WEISS OSCILLATIONS AND THE HALF-FILLED LANDAU LEVEL

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INTRODUCTION

We compare Son's particle hole symmetric theory of Dirac composite fermions[1,2,3] of the half-filled Landau level of a 2DEG with experiments on _Weiss oscillations_[4] around half-filling.

Weiss oscillations: Magnetoresistance oscillations arising due to 1D periodic scalar/vector potential in the 2DEG. Oscillation minima occur when magnetic length l_b commensurate with period of potential d,

$$l_b^2 \propto \frac{d}{2k_F}; \quad k_F = \text{CF Fermi momentum}$$

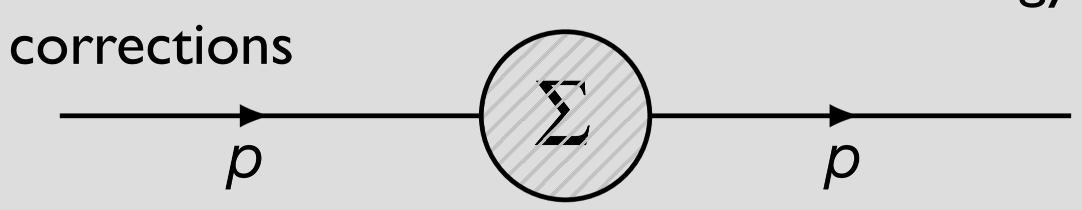
Tuning of the periodicity of the potential, d leads to oscillations arbitrarily close to half-filling and hence act as a good probe of the emergent Fermi sea at $\nu = 1/2$

ANALYSIS

- The Dirac composite fermion theory manifestly preserves particle-hole (PH) symmetry at half-filling when the Dirac fermion mass is zero
- Weiss oscillations occur _away_ from half-filling → PH symmetry explicitly broken
  - Incorporate composite fermion *mass* term into Son's theory

$$\mathcal{L} = \bar{\psi}\gamma^{\mu}(i\partial_{\mu} + a_{\mu})\psi + m\bar{\psi}\psi + \frac{1}{4\pi}\epsilon^{\mu\nu\rho}a_{\mu}\partial_{\nu}A_{\rho} + \frac{1}{8\pi}\epsilon^{\mu\nu\rho}A_{\mu}\partial_{\nu}A_{\rho}$$

- Away from half-filling, fluctuations of the emergent gauge field expected to generate a fermion mass via Dirac fermion self-energy corrections



PHENOMENOLOGY

- Composite Dirac fermion (CF) mass assumed to be ∝ effective magnetic field: $\sqrt{|B - B_{1/2}|}$
  - Satisfies requirement of massless theory at half-filling
    - Proportionality constant determined by fitting _one_ oscillation minimum with experiments[5] e.g. p=3 in **Fig. 1**
- CF conductivity determined away from half-filling in presence of a periodic vector potential
- Conductivity is oscillatory → oscillation minima occur when:

$$l_b^2 = \frac{d}{2k_F}\left(1 + \frac{m_{\rm CF}^2}{2k_F^2}\right)\left(p + \frac{1}{4}\right)$$

