Spin-orbital interplay in the nematic phase of iron superconductors

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Understanding the origin of the nematic phase is one of the most challenging open issues in the field of iron-based superconductors. It is well settled that it is electronic origin but it is not known which degree of freedom generates the instability. Traditionally, there have been two schools, spin and orbital driven nematicity. The solution of this question could help to find out the mechanism of superconductivity. FeSe presents a unique opportunity to study the nematic phase below the structural transition at Ts~90K since in contrast to most iron superconductors, it lacks the columnar antiferromagnetic phase. The spin driven scenario for the nematic phase is then questionable. In addition, ARPES experiments report a momentum-modulated orbital ordering between the Gamma and M point of the Brillouin zone. This has prompted several proposals within the orbital ordering scenario. On the other hand, spin fluctuations have been measured in experiments and magnetism emerges with pressure. In this work, we derive an effective action for the magnetic and nematic phases at energies close to the Fermi surface including the orbital weight on each Fermi pocket in FeSe and 122 compounds.[1] We implement the orbital selective spin fluctuation approximation in which the dominant spin scattering is intraorbital.[2] This approach allows us to address the difficult problem of spin-orbital entanglement and give rise to an enormous simplification avoiding tensorial forms as in previous proposed effective actions. The effective action turns out to be very similar to the well-known spin-nematic model based upon band models [3] but including the information of the orbital degree of freedom.
Results of this effective action are the following: (i) it provides a simple scenario to understand how the nematic phase of FeSe can be driven by orbital selective spin fluctuation. (ii) the odd orbital ordering observed in FeSe is naturally explained as a self-energy effect due to the exchange of orbital selective spin fluctuations between the hole and the electron pockets [4]. (iii) The particular nematic and magnetic phases in FeSe and 122 compounds arise because of the different orbital nesting between the electron and outer/inner hole pockets. This is understood because the good orbital nesting between electron and hole pockets has opposite effects on the magnetic and nematic instability. [1](iv) The decrease of the nematic phase in FeSe with pressure could be due to the emergence of the inner hole pocket.[1] (v) Via the spin-orbital entanglement the sign in the anisotropy conductivity depends on the velocity an on the scattering rate which shed light on the strong controversy about the origin of the resistivity anisotropy.[5]

References

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