Driven chiral response of twisted bilayer graphene devices.

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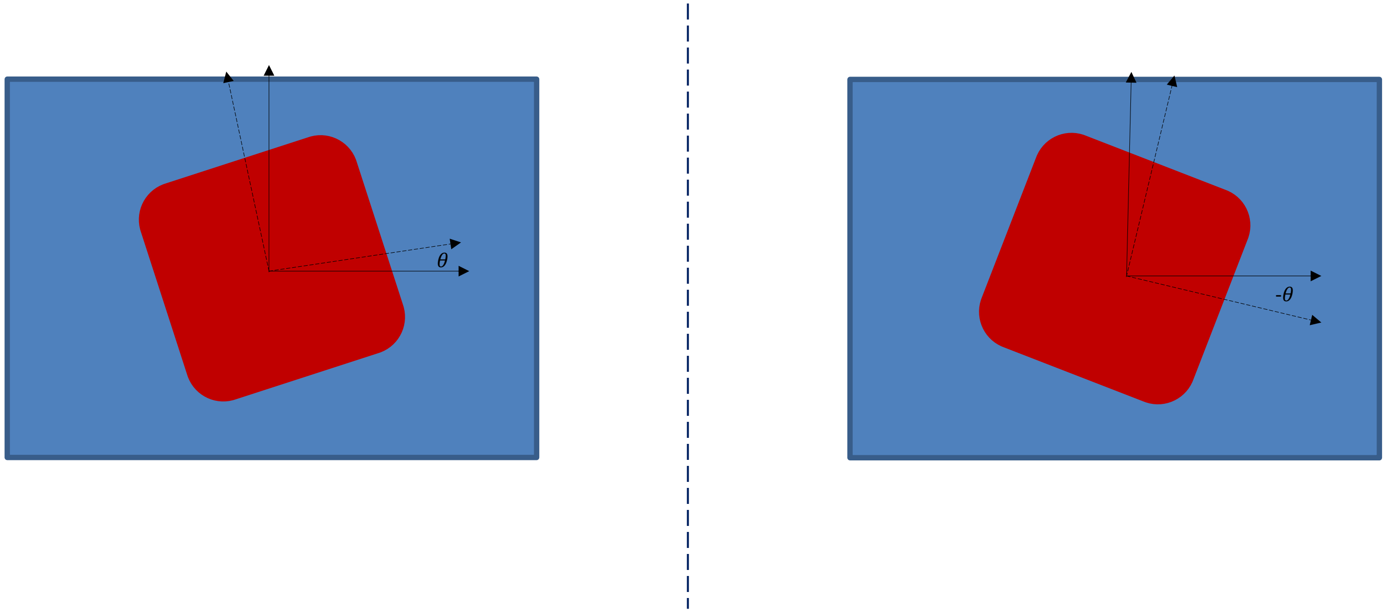
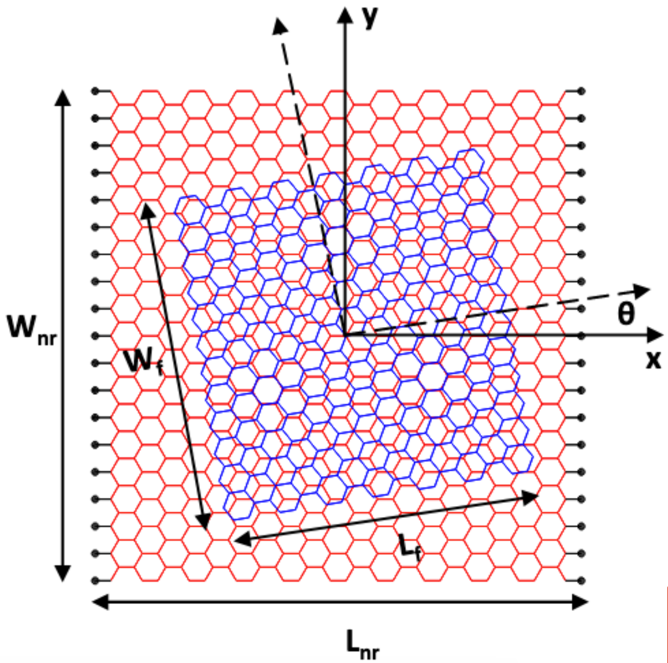
Outline of the talk

- Conductance of the TBG barrier.
- Total and Local current patterns.
- Chiral response and in-plane magnetic moment.
- Summary.



