Tailoring the band structure of twisted double bilayer graphene with pressure

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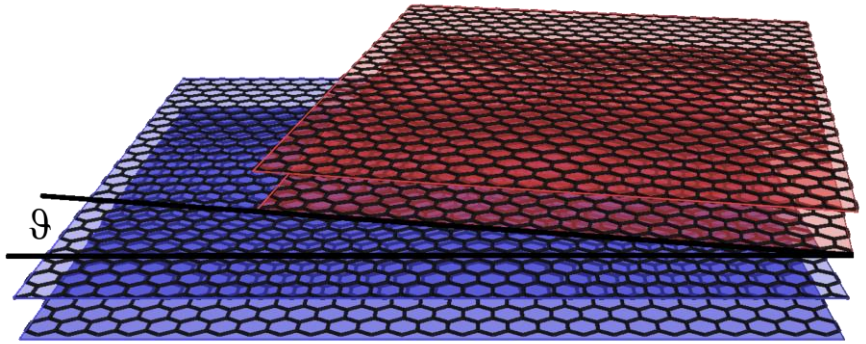
Motivation

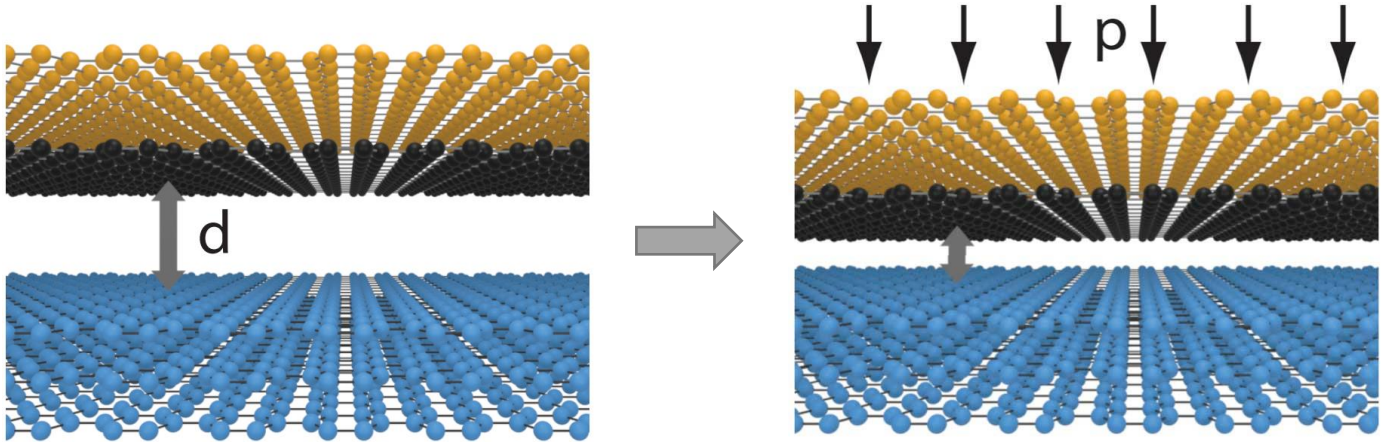
Twisted double bilayer graphene



- Highly tunable system:
  - Electron density
  - Electric field
  - Twist angle
  - **Pressure**

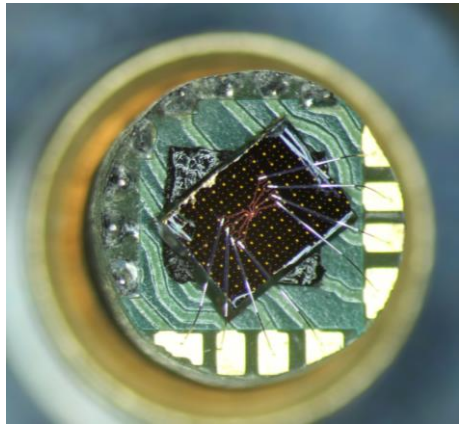
Pressure

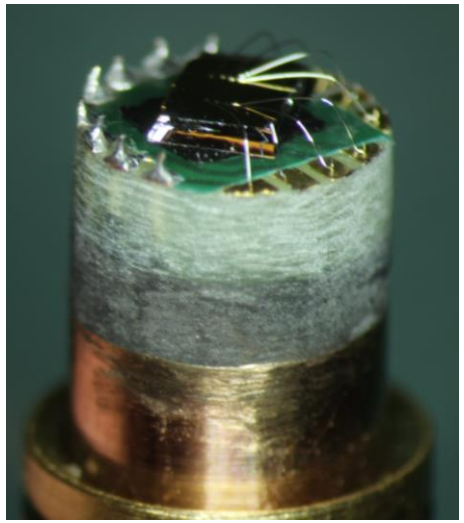
- Tunes the interlayer distance
- Enhance the coupling strength between the layers



Pressure cell

- Unique set-up
- Piston-cylinder hydrostatic pressure cell
- Can press nanodevices
- It doesn’t need any special sample preparation.





