Nematic Phases

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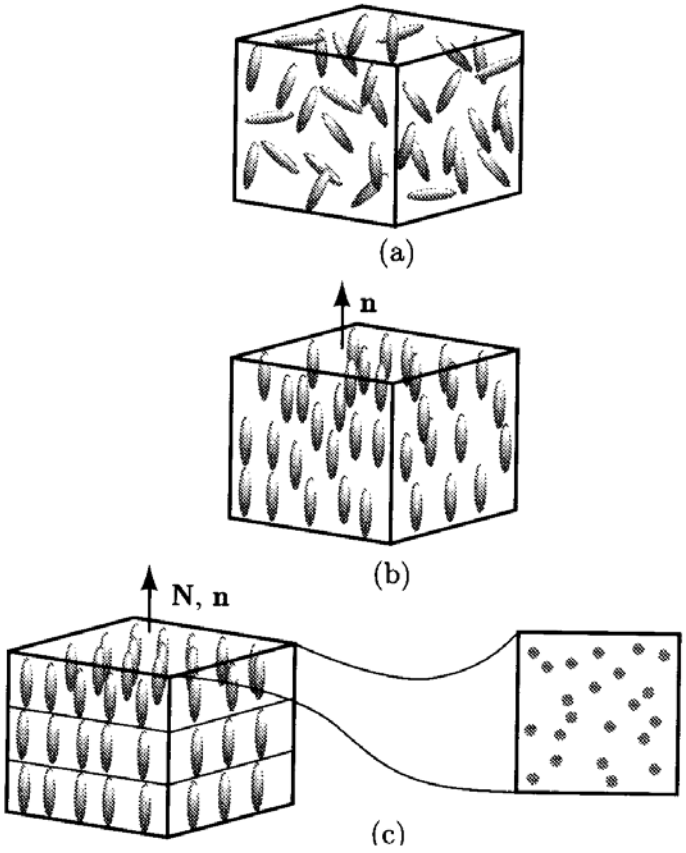
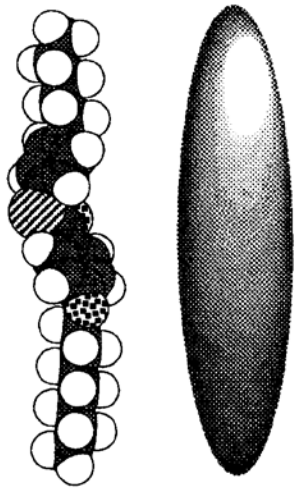
Nematic Order

- Spontaneous breaking of rotational symmetry (down to C_2)
- No translational symmetry breaking

