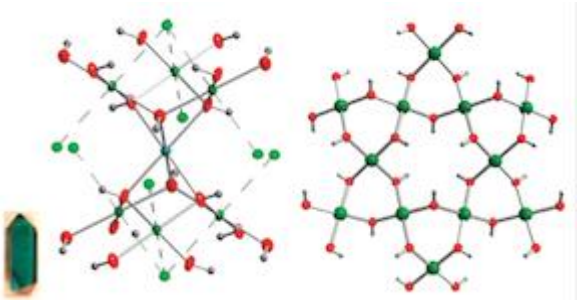


Optical Absorption Inside the Mott Gap

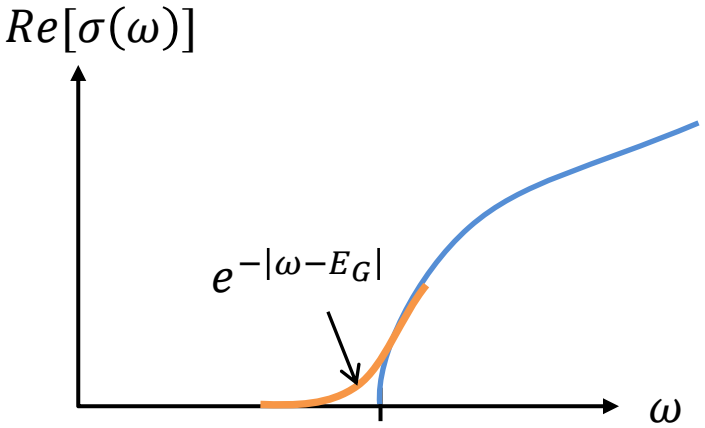
Andrew C. Potter (MIT)

(in collaboration with Patrick Lee)

KITP Fragnets'12 – Tuesday October 23, 2012

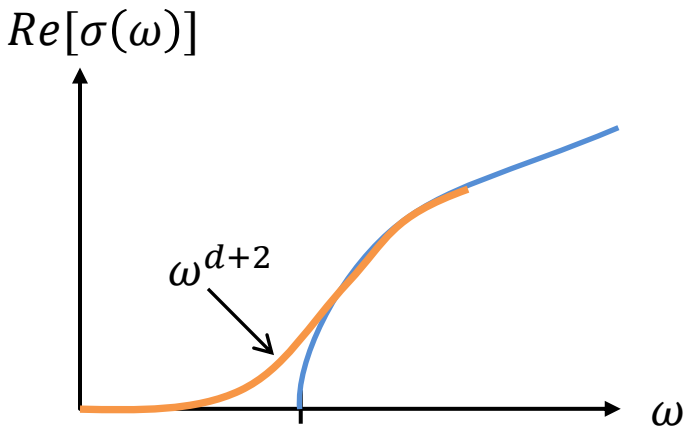
Conductivity in Charge Insulators

Band Insulator



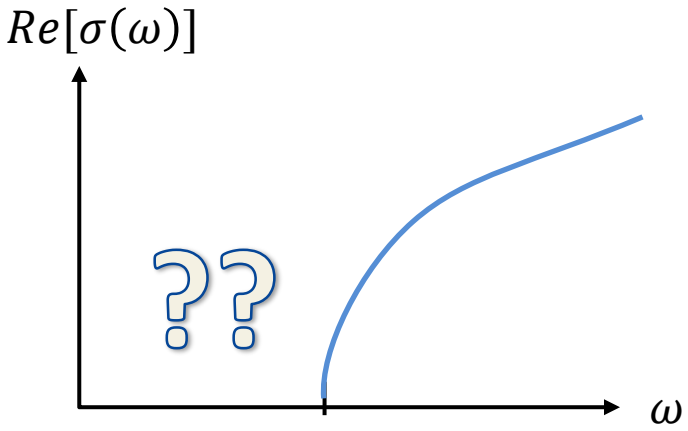
(Urbach Tail)

Antiferromagnetic Insulator



See e.g. TK Ng and PA Lee PRL (2007)