$$p = 1, 2, 3, \cdots$$

WEISS OSCILLATIONS ABOUT HALF-FILLING

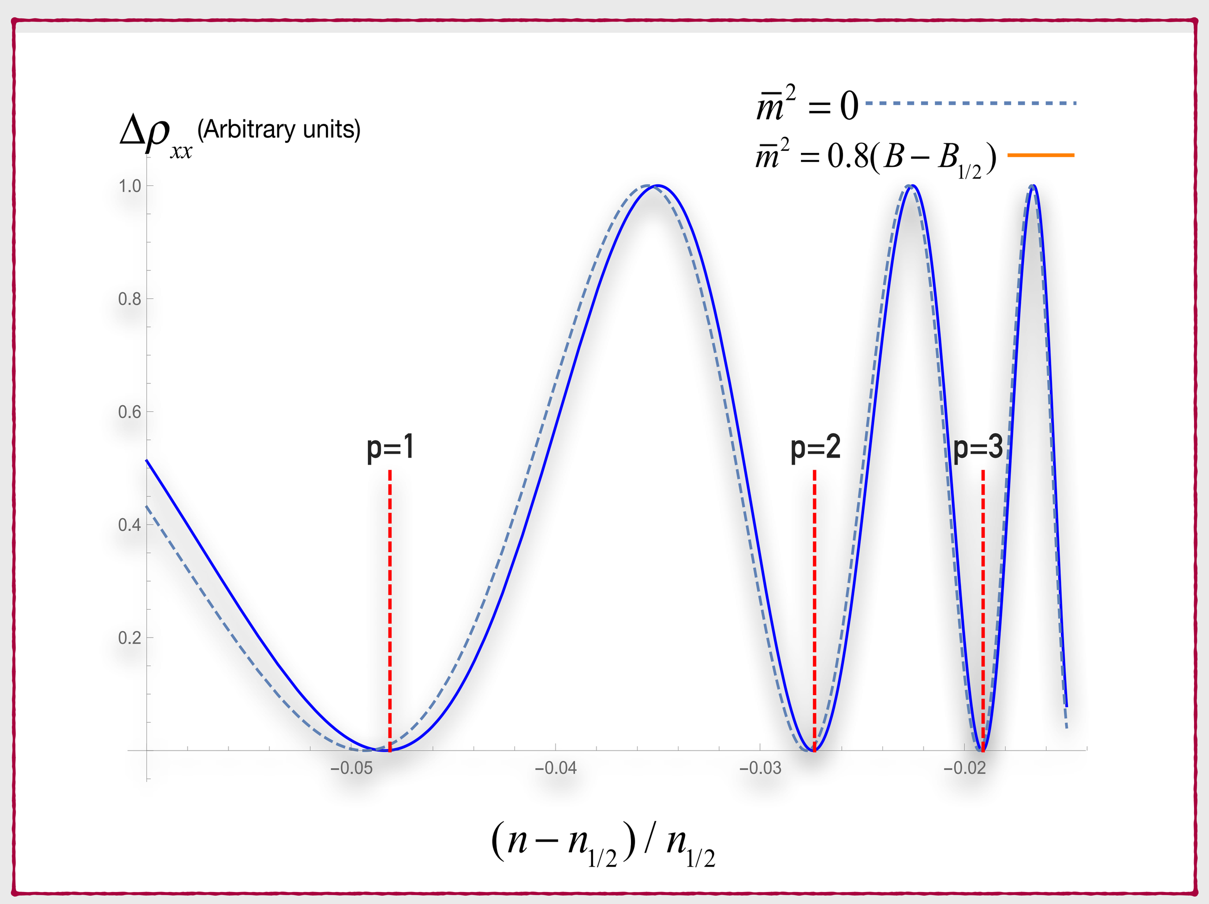


Figure 1. Resistivity oscillations obtained by tuning electronic density, *below* half-filling. Comparison of oscillations due to massive CF's (bold) with massless[6] CF's (dotted). Vertical dashed lines correspond to experimental minima. CF mass parameter fitted w.r.t p=3 experimental minima[5]