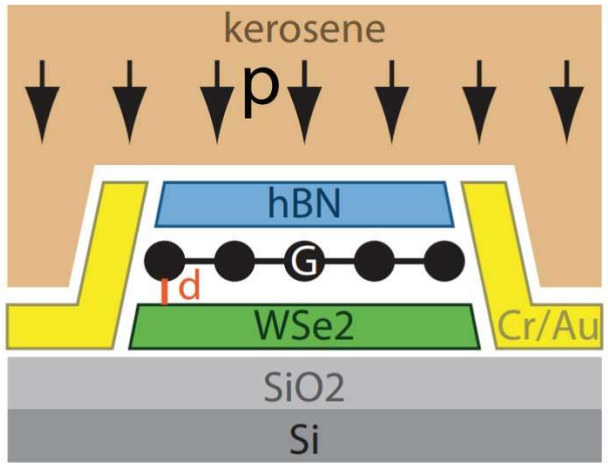
B. Fülöp *et al.*, *J. Appl. Phys.* 130 (2021)

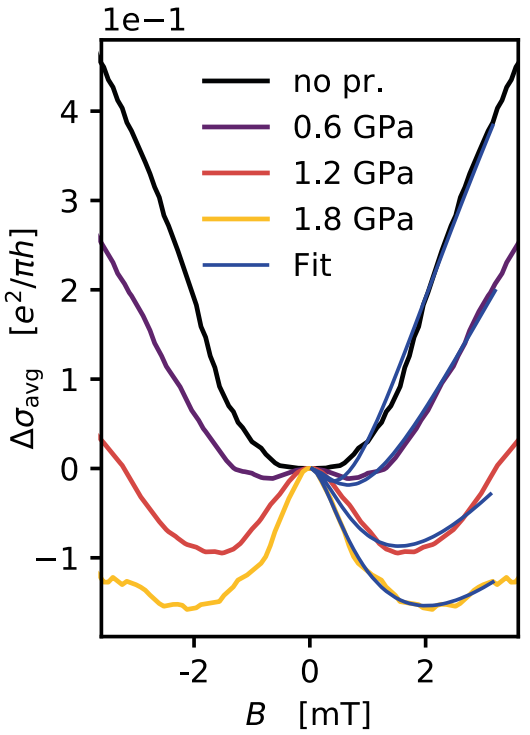
Tuning the interlayer coupling

Demonstration

- The effect of weak localization can be used to measure the proximity SOC strength
- Weak anti-localization signal increases with pressure

SOC strength increases with pressure





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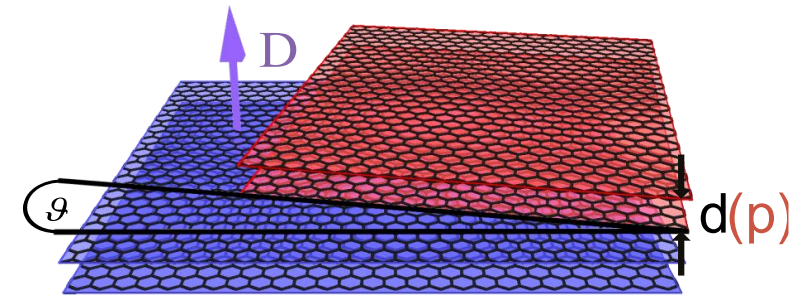
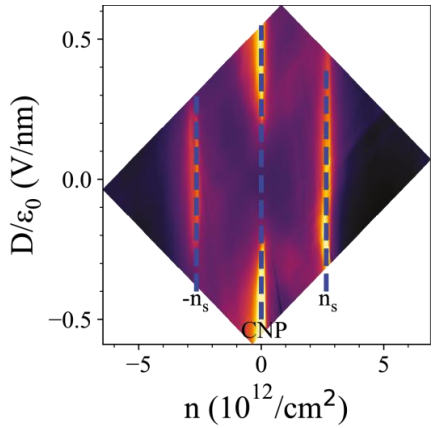
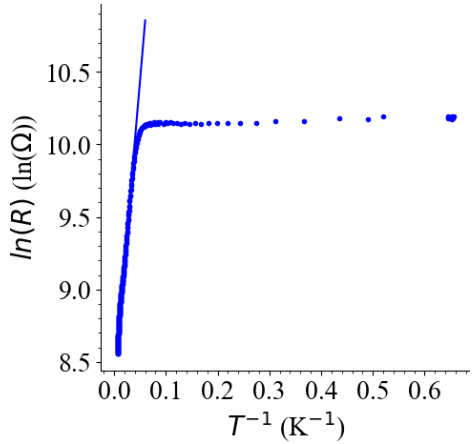
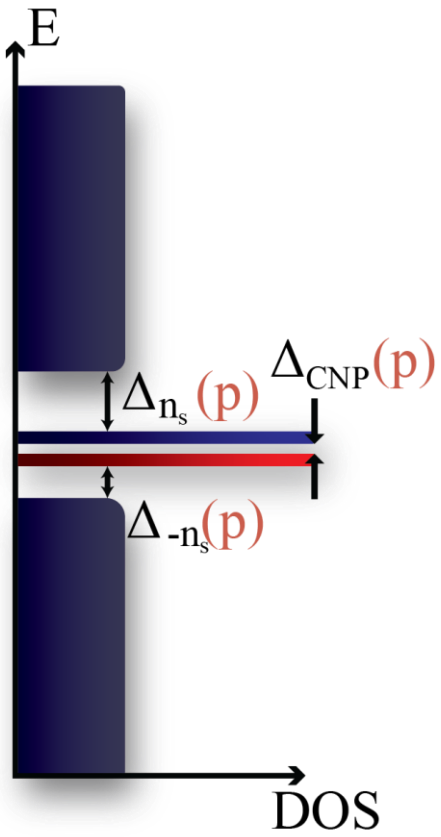
Outline

