MAR16-2015-002564

Abstract for an Invited Paper
for the MAR16 Meeting of
the American Physical Society

What makes the nematic phase of FeSe different than other iron-based superconductors?[1]

RAFAEL FERNANDES, University of Minnesota

Most iron-based superconductors display, in their normal state, a transition to a magnetic stripe state that is either accompanied or preceded by a tetragonal-to-orthorhombic transition. The proximity between these two transitions has led to the proposal that they correspond to a two-stage melting of the magnetic stripe state, resulting in a vestigial orthorhombic-paramagnetic nematic phase. Despite the success of this scenario to describe many iron-based materials, the simplest of them, FeSe, displays a high-temperature nematic transition but no long-range magnetic order. Interestingly, in its monolayer form, FeSe displays the highest T_c of all iron-based materials, raising the question of whether the nematic state of its bulk form could be related to the superconducting state of its monolayer form. In this talk, we investigate theoretically the microscopic origin of the nematic phase of FeSe. By extending the standard RPA formalism, we compare the orbital-order susceptibility and the spin-driven nematic susceptibility of a generic multi-orbital Hubbard model. We find that the former cannot in general drive the nematic transition, and that high-energy magnetic fluctuations play a fundamental role in stabilizing the nematic state in the absence of long-range magnetic order. Focusing on FeSe, we identify two features that distinguish it from all other iron-based materials: a very small Fermi energy and a large degeneracy of the magnetic ground state. We show that both effects enhance the nematic transition temperature at the same time as they suppress the magnetic transition. These results may explain why, in FeSe, the onset of nematic order does not require strong magnetic fluctuations, in contrast to other iron-based materials. Finally, we discuss how the interplay between magnetic fluctuations and small Fermi energy in FeSe can lead to the emergence of different types of Pomeranchuk instabilities, and discuss their experimental manifestations.

[1]This work was supported by the U.S. Department of Energy, Office of Science, Basic Energy Sciences, under award number DE-SC0012336