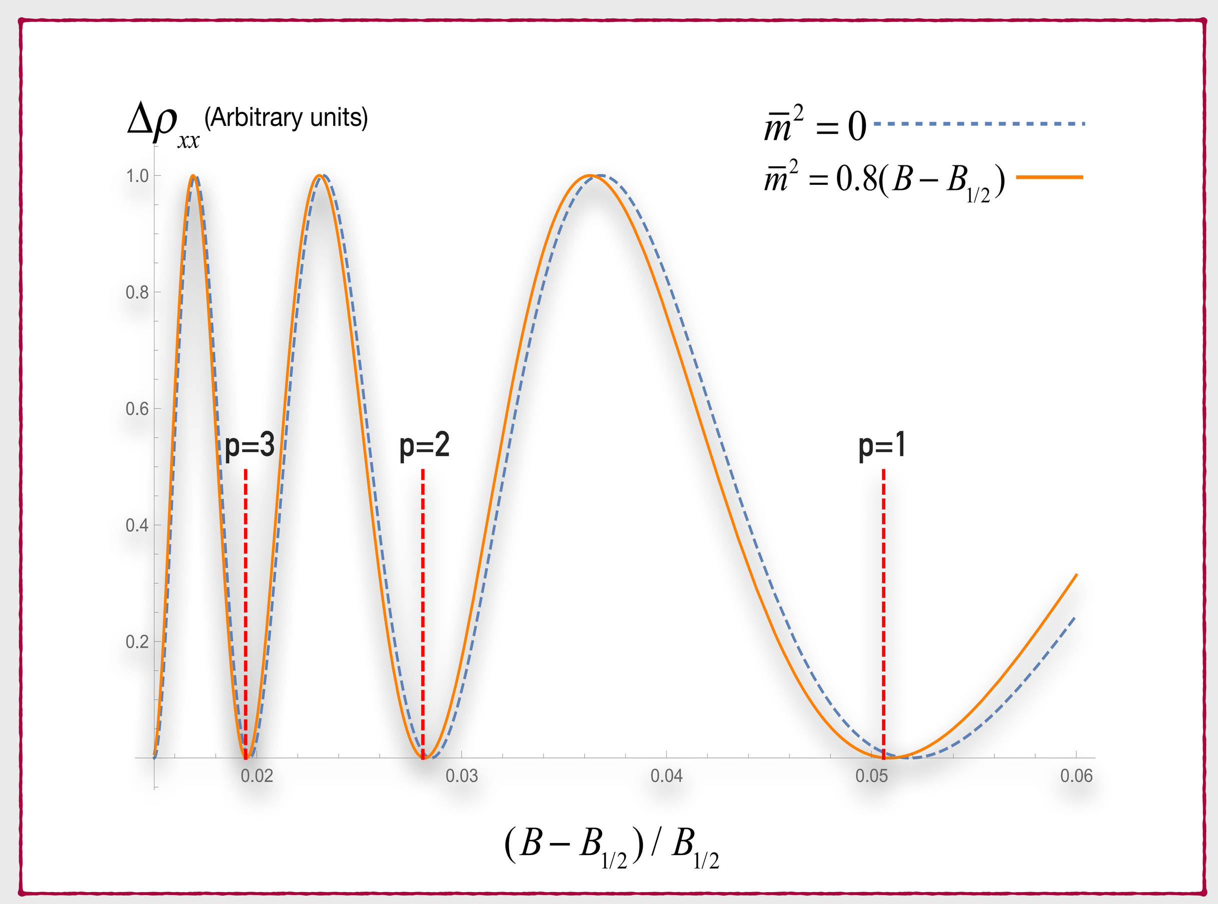


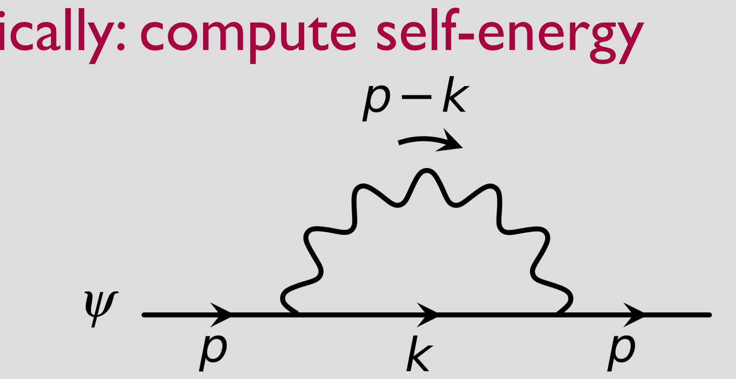
Figure 2. Resistivity oscillations obtained by tuning magnetic field, *above* half-filling. Comparison of oscillations due to massive CF's (orange) with massless[5] CF's (blue). Vertical dashed lines correspond to experimental minima. Value of CF mass parameter same as in **Fig. 1**

CONCLUSION

- Phenomenological treatment of Weiss oscillations using _massive_ Dirac CF provides good match with experiments
  - _Same_ phenomenological value of CF mass parameter gives good matching for oscillations due to varying n or B → Consistency

REMARKS

- Check evidence of mass generation, field theoretically: compute self-energy



- Compare leading order mass correction with phenomenologically obtained value

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