Homogenous nodal superconductivity coexisting with inhomogeneous charge order in strongly underdoped Bi-2212.

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Recommended and a commentary by Joe Orenstein, University of California, Berkeley.

"Something is happening and you don't know what it is, do you Mr. Jones?" (Bob Dylan)

In a full-sized journal article, Kyle McElroy and co. have released STM images and analysis previously only available at live performances of the Seamus Davis Group. However, be warned that, as is typical of the very best experiments on the high-Tc cuprates, the results are fascinating, complex, confusing, and ultimately, inexplicable.

McElroy et al. report a comprehensive study of the local density of states (LDOS) in crystal samples of the BSCCO superconductor, from under to overdoped. The LDOS spectra are processed into gap maps in real space and spectral density maps in momentum space. The peaks that emerge in the spectral density plots seem to be understandable in terms of the elastic scattering of well-defined Boguliubov quasiparticles. All other observations, such as those highlighted below, still await explanation:

* The spectra separate roughly into two regimes, above and below 25 meV. Below, the spectra are nearly spatially homogeneous, the ripples that give rise to the spectral density peaks have very small amplitude. However, above this energy the spectra vary drastically from one region of the sample to another. How can the material be homogeneous and inhomogeneous at the same time?
* The different regions seem to divide into two basic types: one with a large gap and no sharp "coherence" peaks, the other with small gap and sharp peaks. Is the former the pseudogap phase and the latter the superconductor?
* With sufficient data massaging, the big gap regions seem to possess an additional spectral density peak that has a nondispersing wavevector with period between 4 and 5 lattice constants a. The same feature has been observed previously in vortex cores (Jenny Hoffman et al.) and more recently at elevated temperature by Ali Yazdani's group (Vershinin et al.). Is this incommensure

charge ordering?

And finally, some more questions:

* The incommensurate charge ordering peaks are very near in wavevector to the weakly dispersing q1 feature in the famous “octet” model. Are these really two distinct phenomenon?
* Dung-hai Lee in particular has emphasized the importance of the q1 nesting. Is this an accident of band structure or a manifestation of something more fundamental?
* Can the tiny charge order amplitude observed in STM really explain the large pseudogap and the destruction of quasiparticle-like self-energy peaks near the “hot spots?”
* Before the STM experiments one might have characterized theoretical predictions into two basic groups: stripes and various susceptibilities to broken symmetry based on the proximity to half-filling. Thus we expected to see either 1D ordering or some kind of 2D ordering with wavelength near 2a. Instead the remarkable STM data confronts us with 2D incommensurate order near 4a.

Despite the questions, we may take some comfort from the fact that total confusion is often a prelude to breakthroughs. Certainly a unified explanation of the STM data and the recently clarified inelastic neutron spectra would be a big step forward.