

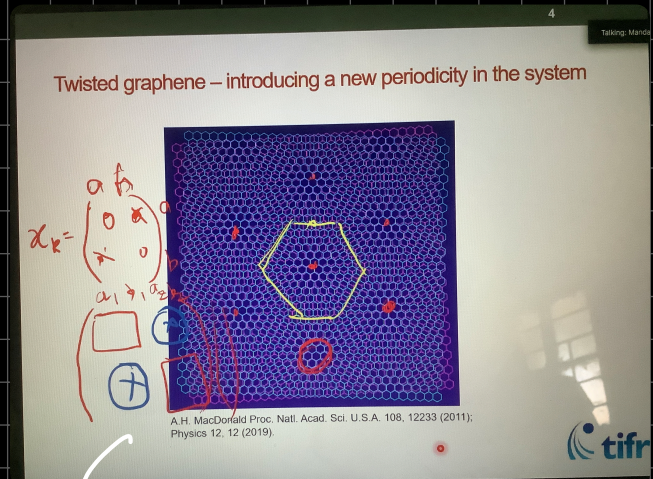
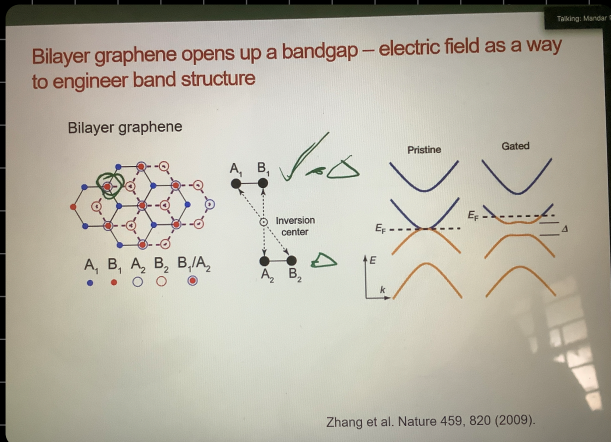
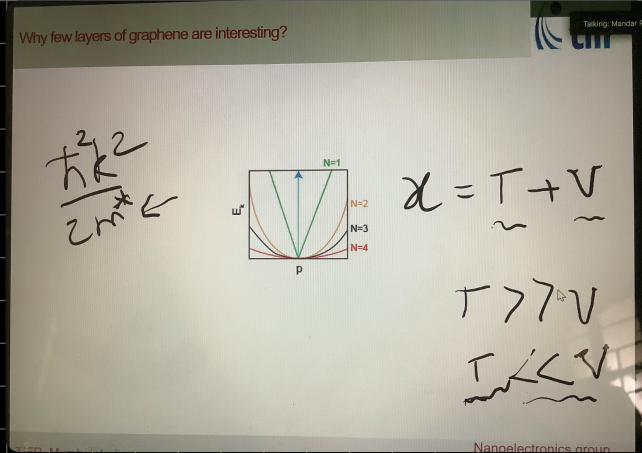
Chern insulator $\rightarrow \phi(\hbar d)$ without magnetic field

$\rightarrow$ can transport S, g without scattering

$$\hbar_{\text{monolayer}} = T + V \quad T \gg V \rightarrow \text{free "electronic"}$$

