A ferromagnetic spin-fermion theory

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Abstract

I consider the problem of 2D fermions interacting with gapless long-wavelength collective bosonic modes. The theory describes, among other cases, a ferromagnetic quantum-critical point (QCP) and a QCP towards nematic ordering. There was a lot of discussions recently about whether one can construct a controllable expansion at the QCP, and what is the correct fermionic and bosonic behavior at criticality. I argue that a controllable, Eliashberg-type expansion at QCP is possible, and is justified under two conditions: the interaction should be smaller than the fermionic bandwidth, and either the band mass m_B should be much smaller than $m = p_F/v_F$, or the number of fermionic flavors N should be large. For a nematic QCP, the Eliashberg theory is stable, and fermionic self-energy scales as $\omega^{2/3}$, for an $SU(2)$ symmetric ferromagnetic QCP, the Eliashberg theory itself includes a set of singular renormalizations which destroy a ferromagnetic QCP. I show how this last effect can be understood in the framework of the ϕ^4 theory of a ferromagnetic quantum-criticality.