- Twisted double bilayer graphene
- Transport measurements
- Thermal activation measurements



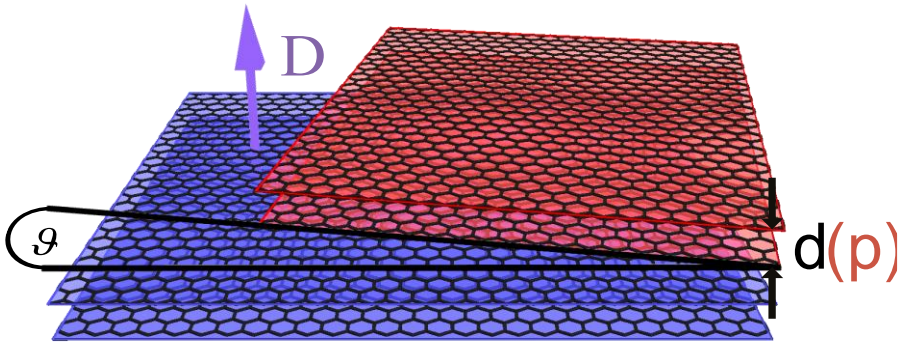


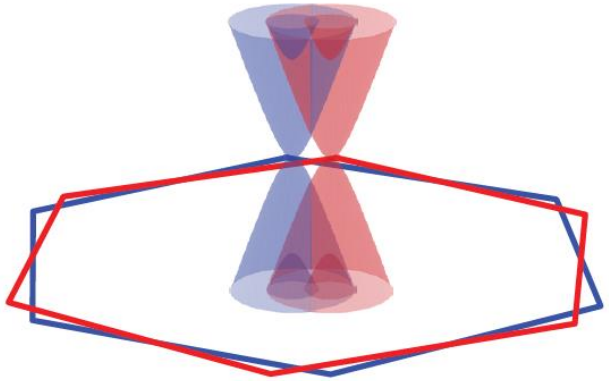




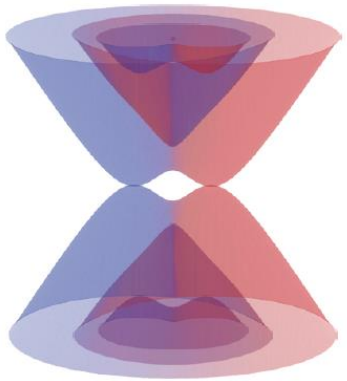
Twisted double bilayer graphene

- Small rotation angle (1.07°) between the BLGs
- Hybridization leads to formation of avoided crossings and formation of flat bands
- Displacement field also tunes the spectrum

