

Summary - Lessons
- Questions

- Minimal model \rightarrow 2D Dirac Hamiltonian
 - \rightarrow interaction connections to HEP
 - Energetic reason: linear dispersion over ~ 3 eV (high freq ok)
 ARPES (Arizona)
 - Symmetry: Invariance, Time reversal (Haldane)
- Low energy physics close to the Dirac point!
 - Disorder
 - Electron-electron
 - Electron-phonon
 - Electron-plasmon (doped)
 - Multilayers
 - Mesoscopics

Disorder

- Conventional (semi-conductors)
 - Long range (Coulomb), short range
- Exotic (connections to soft condensed matter)
 - gauge disorder (Shankar)
 - ripples (Geim)
 - topological defects (Dresselhaus, Vozmediano)
 - pentagons, heptagons, Stone-Wales
- Weak (anti-) localization (Guinea, Efetov, Falcko)
- Strong-localization (Geim, de Heer, Sheng)
 - Zitterbewegung \rightarrow Multi-particle production (interactions?) (Sheng)
 - FQHE? (Goerbig)
 - Applications

(das Sarma, Vos, Oppen, Nonaka, MacDonald, Pereira)

Interactions

- Perturbative RG
 - { Short range → Irrelevant
 - { Long range → Marginally Irrelevant
 - ↳ $\sigma_F = \sigma_F^0 + e^2 \ln(\frac{\Lambda}{k})$
 - (Guinea, Vozmediano, MacDonald, Vafeck, Herbert, Wunsch, Sharapov)
- Intermediate to Strong interactions → New phases
CDW, Ferro, Antiferro
- High magnetic fields (Quenching of Kinetic energy)
 - Landau level splitting (Kim)
 - QH Phenomena (Nonaka, MacDonald, Sheng)

Electron-Boson interactions

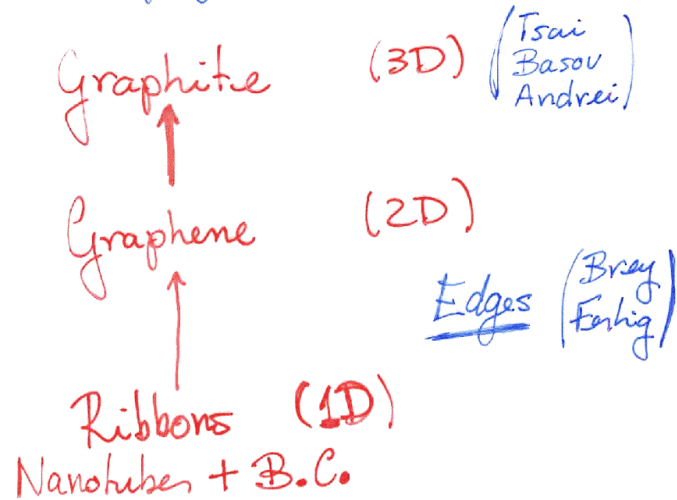
Boson = phonon, plasmon

- Strong-coupling (RPMAN) (Drenthaus, Probert, Kim, Hwang)
- Density dependent (")
- Effect on dispersion "Kink" (ARPES) (Lanzara)
- Where is superconductivity? K.E.
 - Proximity Effect (Lau, Andriei)
 - Cooper pairs
 - Supercurrent flow (?) only Delft (?)
- Can superconductivity be helped? (Uchoa)

Multilayers

- Same issues + inter-plane hopping (Braz, Basov, Nilsson, Stauber)
 - Stacking order
 - Moire patterns (Santos)
 - turbostratic graphene (Dresselhaus)
- Graphene x Epitaxial Graphene (Geim, Kim) (de Heer)

No prejudice!



Mesoscopics

- New quantum numbers (higher symmetries)
 - Valley
 - Chirality
- "valleytronics" (Beenakker)
- "neutrino" billiards (Lau)
- negative refraction index (Fal'ko?)