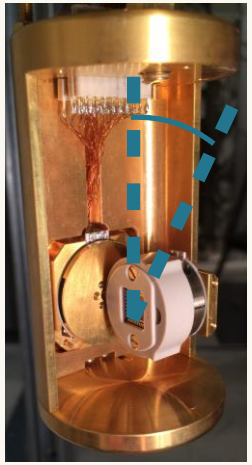
Probing Nature of Magnetism





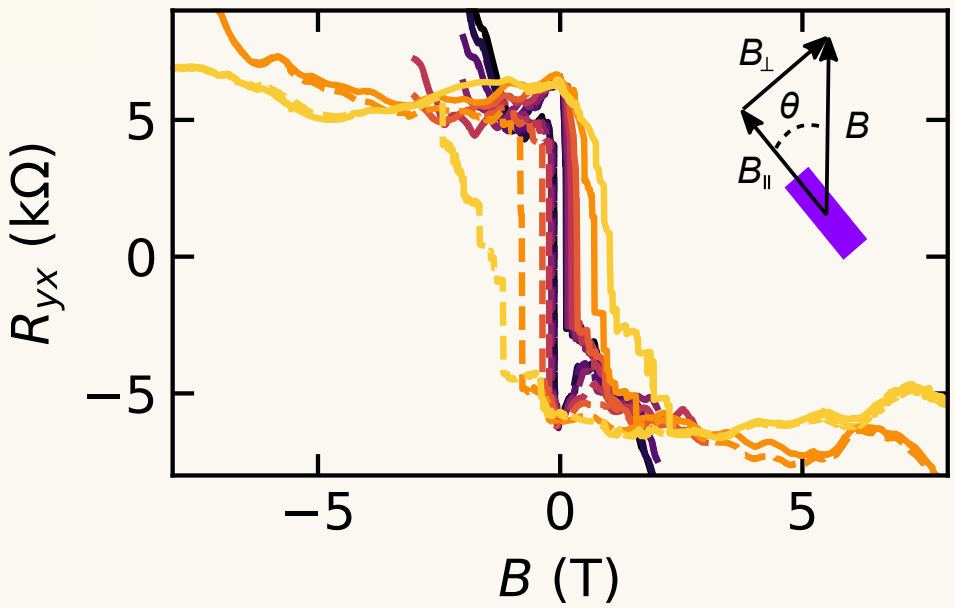