Conductance of the TBG barrier



- $W_{nr} = L_{nr} = 50$ nm.
- $W_f = L_f = 40$ nm.

$$\cos(\theta) = 1 - \frac{1}{2(3i^2+3i+1)}$$

$$t_{i,j} = V_{pp\pi}\left[1 - \left(\frac{\boldsymbol{d}_{ij}\cdot\boldsymbol{e}_z}{d_{ij}}\right)^2\right] + V_{pp\sigma}\left(\frac{\boldsymbol{d}_{ij}\cdot\boldsymbol{e}_z}{d_{ij}}\right)^2$$

$$d_{ij} \leq 4a$$

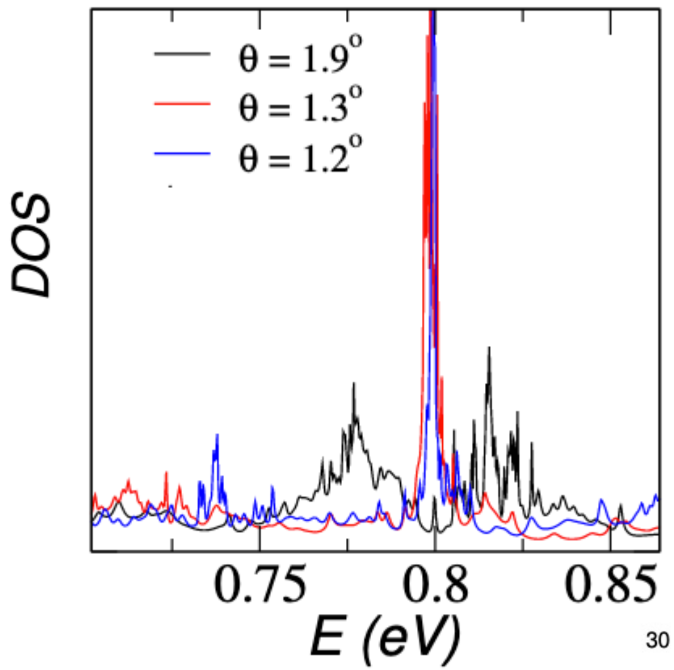
$$G = \frac{2e^2}{h}\mathrm{Tr}[\Gamma_q G^r \Gamma_p G^a]$$

$$G^r = [G^a]^\dagger = [E + i\eta - H - \Sigma_p - \Sigma_q]^{-1}$$

$$\Sigma_q = -i\Delta = -i\pi\rho_c|t_{dq}|^2$$

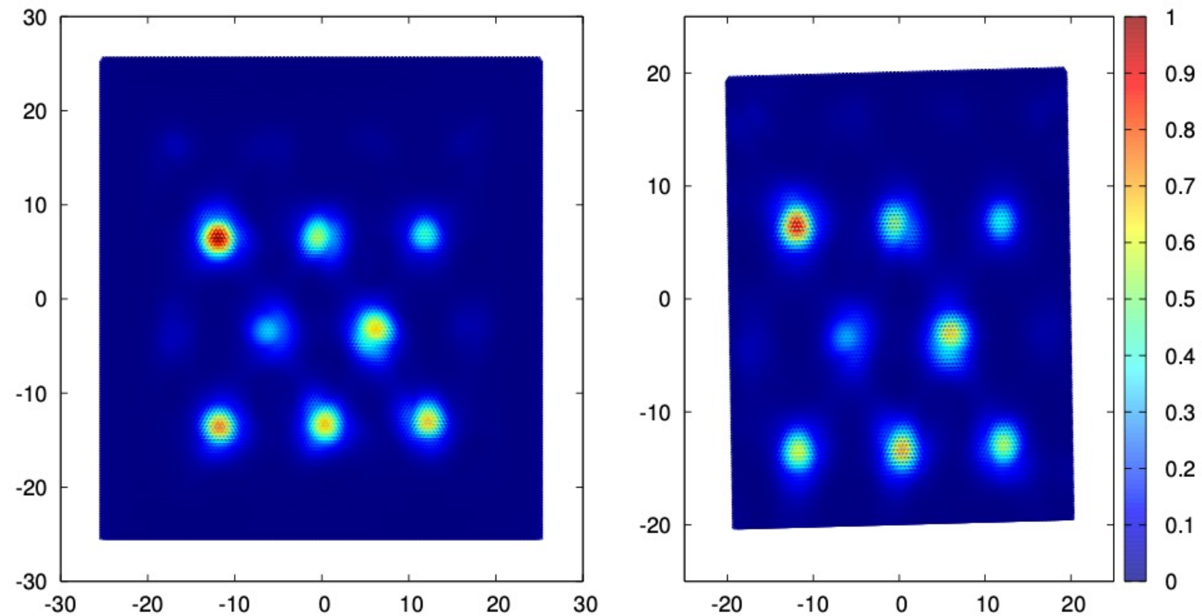
$$\Sigma_q = -i(2/\sqrt{3})t \approx -it$$

