Superconductivity and charge density wave physics near an antiferromagnetic quantum critical point: insights from Quantum Monte Carlo studies

Xiaoyu Wang[1]

[1] *James Frank Institute, University of Chicago, Chicago, IL 60637, USA*

One of the most important questions in condensed matter physics is to understand the phase diagrams of high temperature superconductors, including cuprates and iron-based materials. These materials are layered quasi-two-dimensional quantum systems with strong electronic interactions. Superconductivity arises when an antiferromagnetic phase is suppressed, and that a "putative" antiferromagnetic quantum critical point (QCP), i.e., a zero-T phase transition, may be responsible for the maximal transition temperature as well as the non-Fermi liquid normal state properties.

In this talk, I discuss our recent studies on the low-temperature phases of the so-called spin-fermion model, in which electrons near the Fermi surface are coupled to quantum critical antiferromagnetic fluctuations. This work combines sign-problem-free Determinantal Quantum Monte Carlo techniques with field theoretical calculations.

I will mainly address two questions. First, I discuss the microscopic system parameters governing the superconducting transition temperature Tc near an antiferromagnetic QCP. I show that Tc is determined not by the properties of the entire Fermi surface, but only those of the antiferromagnetic "hot spots". Furthermore, for weak to moderately strong couplings, the numerical results are quantitatively captured by Eliashberg theory. Next, I discuss an emergent low-energy symmetry of the model that relates d-wave superconductivity to d-wave charge order with momentum connecting between hot spots. I show numerically that such approximate symmetry is insufficient to drive a near-degeneracy between the two electronic states. Instead, small symmetry-breaking perturbations at the lattice level render the emergent symmetry inaccessible.

[1] X. Wang, Y. Schattner, E. Berg, and R. M. Fernandes, Phys. Rev. B **95**, 174520 (2017).
[2] X. Wang, Y. Wang, Y. Schattner, E. Berg, and R. M. Fernandes, arXiv:1710.02158.