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Santanu Dey
(University of Alberta)

Quantum-critical electrodynamics of Luttinger fermions

We study the quantum electrodynamics of Luttinger fermions with quadratic band-crossing dispersion in three dimensions. The model can be viewed as the low-energy effective theory of a putative U(1) quantum spin liquid with fermionic Luttinger spinons, or as an extension of the Luttinger-Abrikosov-Beneslavskii (LAB) model that accounts for transverse gauge fluctuations with finite photon velocity. Aided by a renormalization group analysis below four dimensions, we elucidate the presence and stability of quantum critical phenomena in this model. We find that the non-Fermi liquid LAB phase is stable against gauge fluctuations and can thus also be viewed as a U(1) spin liquid with gapless Luttinger spinons. We discover a multicritical point with Lifshitz scaling that corresponds to a time-reversal symmetry-breaking quantum phase transition from the LAB state to a chiral spin liquid with spinon Landau levels and birefringent emergent photons. This multicritical point is characterized by a finite fermion-photon coupling in the infrared and can be viewed as a fermionic analog of the Rokhsar-Kivelson point in three-dimensional quantum dimer models.