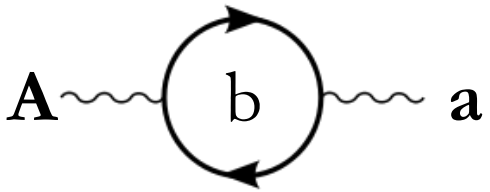
Spin-Liquid Mott Insulator



Effective Field Theory Description

$$c_\sigma = b f_\sigma$$

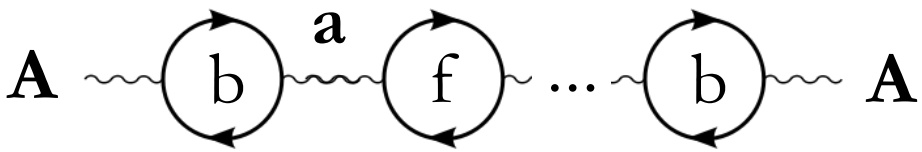
$$L = S_{0b} + S_{0f} + j_b \cdot (a + A) + j_f \cdot a$$



$$\int Db \Rightarrow L[a, A, f] = K_b (a + A)^2 + S_{0f} + j_f \cdot a$$

$$\int Df \Rightarrow L[a, A] = K_b (a + A)^2 + K_f a^2$$

$$\int Da \Rightarrow L[A] = \frac{K_b K_f}{K_b + K_f} A^2$$



$$\sigma_{physical} = \frac{\sigma_b \sigma_f}{\sigma_b + \sigma_f}$$

$$Re[\sigma] \approx \frac{Im[\sigma_b]^2}{Re[\sigma_f]}$$

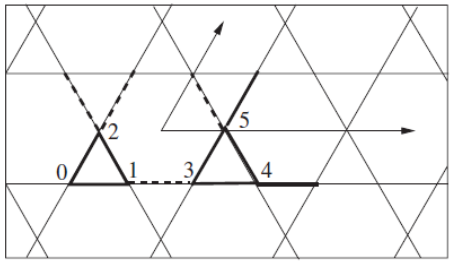
$$\omega^2 \left(\frac{\varepsilon_c - 1}{4\pi} \right)^2$$

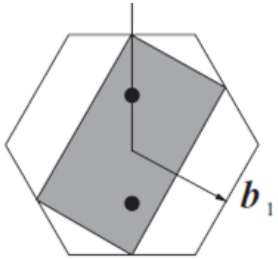
L. B. Ioffe and A. I. Larkin – *Gapless Fermions and Gauge Fields in Dielectrics* . PRB (1989)

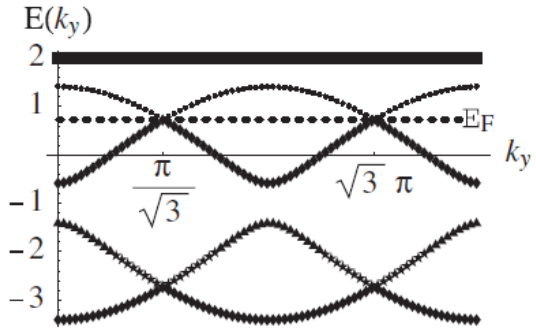
TK Ng and PA Lee – *Power-Law Conductivity inside the Mott Gap: Application to [K-ET]*. PRL (2007)