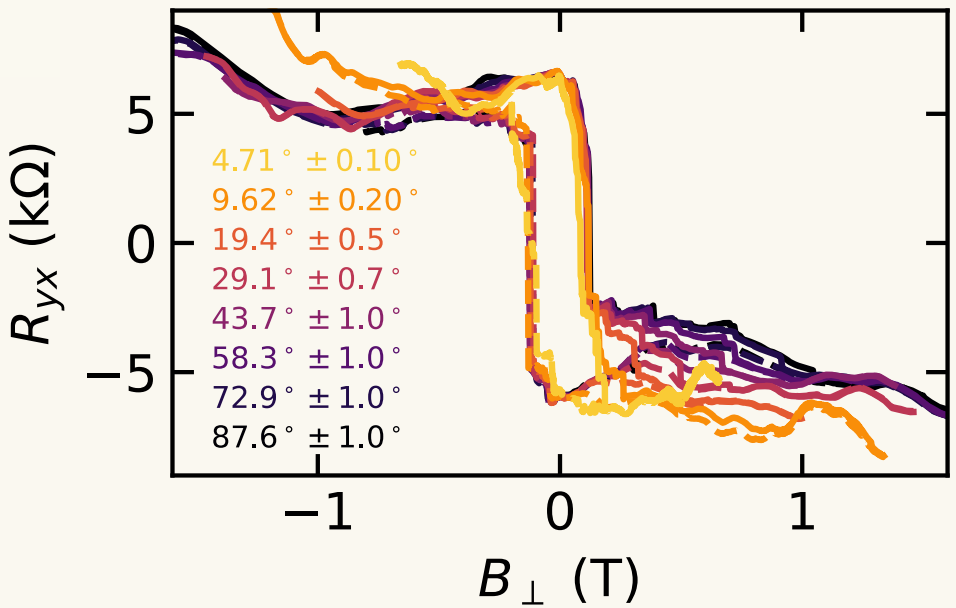
φ = 0



φ > 0

Hysteresis Loops in Tilted Field

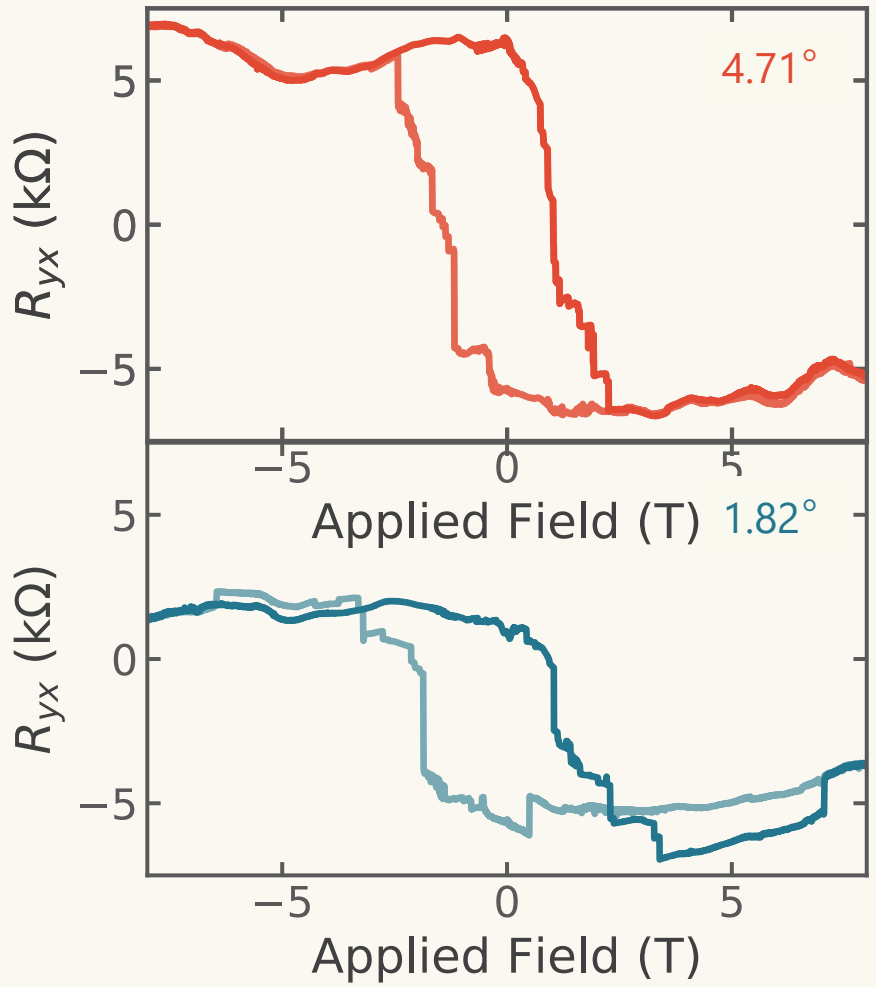