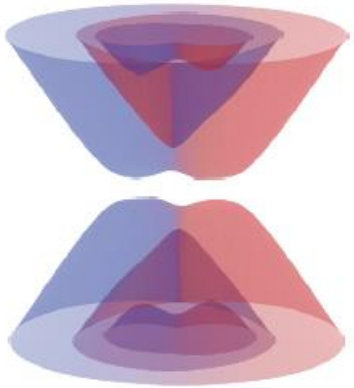




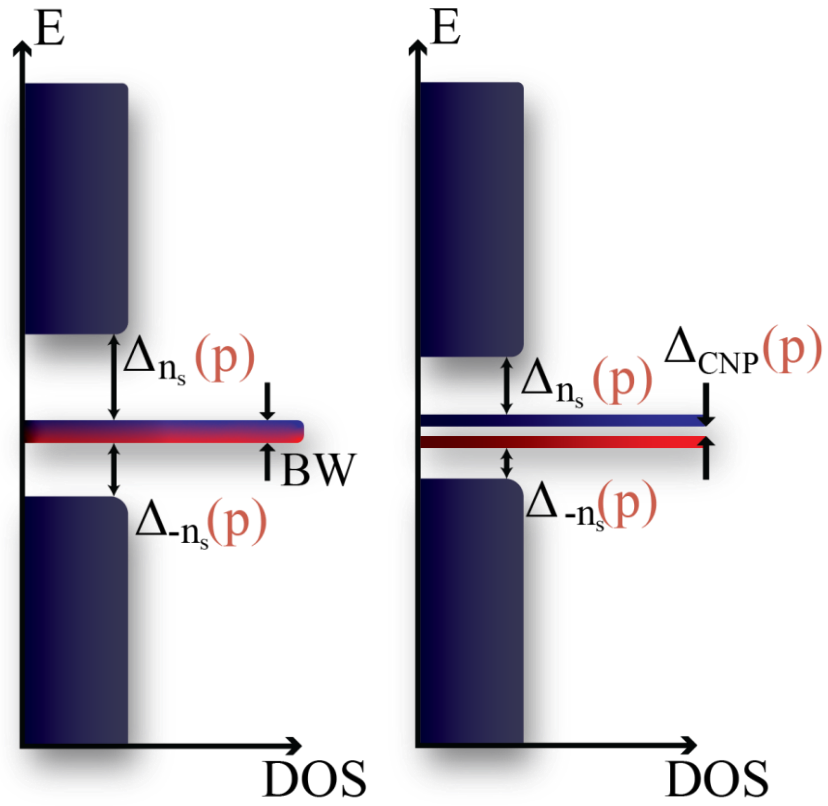
ω=0
D=0



ω≠0
D=0

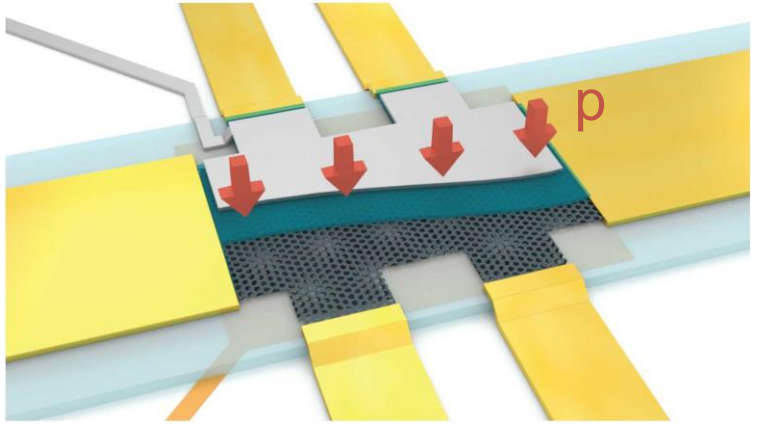