Conductance of the TBG barrier

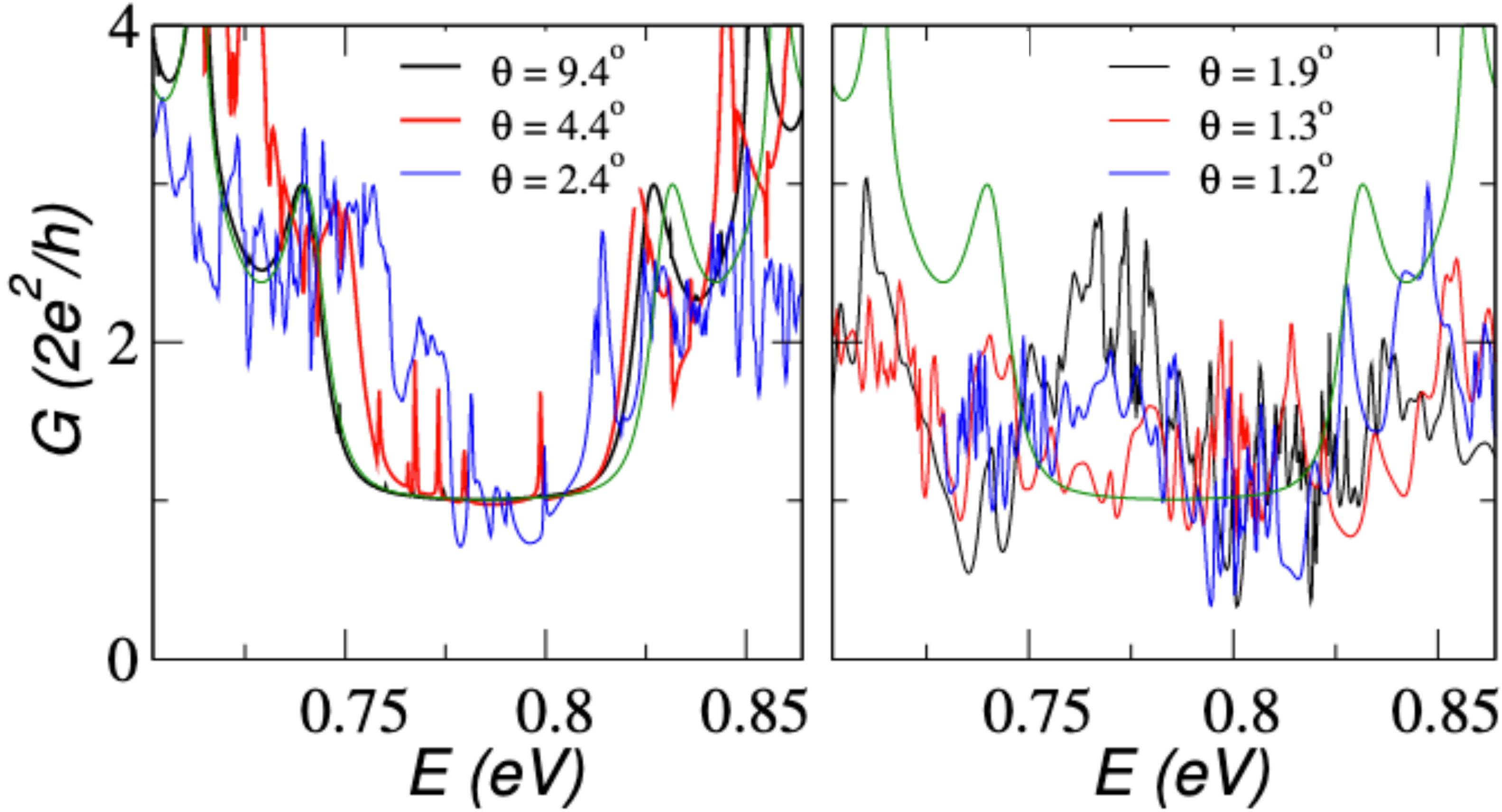


- High DOS at CNP for low twist angles
- CNP is not longer at 0 eV.
- High LDOS on AA-stacked regions near the CNP