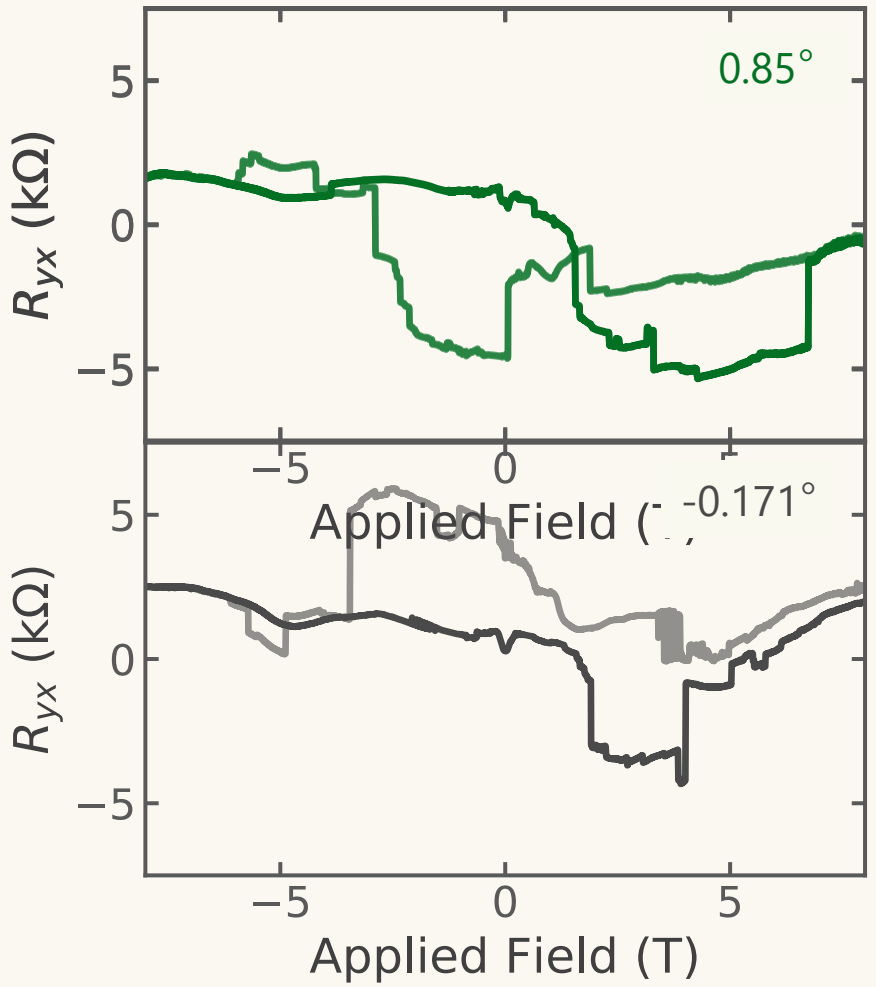


Mostly sensitive to perpendicular component!

Sharpe et al., Nano Lett. (2021)