classical liquid crystals





Mechanism

Interrupt a long-range strip order

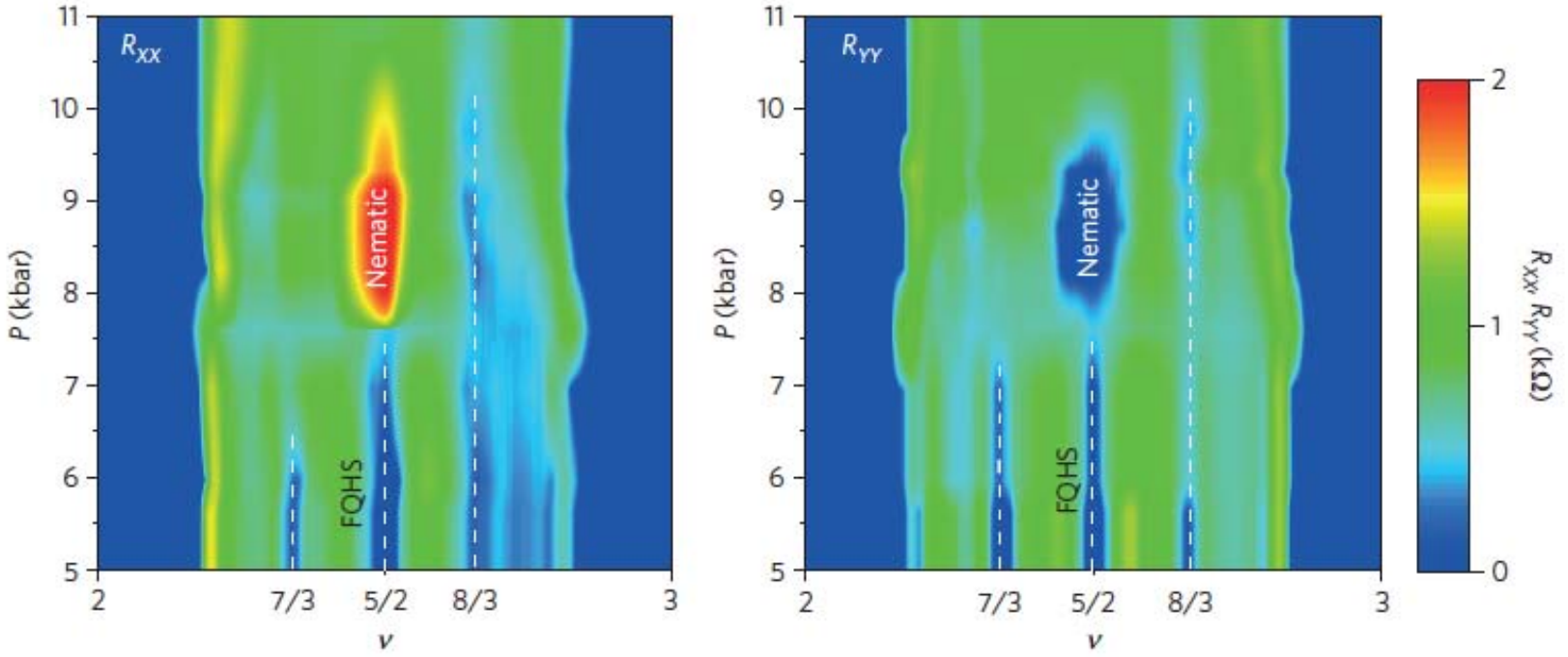
- Quantum/ thermal melting
- Disorder
- Frustrations

Nematic phases in Fe-based superconductors and high-Tc cuprates

Without the assistant of translational symmetry breaking

- Pomeranchuck instability
- Lattice systems can be enhanced by:
  - van Hove singularity
    (Hae-Young Kee 2004
    …).
  - Quadratic band crossings
    (Vafek and Yang, 2010
    KS, Yao, Fradkin, Kivelson,
    …)

Nematic quantum Hall phase



Samkharadze, et. al., Nat. Phys., (2016)

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Nematic quantum critical point

Challenge: fermionic low-energy excitations coupled with critical modes

Part of a bigger problem: quantum criticality in itinerant systems

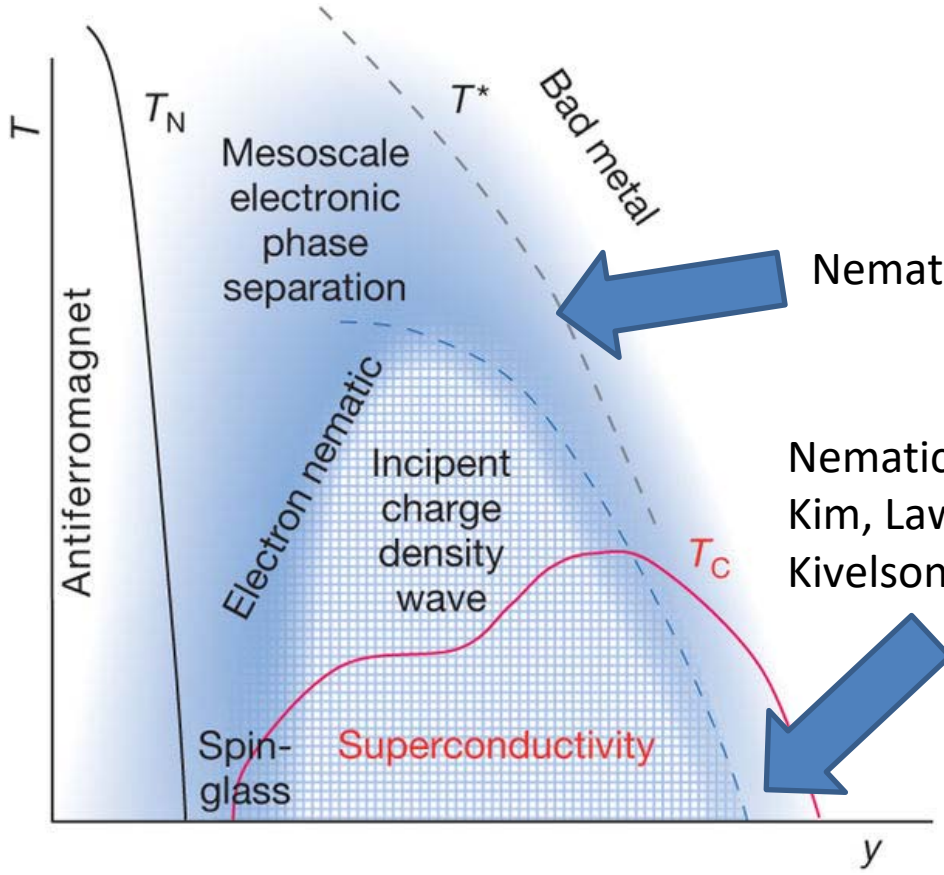
- Hertz-Millis: mean-field scaling
  - Nematic z=3 mean-field (Oganesyan, et. al., PRB 2001)
  - Smectic z=2 mean-field
  - non-Fermi liquid