E = CNP, $\boldsymbol{\theta}$ = 1.2°



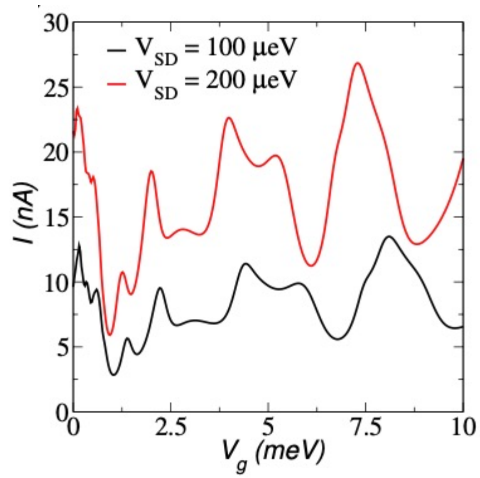
Conductance of the TBG barrier

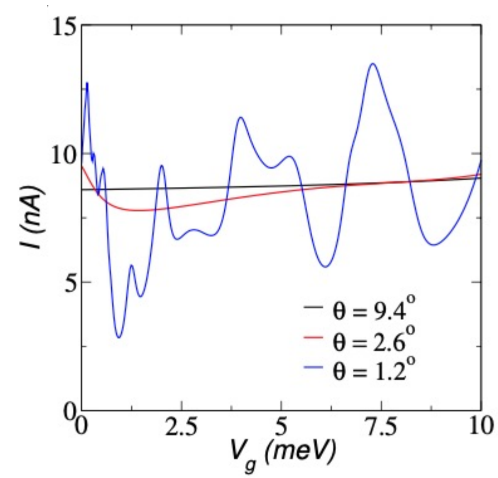


- Weak coupling regime: large: $\boldsymbol{\theta} > 10^{o}$
- Intermediate coupling regime: $2^{o} < \boldsymbol{\theta} < 10^{o}$
- Strong coupling regime: $\boldsymbol{\theta} < 2^{o}$

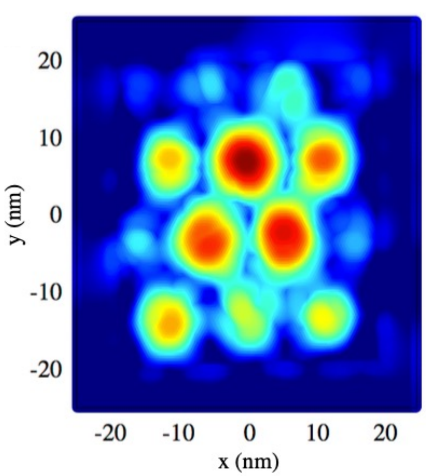
Total and local current patterns

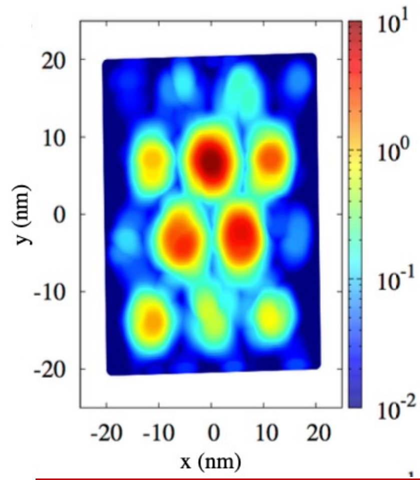
$$I(V) = \frac{2e}{h} \int_{-\infty}^{+\infty} T(E,V)\,[f_L(E) - f_R(E)]\,dE$$





- Total source-drain current is not reduced in the strong coupling regime.
- Similar magnitudes of current in the top and bottom layer.
- Current hot spots in AA-stacked regions.





$$I_{ij} = \frac{2e}{h} \int_{E_F - eV_{SD}/2}^{E_F + eV_{SD}/2} t_{ij}\,[G^<_{ji} - G^<_{ij}]\,dE$$