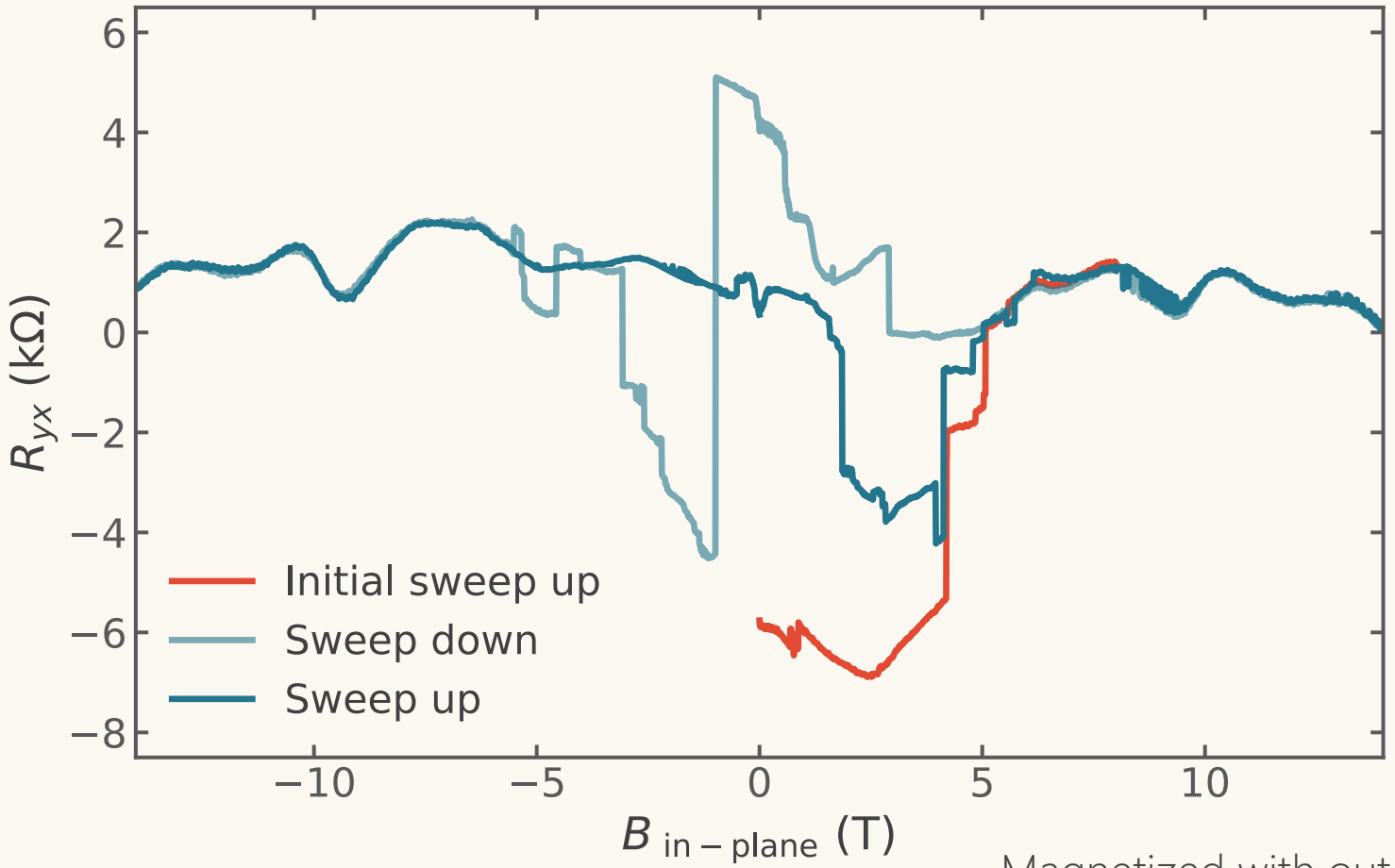
Behavior Near In-Plane Field





Sharpe et al., Nano Lett. (2021)

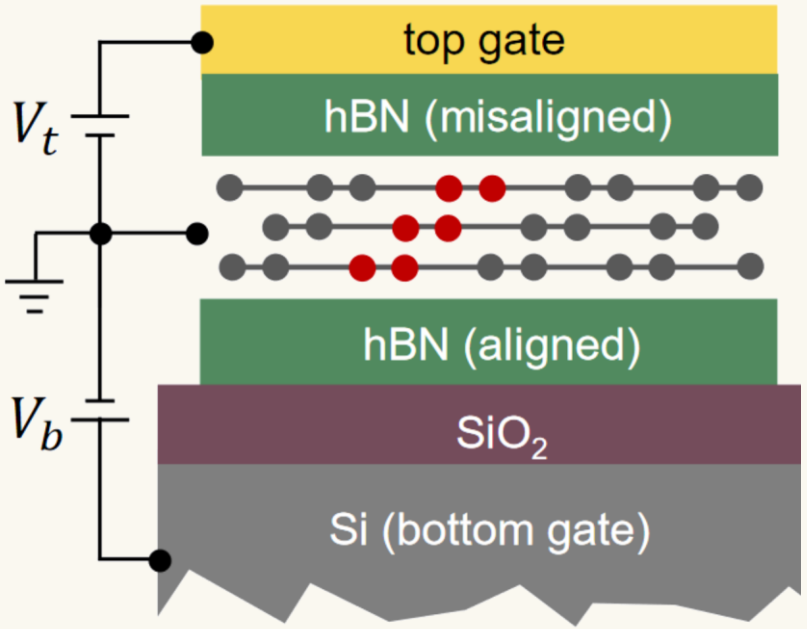
Applying In-Plane Field to a Magnetized State