- Beyond Hertz-Millis:
  - Contributions from non-Fermi liquid
  - Deviations from Hert-Millis can arise
    (Chubukov, Lee, Sachdev, Senthil, …)

- Recent sign-problem free QMC:
  - q=0 (nematic): deviations from Hertz-Millis, possible anomalous dimensions
  - Finite q (smectic): very nice agreement with Hertz-Millis
    (Berg, Hong, Meng, …)

Interplay with other phenomena in complex materials

- Superconductivity and Pseudo gap:



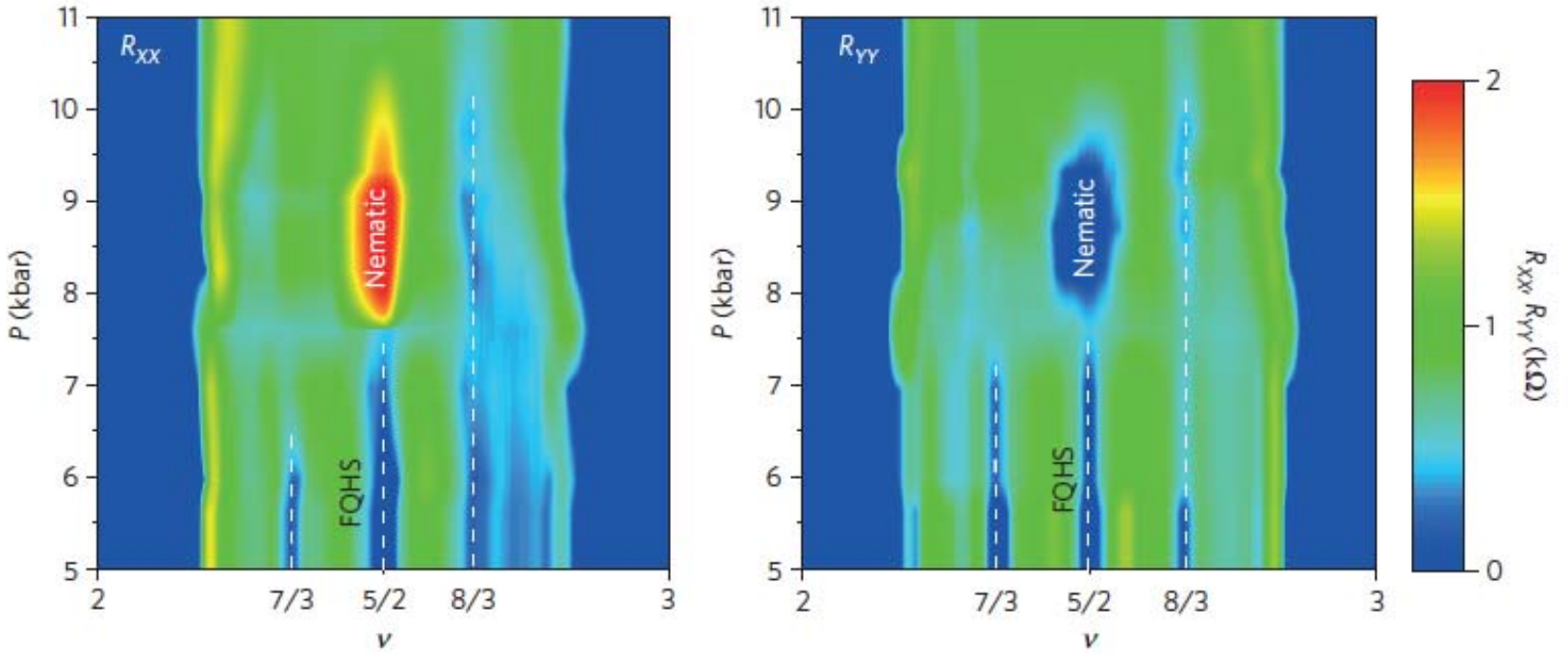
Nematic and Pseudo gap

Nematic intertwines with SC: Nodal nematic