$\boldsymbol{\theta} = 1.2^{o}$

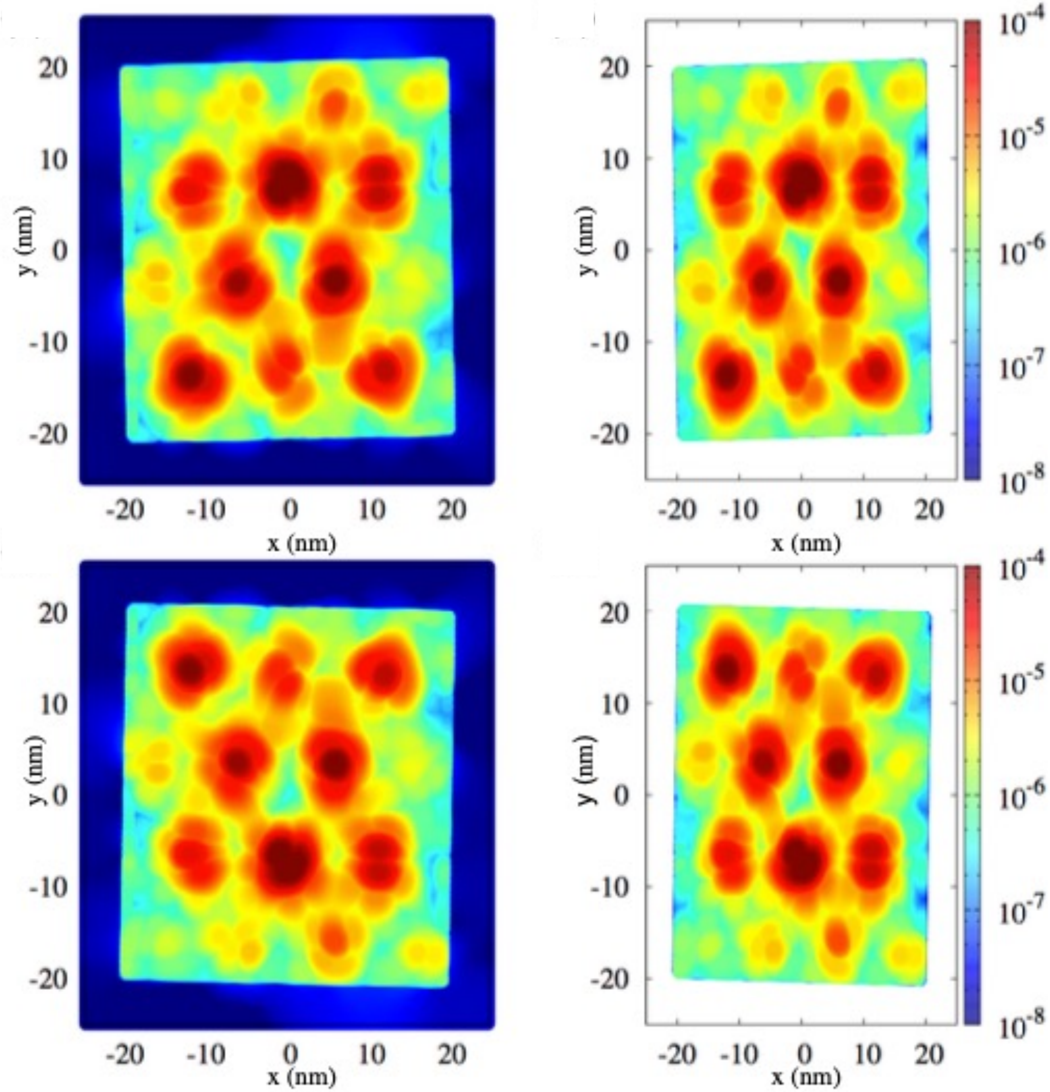
$V_g = 0.1$ meV

$V_{SD} = 100$ µeV

Chiral response and in-plane magnetic moment

- There is magnetic response of the TBG barrier.