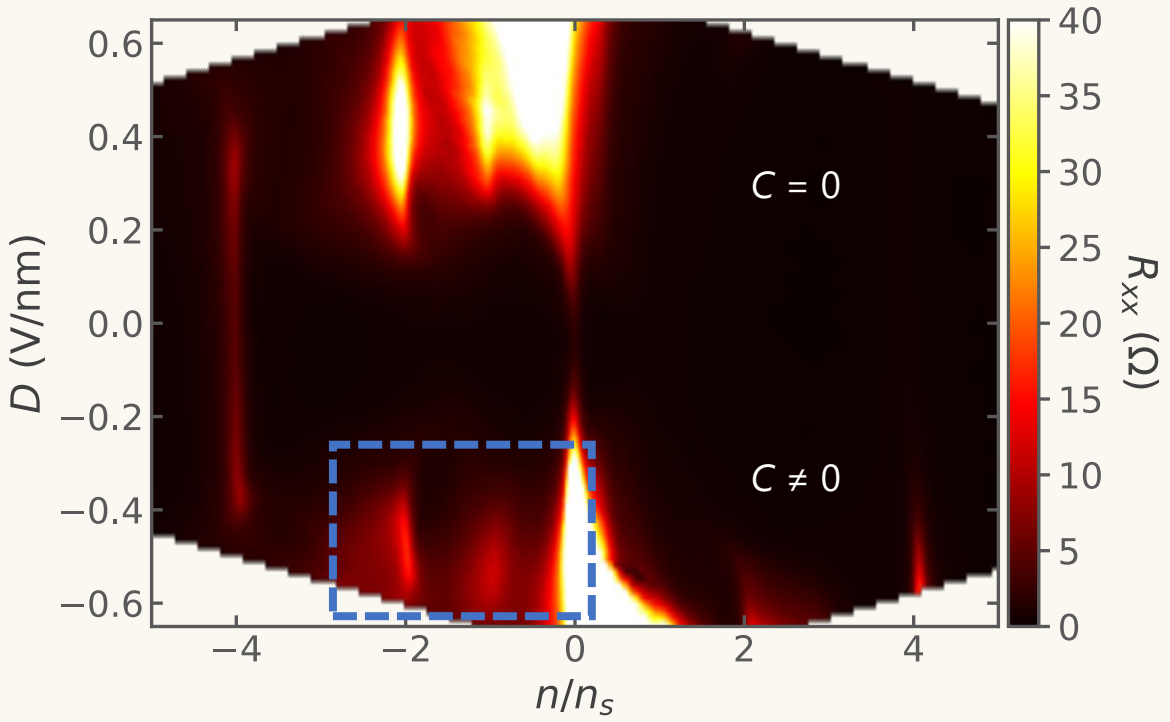


Magnetized with out-of-plane field
Rotated to in-plane in zero field

Sharpe et al., Nano Lett. (2021)