Fermionic Spin-Liquids

Dirac Spin Liquid





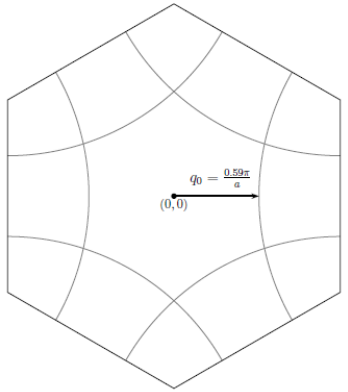


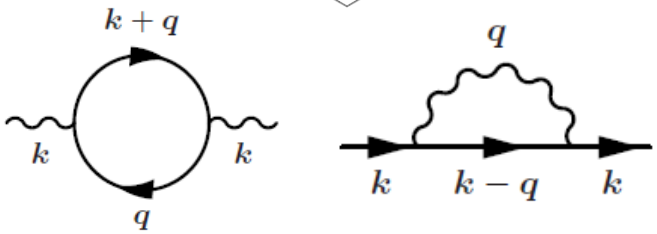
$$\sigma_f \sim \frac{\#e^2}{h}$$

$$\sigma_{electron} \sim \omega^2$$

See e.g. M. Hermele et al. PRB 2008

Spinon Fermi-Surface



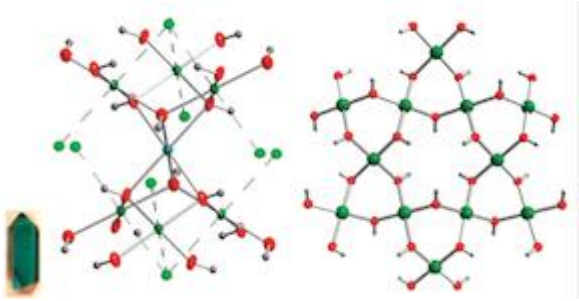


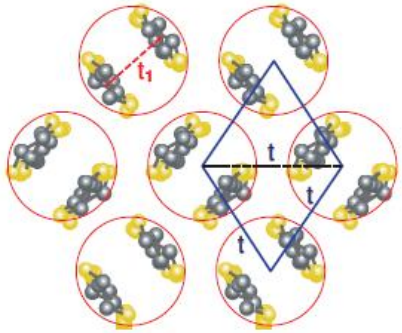
$$\sigma_f \sim \omega^{-4/3}$$

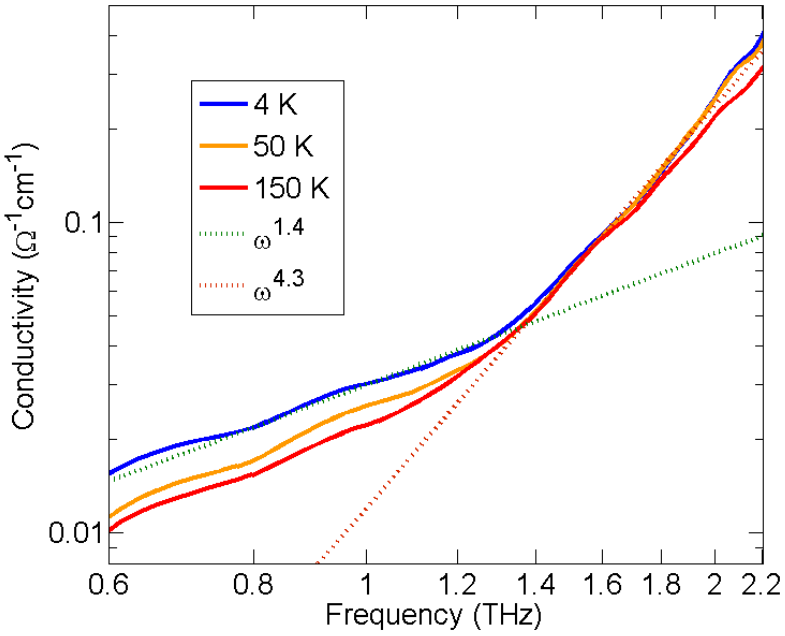
$$\sigma_{electron} \sim \omega^{3.33}$$