$$\vec{m} = \frac{1}{2} \sum_{<ij>} I_{ij} (\vec{r}_i \times \vec{r}_j)$$



$\boldsymbol{\theta}$ = +/- 1.2°

V_g = 0.1 meV
V_{SD} = 100 µeV

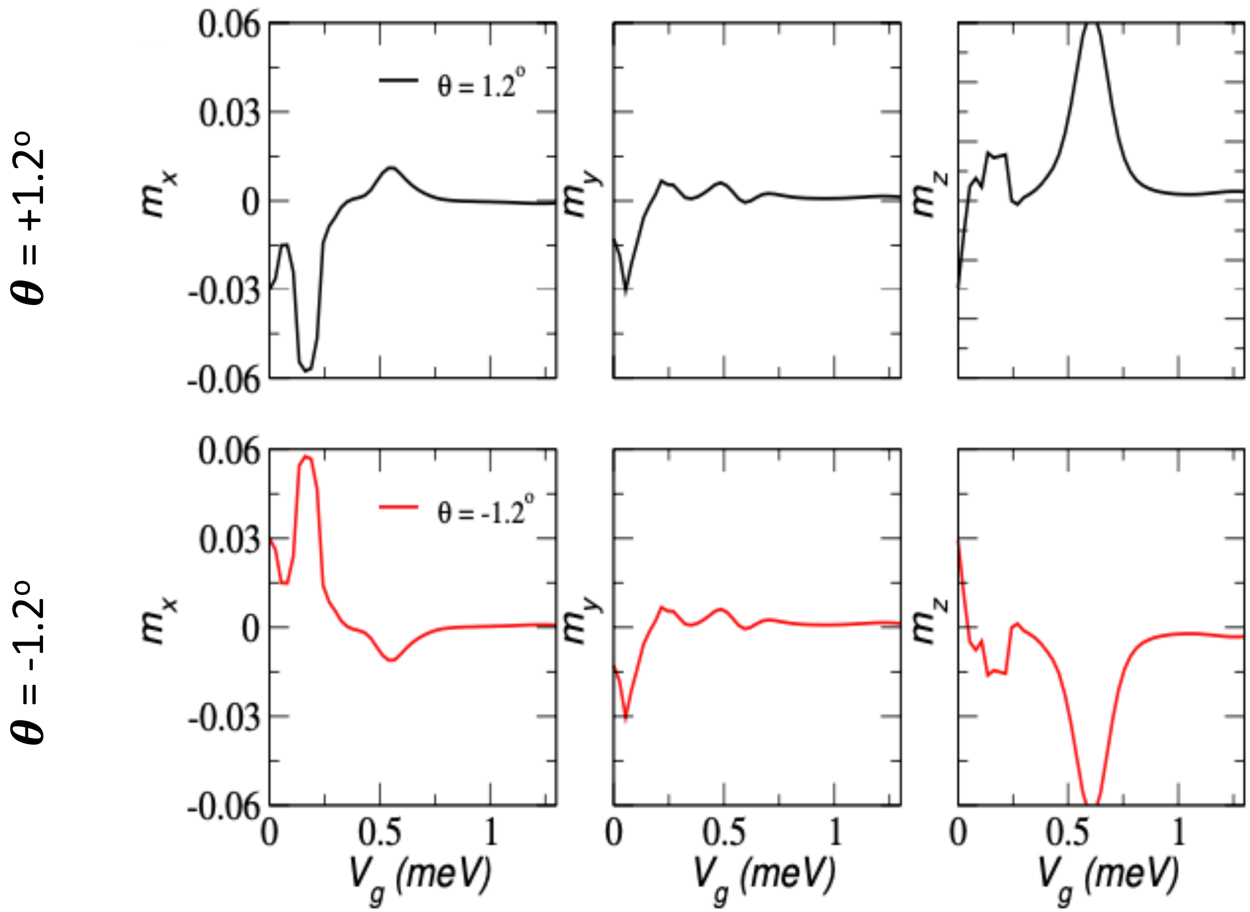
The infinite twisted bilayer system can be transformed from a positive to a negative twist angle by performing a parity-transformation r → − r and subsequent mirror-transformation (π rotation around the y-axis).

$$(x, y, z) \rightarrow (x, -y, z)$$

Chiral response and in-plane magnetic moment

- For low energies, there is magnetic response induced by chirality.

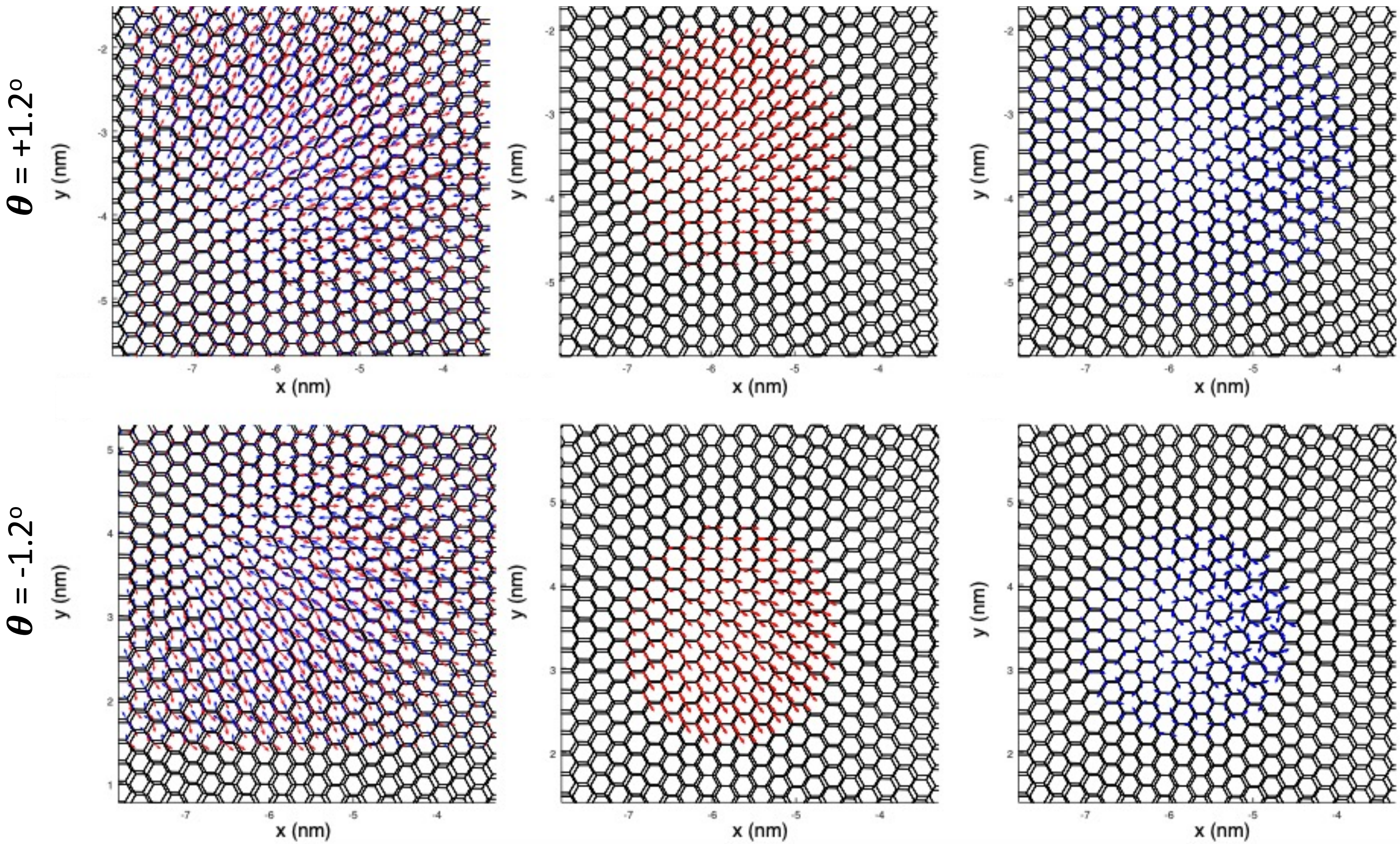
$$(m_x, m_y, m_z) \rightarrow (-m_x, m_y, -m_z)$$