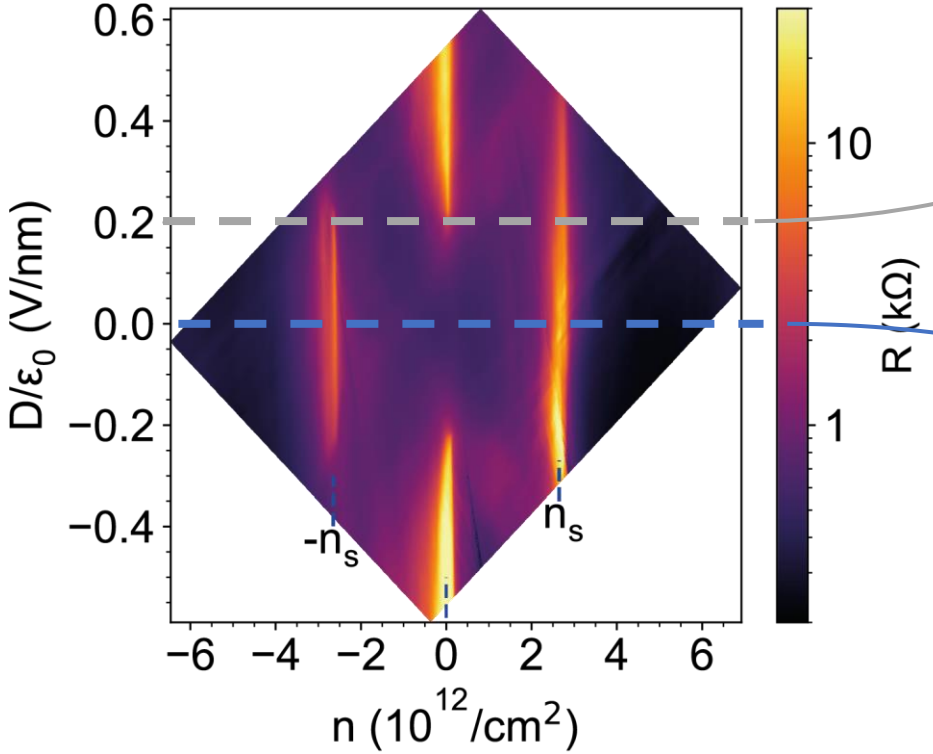
ω≠0
D≠0

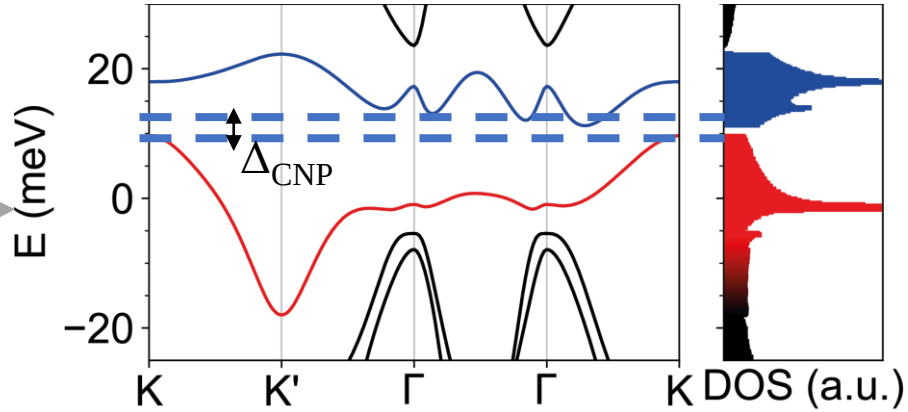


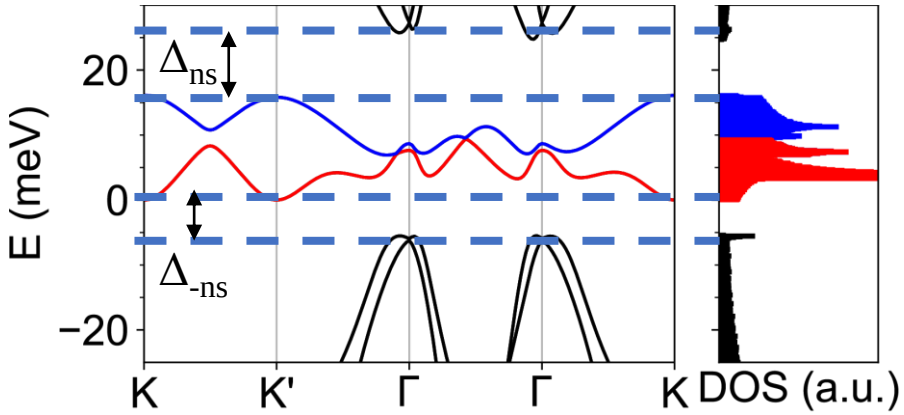
Twisted double bilayer graphene
Transport measurements