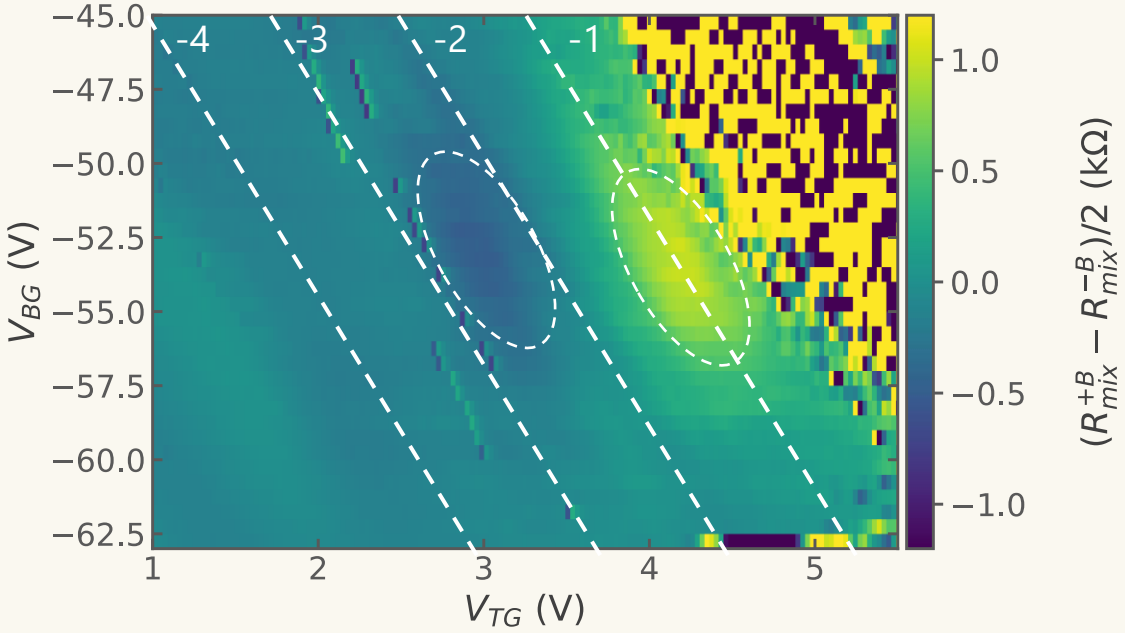
ABC-Trilayer Graphene Aligned with hBN



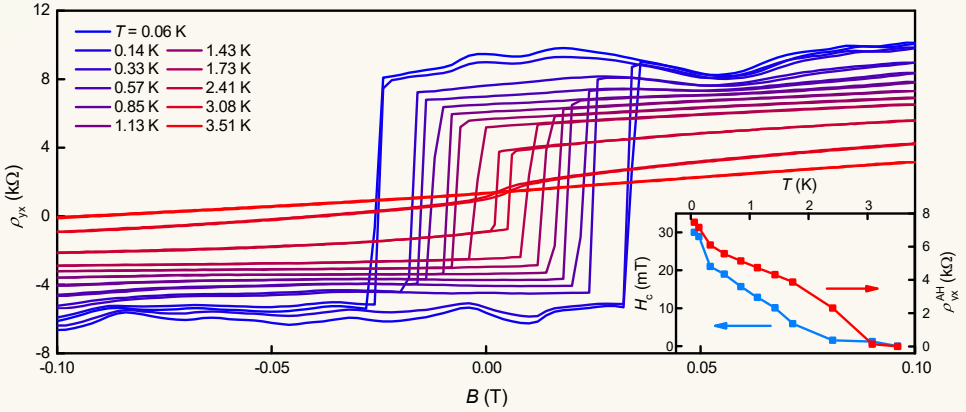


Chen, Sharpe et al., Nano Lett. (2022)
Chen, Sharpe et al., Nature (2020)
Chen, Sharpe et al., Nature (2019)

