

Massachusetts Institute of Technology  
Department of Physics

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CONDENSED MATTER THEORY SEMINAR

“Dynamical Cluster Quantum Monte Carlo Studies on  
Strongly Correlated Electron Systems”

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**Abstract:** Using large-scale dynamical cluster quantum Monte Carlo simulations, we study properties of Hubbard model on square and triangular lattices. In the square lattice case, the control parameters are hole doping, temperature  $T$  and next-nearest-neighbor hopping  $t'$ . We find that for  $t' > 0$ , a line of finite temperature classical critical points converges to the quantum critical point at  $t' = 0$  and zero temperature; for  $t' < 0$ , we identify a line of Lifshitz transition points associated with a change of the Fermi surface topology. At the Lifshitz transition points, a van Hove singularity in the density of states crosses the Fermi level. The observation of the Lifshitz transition at  $t' < 0$  extends our understanding of the nature of the quantum critical point underneath the superconducting dome in the 2D square lattice Hubbard model. In the triangular lattice case, we explore the Mott transition at half-filling as well as the superconducting instability in the hole-doped side of the phase diagram. Due to the interplay of electronic correlations, geometric frustration, and Fermi surface topology, in the hole-doped side, we find a doubly degenerate singlet pairing state at interaction strength close to the bare bandwidth. This superconducting state is mediated by antiferromagnetic spin fluctuations and has a chiral,  $d+id$  pairing symmetry. Our findings have immediate relevance with the superconductivity in water-intercalated sodium cobaltates  $\text{Na}_x\text{CoO}_2 \cdot y\text{H}_2\text{O}$ , as well as the superconducting phases of the organic compounds  $\kappa\text{-(ET)}_2\text{X}$  and  $\text{Pd}(\text{dmit})_2$ .

**Reference:**

1. Lifshitz Transition in the Two Dimensional Hubbard Model, K. S. Chen, Z. Y. Meng, T. Pruschke, J. Moreno, and M. Jarrell, Phys. Rev. B 86, 165136 (2012).
2. Unconventional superconductivity on the triangular lattice Hubbard model, K. S. Chen, Z. Y. Meng, U. Yu, S. Yang, M. Jarrell, and J. Moreno, arXiv:1304.7739.

1:30pm  
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