Kim, Lawler, Oreto, Sachdev, Fradkin, Kivelson, 2008

Fradkin and Kivelson, 2012

Interplay with other phenomena in complex materials

- Topological Order



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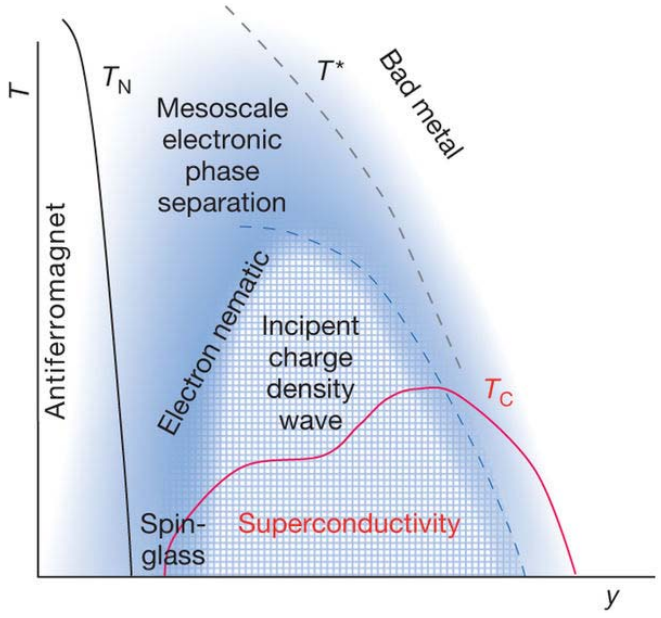
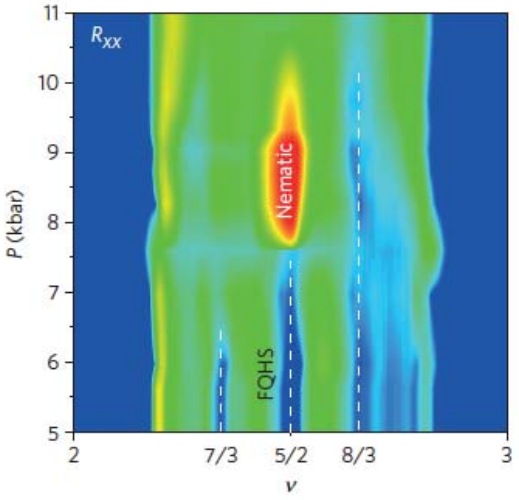
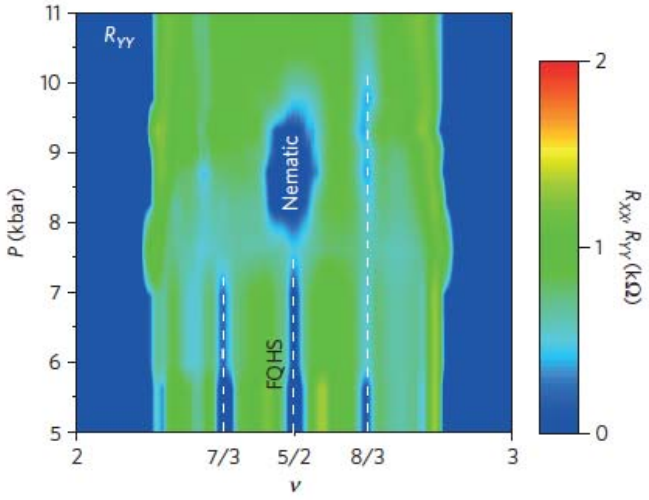
Interplay with other phenomena in complex materials

- Common in both systems:

  Interplay between nematic order and pairing







Could there be some possible connections between these two seemingly unrelated systems?