Chiral response and in-plane magnetic moment

$$(j_x, j_y, j_z) \rightarrow (j_x, -j_y, j_z)$$

$$\vec{I}_m = (\vec{I}_1 - \vec{I}_2)/2 \qquad \vec{I}_T = \vec{I}_1 + \vec{I}_2$$



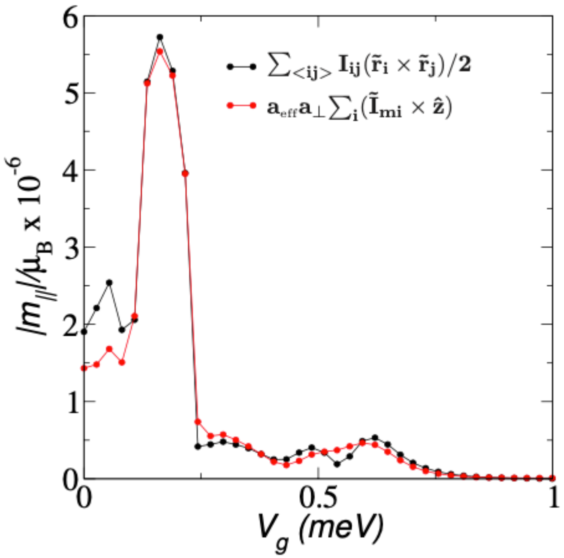
Global *vs* local definition of magnetic moment

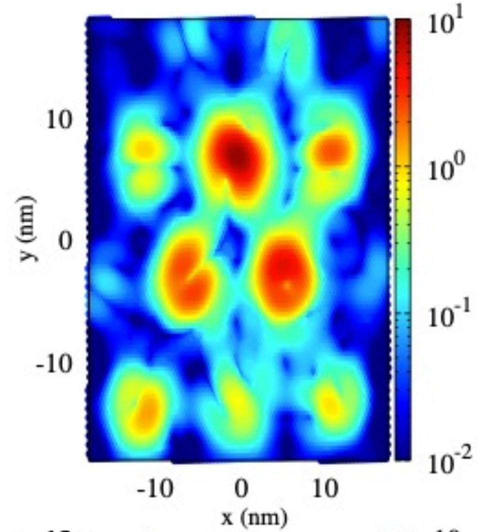
$$\vec{m} = \frac{1}{2}\sum_{<ij>} I_{ij}(\vec{r}_i \times \vec{r}_j)$$