S.S. Lee and P.A. Lee PRL 2005
C.Nave & P.A. Lee PRB 2007

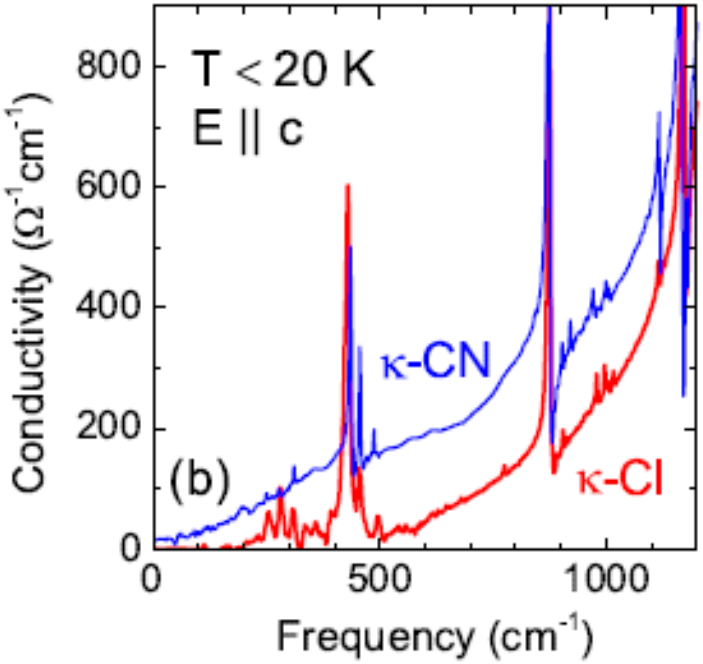
Experiments







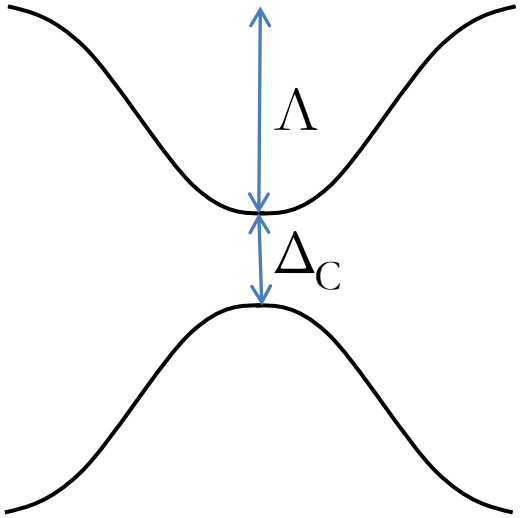
D. Pilon, J. Lui, A. Frenzel, Y. Lee, and N. Gedik (Unpublished)



Elsaesser et al. arXiv:1208.1664 (2012)

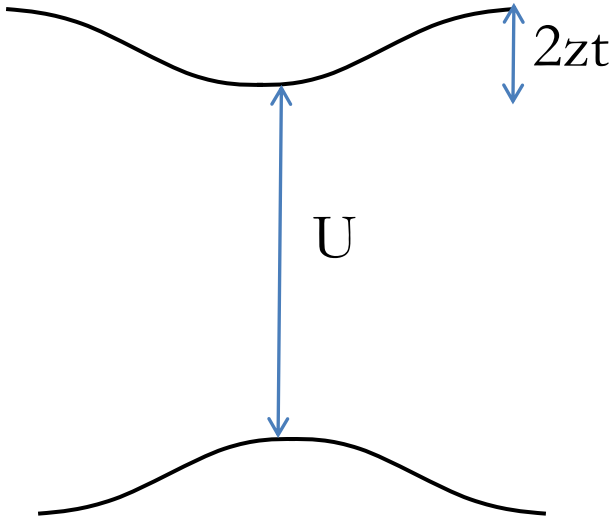
Weak vs. Strong Mott Insulator

Weak Mott Insulator



$$Im[\sigma_b] \approx \frac{\#e^2}{h}\left(\frac{\omega}{\Delta_c}\right)$$

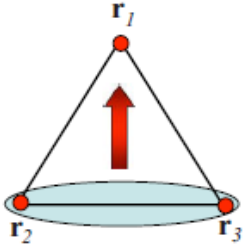
Strong Mott Insulator



$$Im[\sigma_b] \approx \frac{\#e^2}{h}\left(\frac{t}{U}\right)^3\left(\frac{\omega}{t}\right)$$

$$\sigma(Thz) \sim 10^{-12}\Omega^{-1}$$

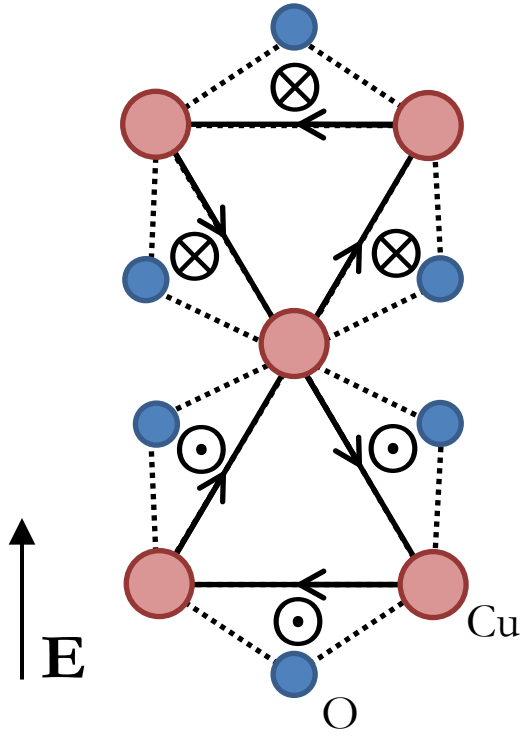
Compare to t/U expansion: $\tilde{P}_y = 4\sqrt{3}ea(t/U)^3[\mathbf{S}_1 \cdot (\mathbf{S}_2 + \mathbf{S}_3) - 2\mathbf{S}_2 \cdot \mathbf{S}_3]$



