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Magnetism and the Fermi surface in heavy fermion metals

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With a plethora of different phases and quantum critical points, heavy fermion materials should reign supreme as the prototype for competing order, a major contemporary theme in condensed matter physics. One key feature that differentiates the types of magnetic phases/critical points is the presence or absence of Kondo screening. This singlet formation is dramatically manifested in the Fermi surface, which provides important experimental insight into the problem. The size of the Fermi surface therefore becomes an important issue. To provide a theoretical basis for the different types of magnetism, we have recently carried out asymptotically exact studies of the Kondo lattice model inside both the antiferromagnetic [1] and ferromagnetic [2] phases. A fundamental aspect of the approach is to map the magnetic Hamiltonian for the local f-moments onto a quantum nonlinear sigma model (QNLsM). The Kondo interaction results in an effective coupling between the QNLsM fields and the conduction electrons. Renormalization group analyses show that the Fermi surface in the corresponding ordered states is small (not incorporating the f-moments) for both the ferromagnetic and antiferromagnetic cases. These results are of relevance to a number of materials, including YbRh2Si2 and CeRu2Ge2, where experimental measurements of magnetotransport and de Haas van Alphen effects [3,4] have provided evidence for the small Fermi surface phases. The implications of our results for the heavy fermion quantum critical points will also be discussed.

[1] S. J. Yamamoto and Q. Si, PRL 99, 016401 (2007); Physica B 403, 1414 (2008);
[2] S. J. Yamamoto and Q. Si, to be published;
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[4] C. A. King and G. G. Lonzarich, Physica B 171, 161 (1991).