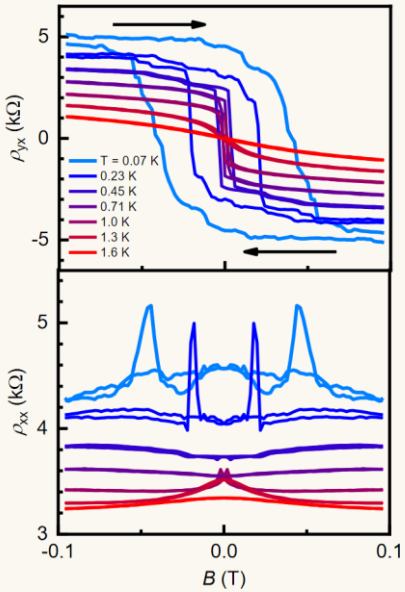
Magnetic Correlated States



n/n_s = -1

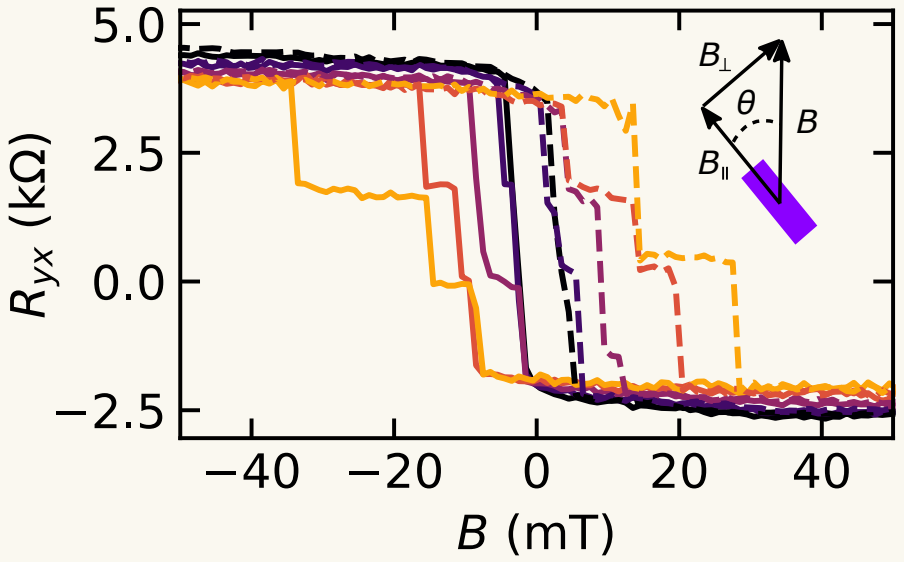


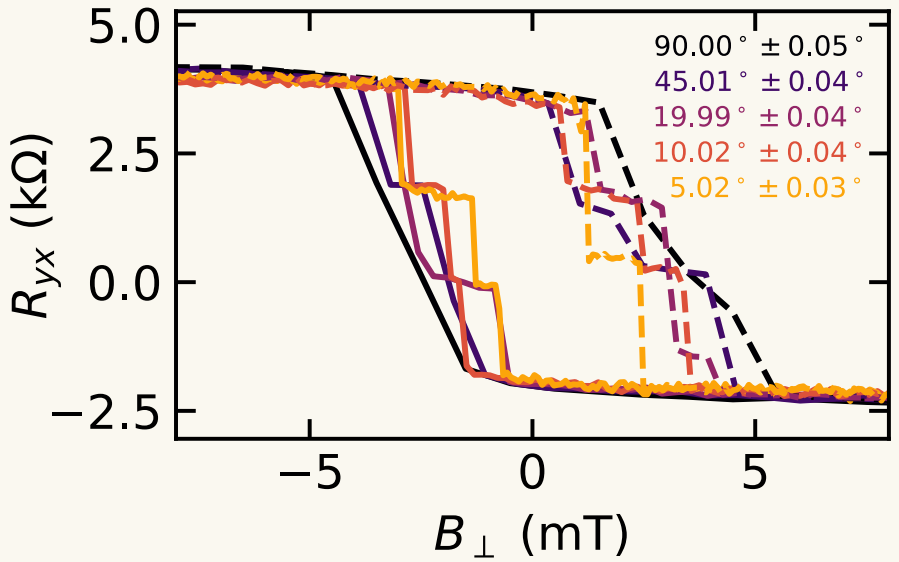
n/n_s = ~-2.5



Chen, Sharpe et al., Nano Lett. (2022)
Chen, Sharpe et al., Nature (2020)