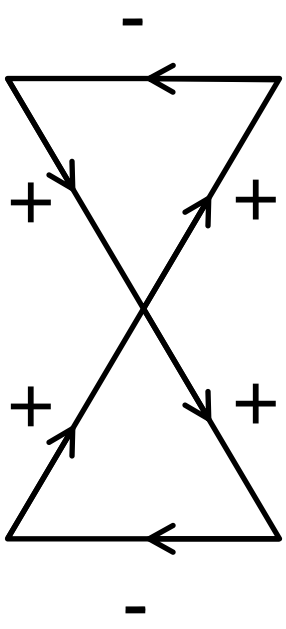
LN Bulaevskii, et al. PRB, 2008

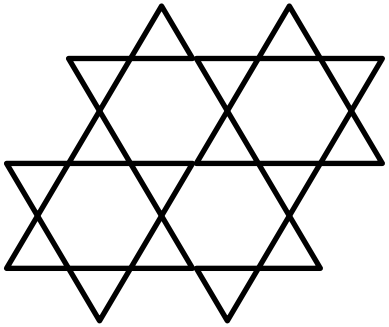
Other Mechanisms

DM Interactions



E-Field Modulation of DM





$$\boldsymbol{D}_{ij} \cdot \left(\boldsymbol{S}_i \times \boldsymbol{S}_j\right) \Rightarrow i\boldsymbol{\lambda}_{ij} \cdot \left(f_{ia}{}^{+} \boldsymbol{\sigma}_{ab} f_{jb}\right) + h.c.$$

$$\sigma \sim \omega^2$$

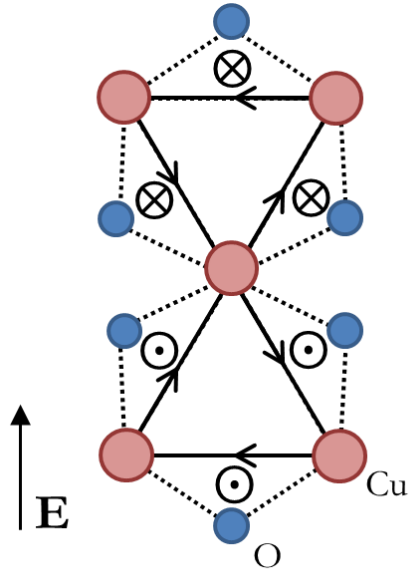
$$(\boldsymbol{E}(t) \times \hat{z}) \cdot \boldsymbol{J}^{\boldsymbol{Sz}}$$

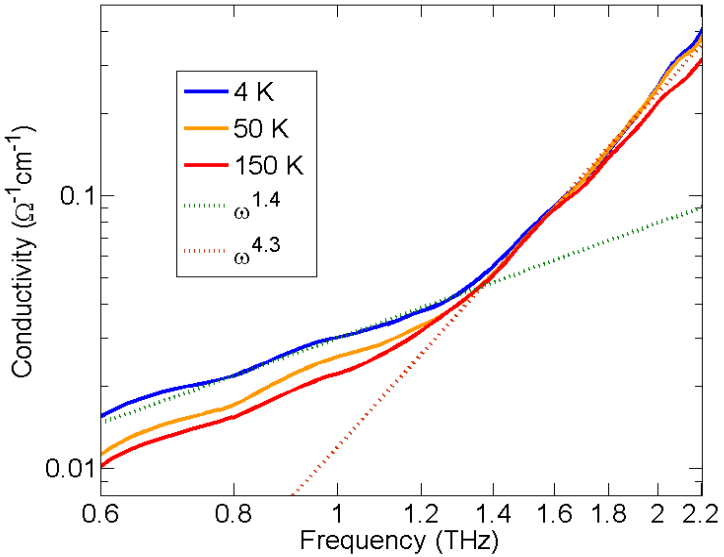
$$\sigma(Thz) \sim 10^{-9}\Omega^{-1}$$

Thanks for your attention – Questions?

Thank you to:

- KITP – Hosting this Research/Program
- Patrick Lee – Many helpful conversations





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