Order by Disorder in Underdoped Cuprate Superconductors

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Introduction

We study the effect of disorder on the dynamical spin susceptibility of a correlated *d*-wave superconductor (dSC) in the presence of nonmagnetic disorder, using both an unrestricted Hartree-Fock approach and the inhomogeneous Gutwiller approximation[1]. This model provides a concrete realization of the notion that disorder slows down spin fluctuations, which eventually "freeze out". The evolution of disorder-induced spectral weight transfer agrees qualitatively with experimental observations on underdoped cuprate superconductors[2]. We also studied the effect of a small symmetry-breaking term in the electronic structure and illustrated how proximity to the antiferromagnetic transition enhances the "nematic susceptibility" in such a system[3].

Results and Discussion

Fig. 1 (a-d) shows how impurities influence local magnetism in the Hubbard model [1] with a small x-y symmetry-breaking term in the hopping: (a) strong impurities induce magnetic droplets in their vicinity, as expected; (b) one observes a strong nematic symmetry-breaking in the spin response at low energies; (c) which disappears when one reaches energies close to the gap. Cuts in both directions through $\chi(\theta,\omega)$ shown in Fig 1(d) are very similar to experiment. Fig 1(e) shows what happens in the t-J model in the case of weaker (dopant) impurities, which create pockets of AF order *between* them. Fig. 1(f) shows that if they are strong (e.g. Zn), they create magnetic droplets around themselves as in the Hubbard case.

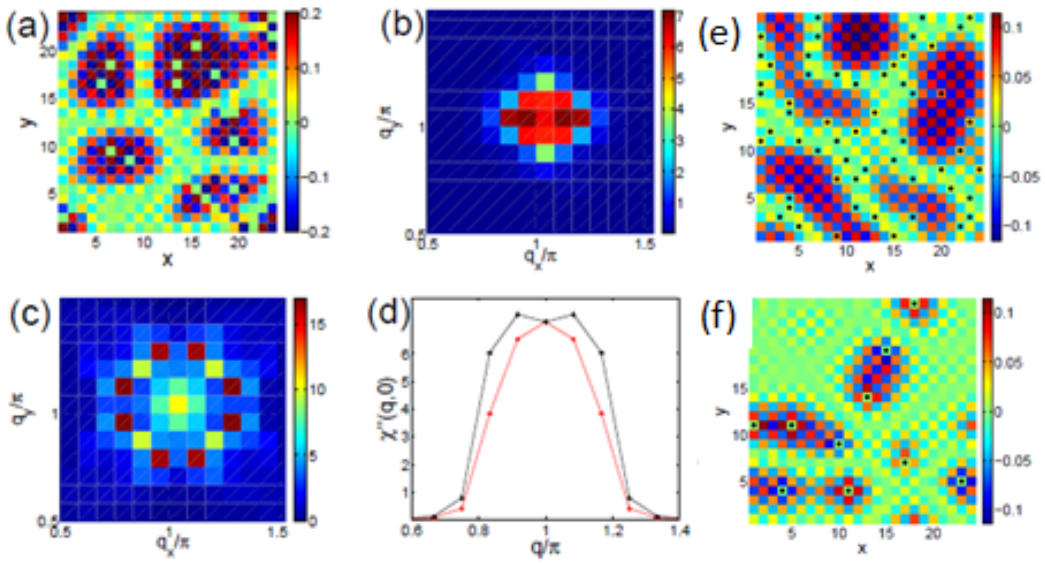

Figure 1

Conclusions

Many of the effects observed in underdoped cuprates are enhanced or driven by disorder, which has a strong influence on local magnetism. To understand recent neutron experiments on intrinsically disordered cuprates like LSCO, but also on cleaner ones like YBCO, a description of disorder is necessary for any complete theory.

Acknowledgements

Supported by NSF-DMR-1005625.

References

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