Angular Dependence at n/n_s = ~-2.5

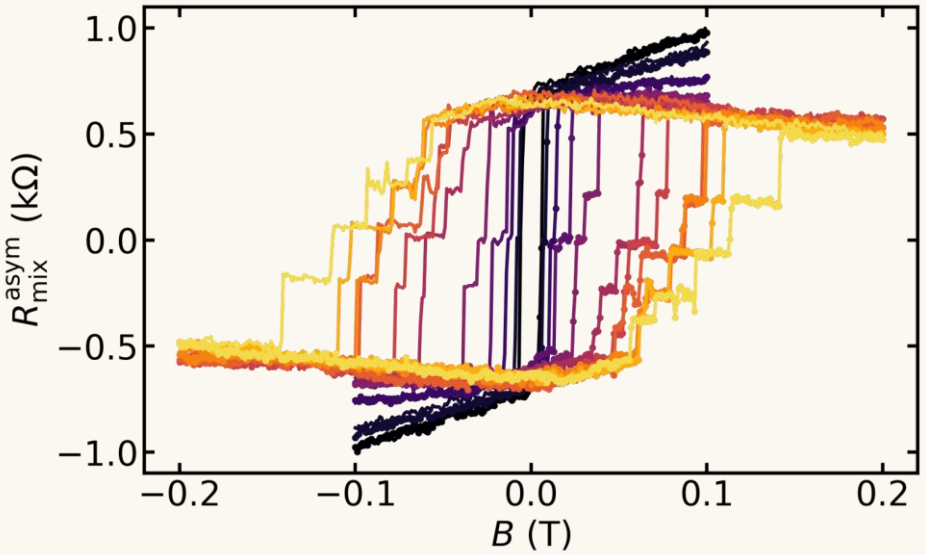


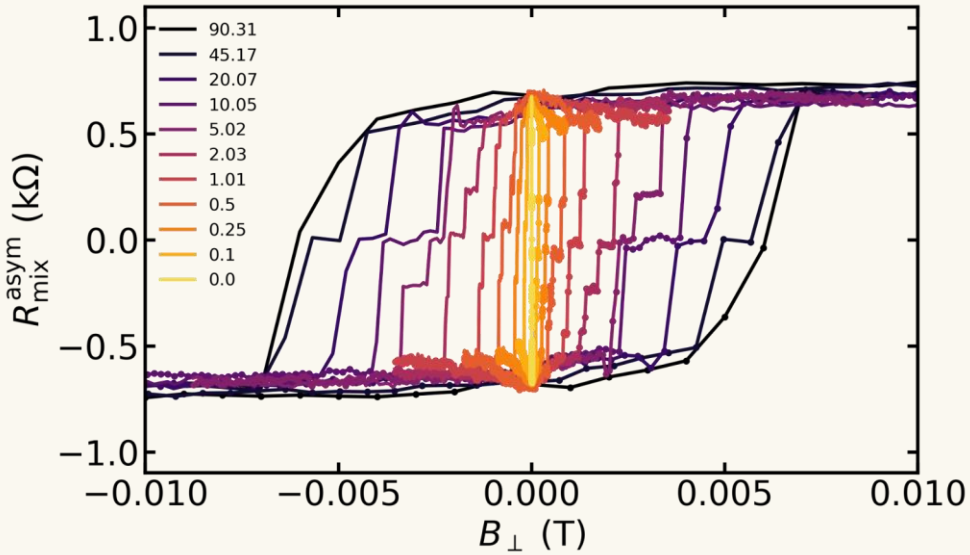


Mostly sensitive to perpendicular component
Similar to MATBG

Chen, Sharpe et al., Nano Lett. (2022)

Angular Dependence at $n/n_s = -1$





No clear dependence as a function of angle!
In-plane field is coupling to sample

Conclusions

Orbital ferromagnets

n/n_s = 3 in MATBG

n/n_s = ~-2.5 in ABC-trilayer/hBN

n/n_s = -1 in ABC-trilayer/hBN displays less clear behavior

Coercive field not a fixed out-of-plane value

In-plane field is coupling to the magnetic state

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