$$\hbar_{>1 \text{ layer}} = T \ll V$$

electric field
 $\rightarrow$ Gaps the spectrum by, diff
 voltages

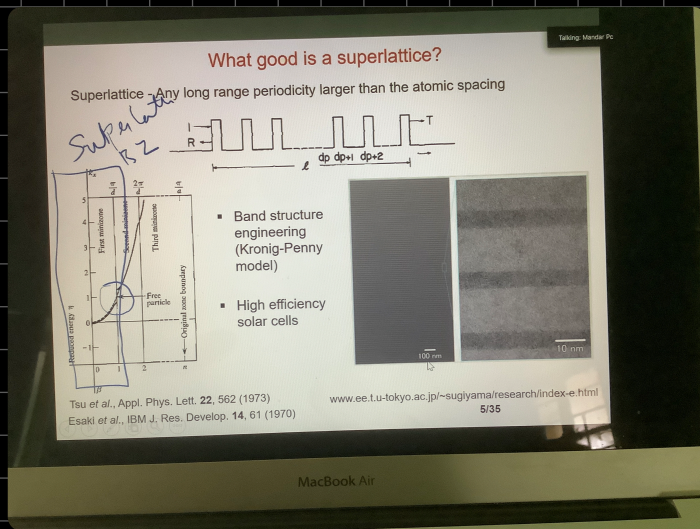


$\nwarrow$

$$\hbar_{\text{blw layers}} = f(\text{angle} + \text{space})$$

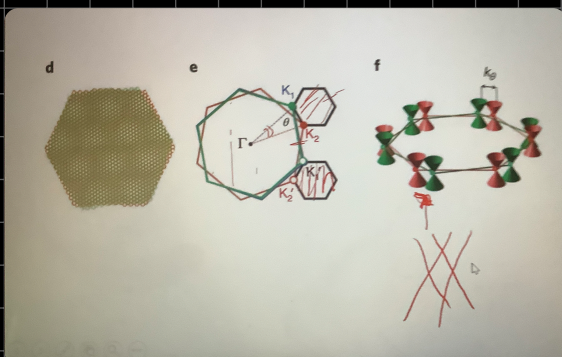
$\nearrow$ "super lattice structure"
 "periodicity is enlarged by the rotation angles"

Superlattice :- Kronig Penny model



→ "quantum cascade laser" uses such ideas

way to think about the rotation

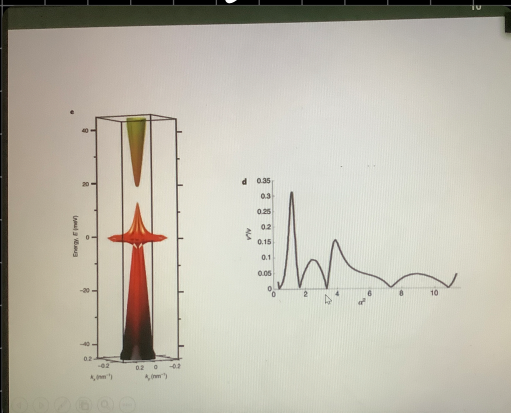


@ large angles → layers behave like they're independent
 ↳ low overlap b/c comes

under right choice of angles, we get a "flat band"

bandwidth ~ 0 eV in others

↳ here bandwidth ~ 10 meV



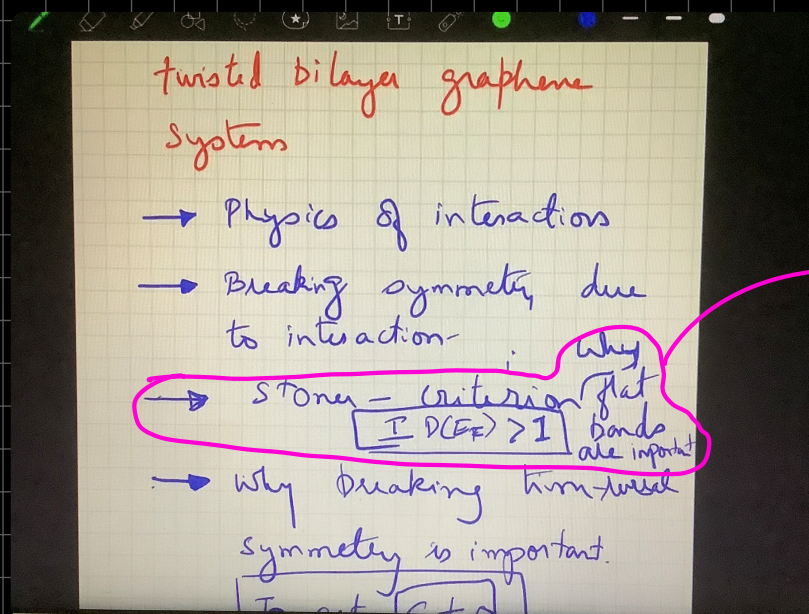
→ "new crystal structure" can emerge from relaxation

$$v_{eff} \sim \frac{\partial E}{\partial k} \quad m_{eff} \sim \frac{1}{\frac{\partial^2 E}{\partial k^2}}$$

↳ for a linear disp., $m \sim \frac{1}{a^2} \propto v \propto t$

Superconductivity & insulating behaviours exist simultaneously.