- Dual gated structure to tune *n* and *D* separately
- *D* opens a gap at the CNP



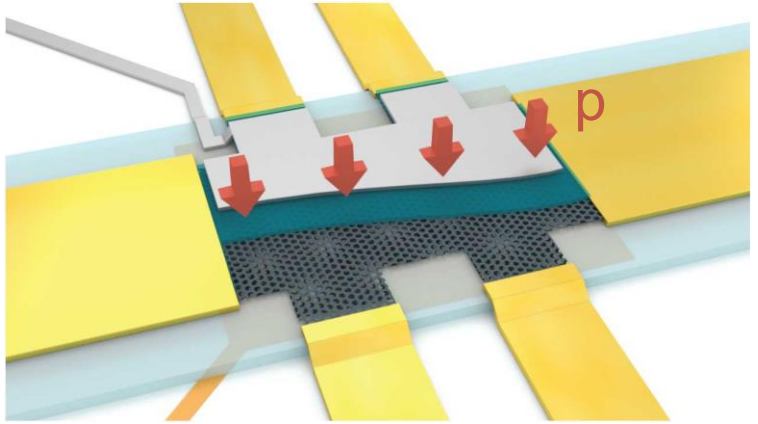


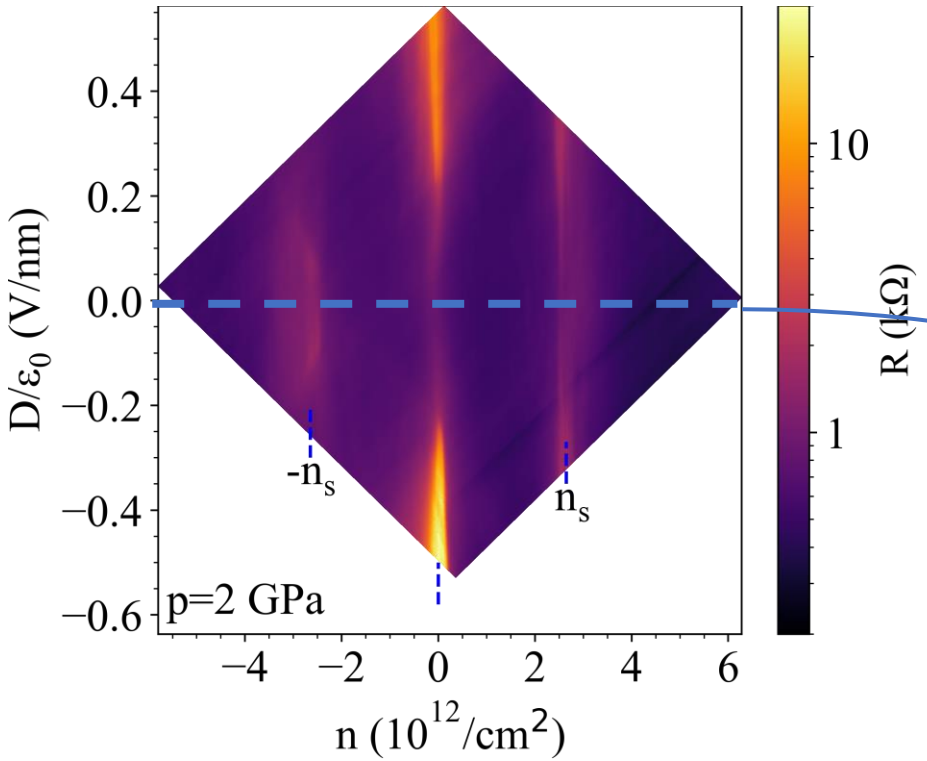


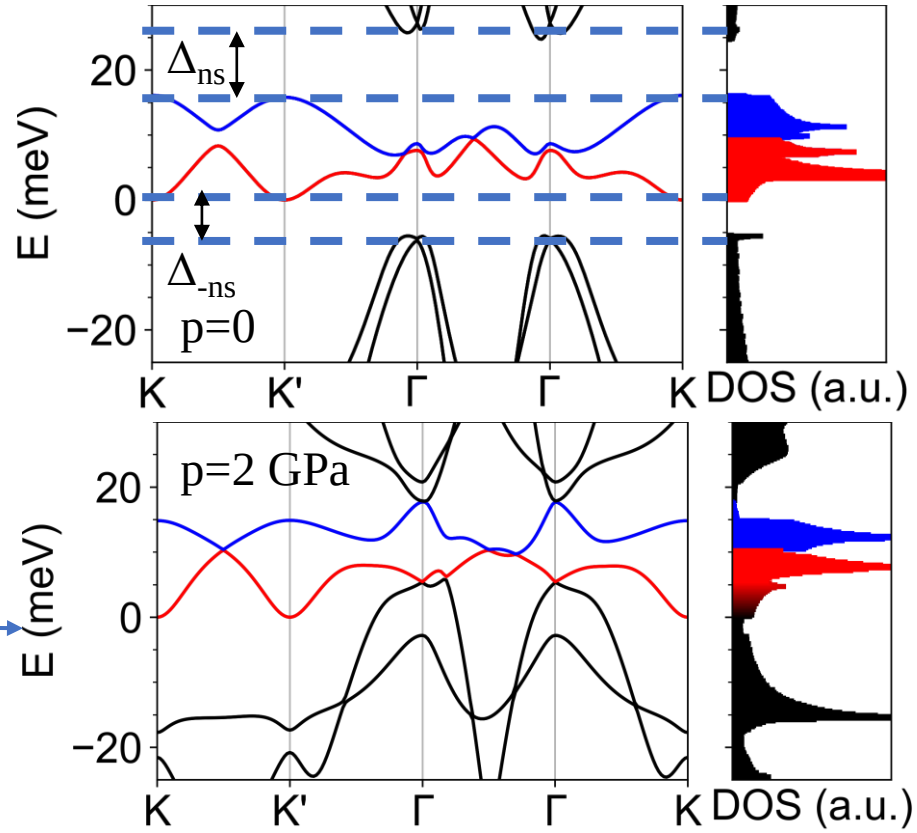


Twisted double bilayer graphene
Transport measurements

- Dual gated structure to tune *n* and *D* separately
- *D* opens a gap at the CNP
- Pressure decreases the moiré gaps

