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RG Analysis on a Neck-Narrowing Lifshitz Transition in the Presence of Weak Short-Range Interactions in Two Dimensions SEDIGH GHAMARI, McMaster University, SUNG-SIK LEE, McMastre University and Perimeter Institute for Theoretical Physics, CATHERINE KALLIN, McMaster University — We present a pertrbative renormalization group (RG) analysis for a neck-narrowing Lifshitz transition in the presence of weak short-range interactions in two dimensions. The model we examine is described by the dispersion $\varepsilon(\mathbf{k}) = \mathbf{k_x^2} - \mathbf{k_y^2}$, which would be at the critical point of the neck-narrowing transition at zero chemical potential, $\mu = 0$. At the critical point ($\mu = 0$), we find that one-loop quantum corrections to the interaction vertex are non-analytic. This makes capturing the evolution of the low-energy effective theory, as the energy cutoff is progressively lowered, in terms of β-functions for local operators impossible. Thus we conjecture that any consistent RG description at the critical point of this neck-narrowing transition will involve non-local operators. Slightly away from the critical point ($\mu > 0$), where the Fermi surface has a narrow neck, we find that the quantum corrections are analytic only over a finite momentum range, which shrinks to zero as the chemical potential approaches zero. More importantly, within this analytic range, where a local RG description is possible, we show that the narrower the width of the neck, the larger the couplings of irrelevant interactions become, leading to the breakdown of perturbative RG.

Sedigh Ghamari
McMaster University

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