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Quantum critical behavior in itinerant electron systems: Eliashberg theory and instability of a ferromagnetic quantum-critical point

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— We consider the problem of fermions interacting with gapless long-wavelength collective bosonic modes. The theory describes, among other cases, a ferromagnetic quantum-critical point (QCP). We construct a controllable expansion at the QCP in two steps: we first create a new, non Fermi-liquid "zero-order" Eliashberg-type theory, and then demonstrate that the residual interaction effects are small, provided we meet two conditions on the parameters of the system. For an $SU(2)$ symmetric ferromagnetic QCP, we find that the Eliashberg theory itself includes a set of singular renormalizations which can be understood as a consequence of an effective long-range dynamic interaction between quasi-particles, generated by the Landau damping term. These singular renormalizations give rise to a negative non-analytic $q^{3/2}$ correction to the static spin susceptibility, and destroy a ferromagnetic QCP. We demonstrate that this effect can be understood in the framework of the ϕ^4 theory of quantum-criticality, and show that it is specific to the $SU(2)$ symmetric case.

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