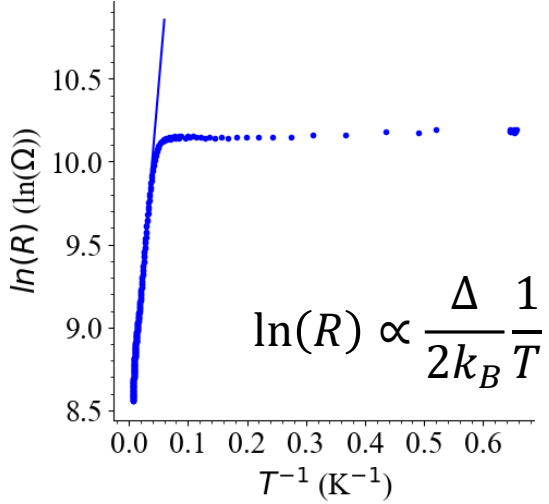


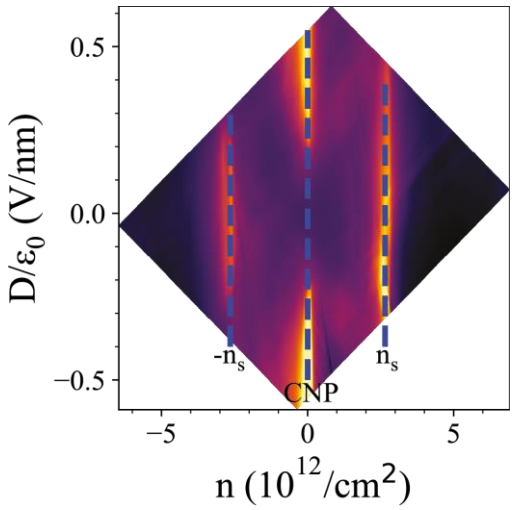


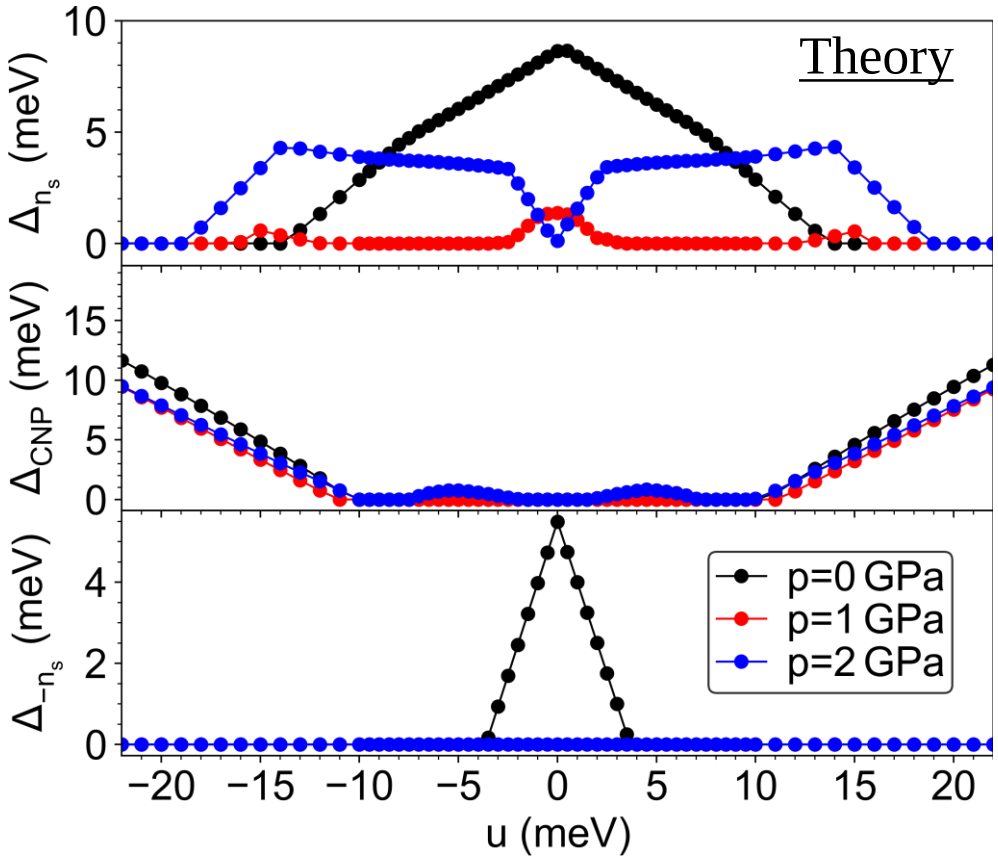


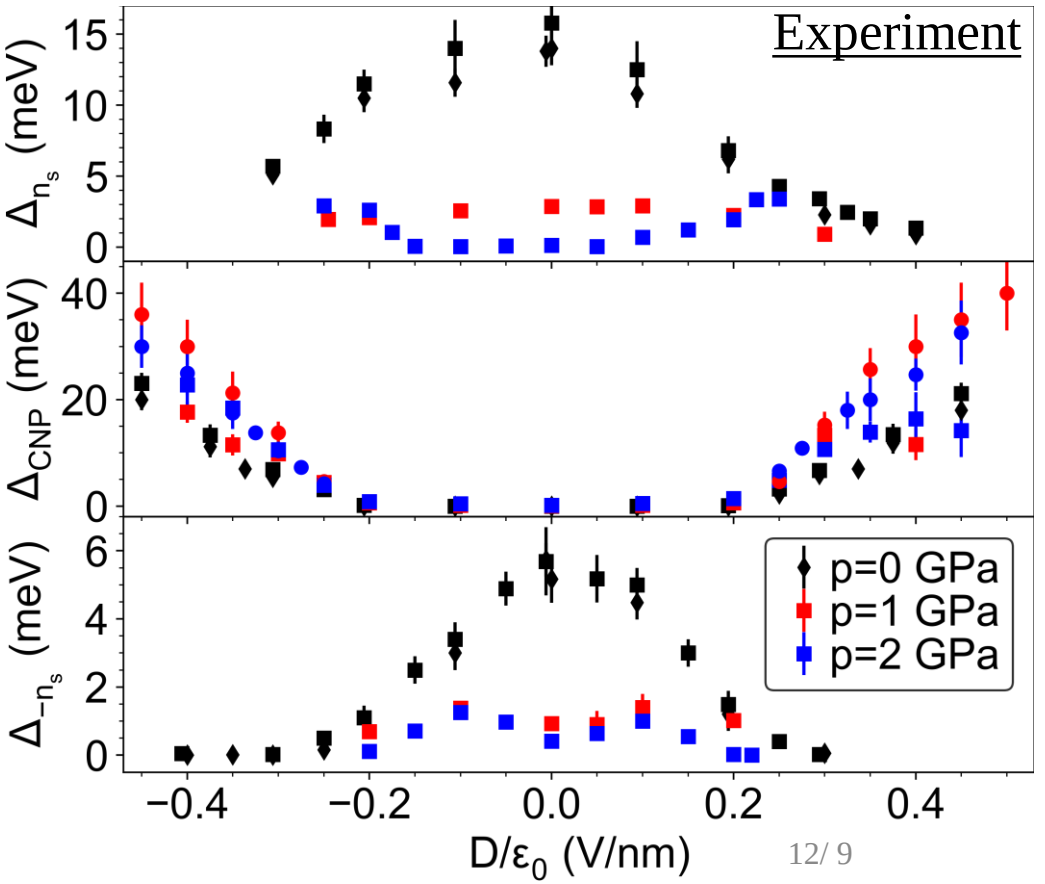
Thermal activation measurements

- Gap values can be determined from thermal activation measurements
- Gaps can be fully closed with pressure