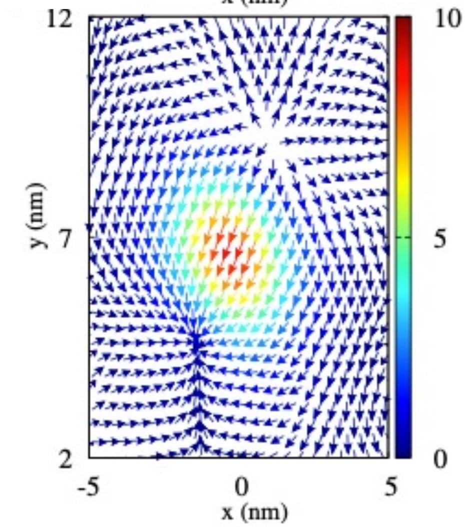
$$\vec{m}_{||} = a_{\text{eff}} a_{\perp} \vec{I}_m \times \hat{\mathbf{z}}$$

$$-5 \leq x/\text{nm} \leq 5$$

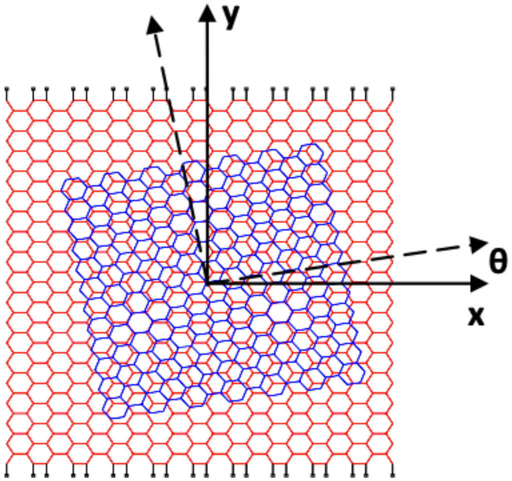
$$2 \leq y/\text{nm} \leq 12$$

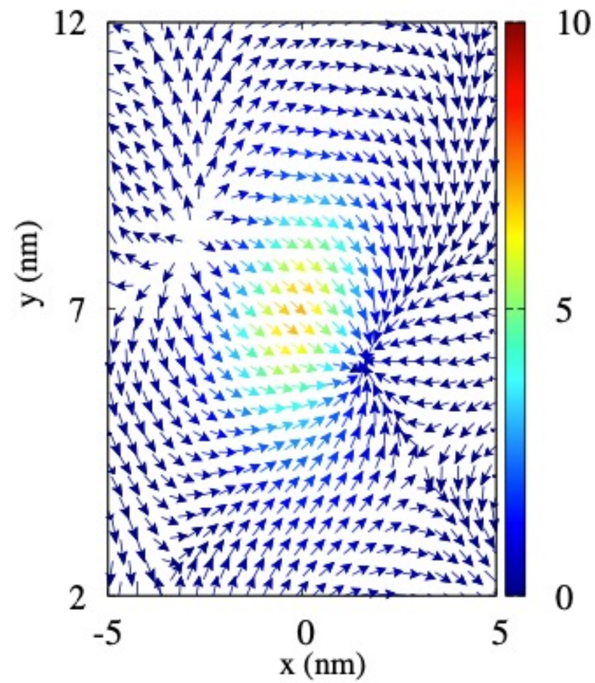


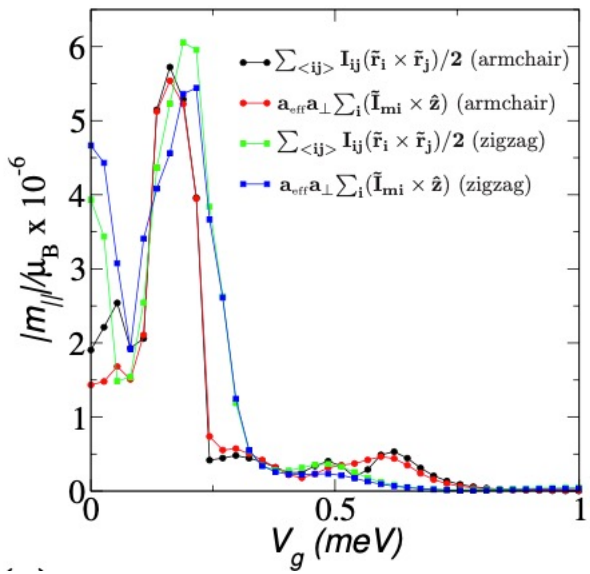




Chiral response of TBG with zigzag edges







- In-plane magnetic moment presents similar values to those observed in the armchair case.
- The magnetic current is rotated 90º compared to the armchair case.

Summary

- We find a non-trivial texture of angular orbital momentum which is arranged in a triangular lattice.

- The magnetic texture is highly tuneable since the induced magnetic moments are directly related to the source-drain voltage.

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In-plane magnetic moment is well defined

$l_z = 0$