↳ some connection to High T_c . → topological aspects of SC



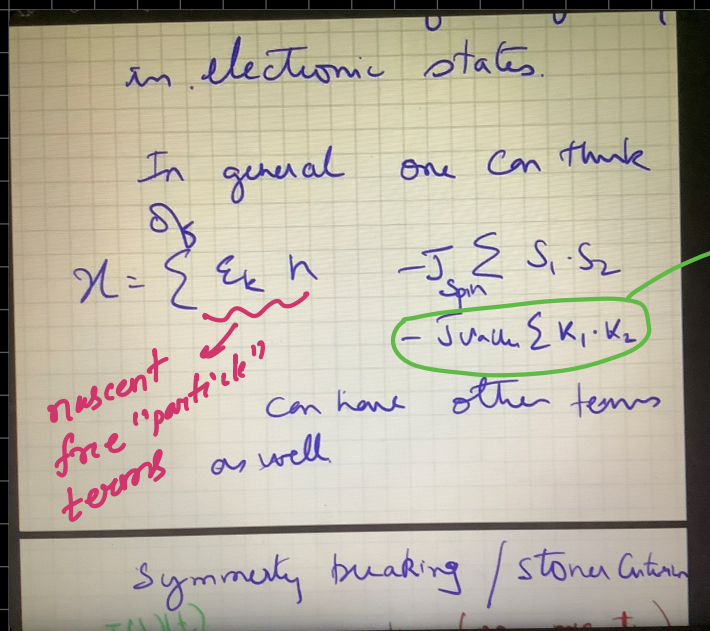
→ Very very important

→ system spontaneously breaks TRS

→ $C \neq 0$ → QASHE / QHE type physics

Two flavours in "graphene"

→ spin -2 } lead to 4 fold deg. in electronic states.
→ valley -2



→ why ???

valleys → have some

angular momentum
↳ $\vec{L}_1 \cdot \vec{L}_2$

[Some discussion here that I missed]

Symmetry breaking / Stoner Criterion

$-J(\frac{1}{2})(\frac{1}{2})$

1 option (non-magnetic)

2 option (magnetic)

$\delta \approx \frac{1}{\text{DOS}}$

$-J(\frac{1}{2})(\frac{1}{2}) = \frac{J}{4}$ ex. mple of spin-degenerate system

$(\delta - \frac{J}{4}) < \frac{J}{4}$

$\delta < \frac{J}{2}$

$\frac{1}{\text{DOS}} < \frac{J}{2}$

Stoner criterion

$1 < J' \text{DOS}$

Stoner criterion

→ PIB

→ here I get ferromagnetism.

→ spin polarized filling of orbitals.

→ as soon as this happens, then we get spin dof breaks PR

→ but when we get a flat band, $\text{DOS} \rightarrow \infty$, then ferromagnetism occurs

$\delta = \text{spacing near } E_F$

→ $\text{DOS} \sim 0$ for graphene.

DOS

$\uparrow\downarrow$

spin-degenerate system

$(\delta - \frac{J}{4}) < \frac{J}{4}$

$\delta < \frac{J}{2}$

$\frac{1}{\text{DOS}} < \frac{J}{2}$

Stoner criterion

$1 < J' \text{DOS}$

having large DOS is ideal for breaking of symmetry

Revolutⁿ → flatband system = another magnetization

≡ orbital magnetization

≡ "valley magnet"

→ ~ 10 Bohr magneton.

Large DOS → Flat bands are great

$C \neq 0$

In general $C=0$

if time-reversal symmetry is intact

$C_k + C_{k'} = 0$

equal and opposite.

Can be non-zero

To break this symmetry

→ valley differentiated Chern numbers

→ we automatically populate one valley more than the other

→ now we have non-zero
chern # materials.

in a nutshell → $S < \frac{J}{2}$ can give rise to
ferromagnetism.

Chern insulating behaviour of tBG has been observed.

Remind → modality of final exam