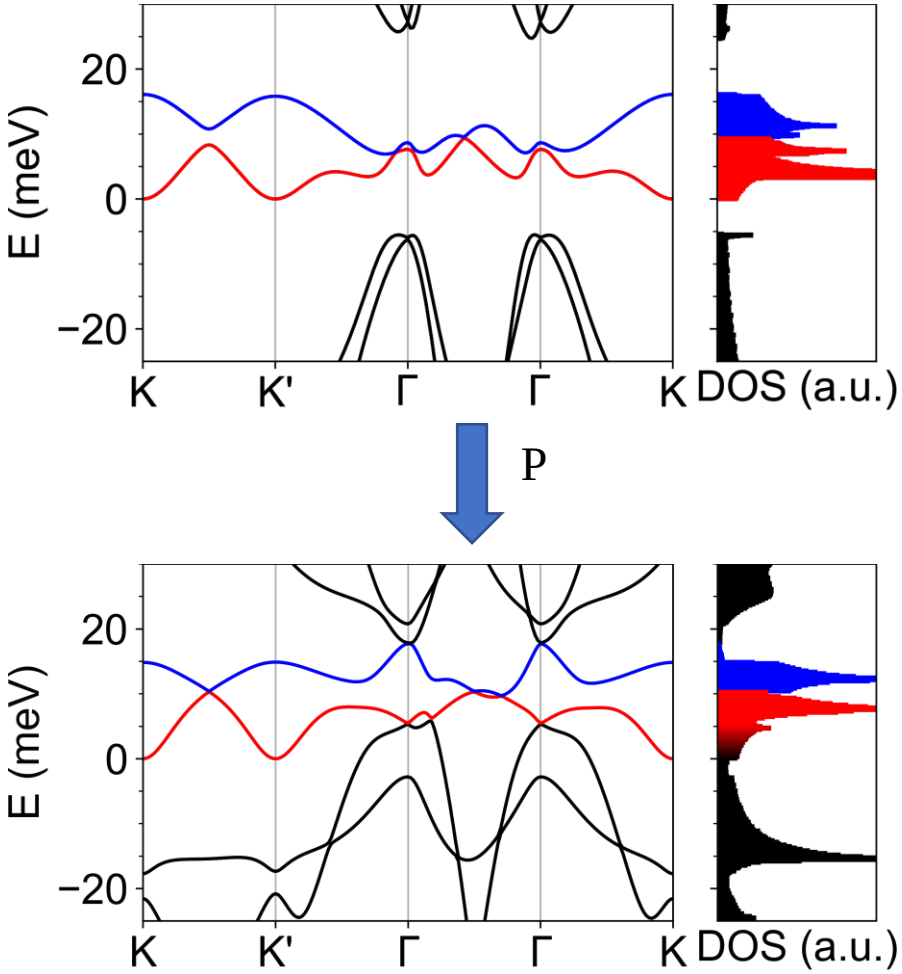
Summary

TDBG is very sensitive to pressure

- Single-particle moiré gaps can be fully closed
- Even a simple model could be used to predict the behavior of pressure at certain twist angles

Pressure cell could be used to study twisted structures

- Universal sample holder
- Open to collaborate to study new twisted structures



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Quantum Information National Laboratory HUNGARY

FLAG-ERA

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Lendület program

B. Szentpéteri et al., Nano Letters 2021, 21, 20, 8777-8784

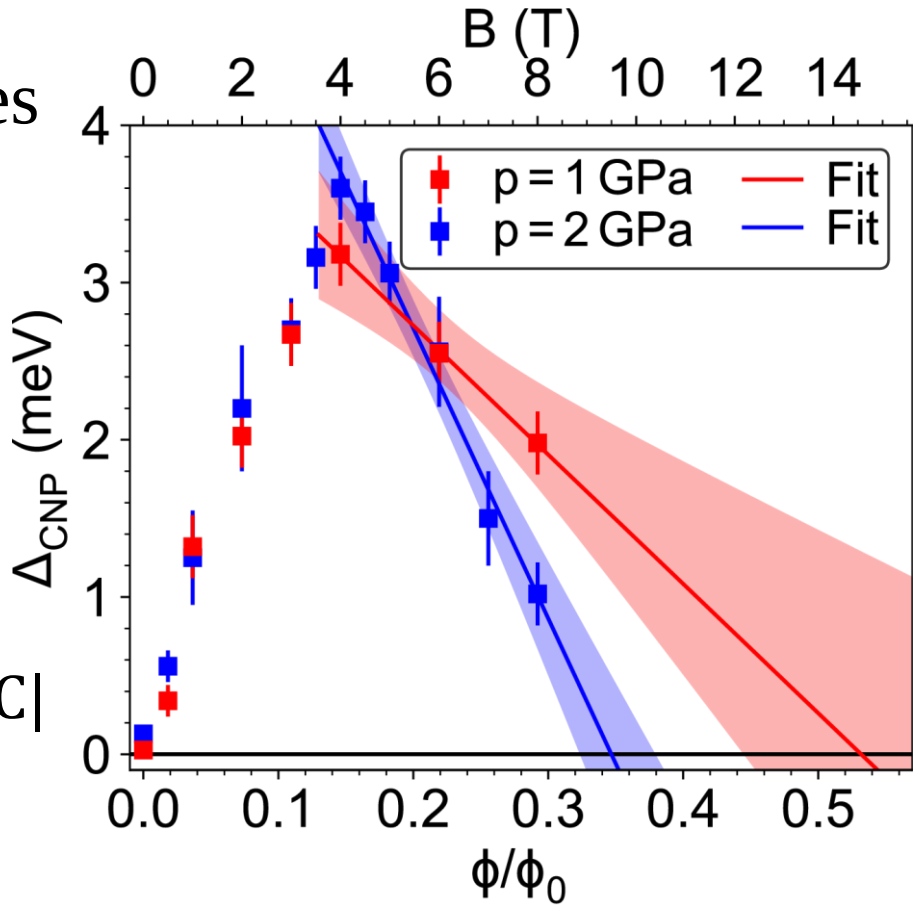
Thank you
for your attention!

Zero *n* & *D* magnetic field dependence

- At n=0, D=0 a gap opens with B, which decreases by further increasing B

- Close at different Φ/Φ_0 at different pressures
  1. For a Chern-insulator → gap closes at $\Phi/\Phi_0 = 1/|C|$
  2. Decrease of the correlation ←

Burg et al., arXiv 2006.14000 (2020)



Decrease of the correlation

Correlated insulator state at half filling at finite D:

- Spin polarized
- No sign of it at p = 2 Gpa