# $T_C$SUH Special Seminar

Texas Center for Superconductivity
University of Houston


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### "Midgap states as a powerful tool to investigate unconventional superconductivity --- An overview"

**Wednesday, June 28, 2006**
Room 102, University of Houston Science Center
4:00 p.m. – 5:00 p.m.


### Abstract

In the summer of 1993, the first **phase-sensitive test** of high $T_c$ superconductors had just appeared in preprint form [1], which was designed to show that the pairing order parameter or gap function of these superconductors has a cos(2θ)-like sign variation on an essentially cylindrical Fermi surface. The speaker proposed [2] then at $T_C$SUH that as a topological consequence of this sign variation alone, at any non-(100) surface of such a superconductor there must exist a sizable number of quasi-particle excitations with energy essentially at the center of the superconducting gap, i.e., at the Fermi energy. These "midgap states" are nearly dispersionless in that they have momentum along the surface ranging from $-k_F$ to $+ k_F$ but essentially no kinetic energy associated with them. These states, called "zero-energy Andreev bound states" by some researchers, are a direct signature of unconventional (i.e. non-s-wave) pairing. Many strong experimental evidences on the existence of such states in high Tc superconductors have since been obtained, and these states have since become a powerful tool to test whether many kinds of more recently discovered superconductors have unconventional pairing. Very recently, the speaker and his collaborators at $T_C$SUH have shown that a variation of these states can also provide a clear signature for the so-called FFLO (Fulde-Ferrell-Larkin-Ovchinnikov) state for pairing of fermions with mismatched Fermi surfaces [3,4]. The FFLO state can also occur in trapped atomic mixtures, and in a quark-gluon plasma, and is therefore also of strong interest to atomic and nuclear/particle physicists.



[1] D. A. Wollman et al., Phys. Rev. Lett. 71, 2134 (1993).
[2] C.-R. Hu, Phys. Rev. Lett. 72, 1526 (1994); J. Yang and C.-R. Hu, Phys. Rev. B, 50, 16766 (1994).
[3] Q. Wang, H.-Y. Chen, C.-R. Hu, and C. S. Ting, Phys. Rev. Lett.96, 117006 (2006), and Q. Wang, C.-R. Hu, and C. S. Ting, arXiv cond-mat/0605417, to be published.
[4] Q. Cui, C.-R. Hu, J. Y. T. Wei, and K. Yang, to appear in the proceedings of the 24th International conference on Low Temperature Physics; and arXiv cond-mat/0510717, to appear inPhys. Rev. B.


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