Condensed Matter Theory Center
Seminar

Tuesday, December 13
11:00am-12:30pm
2205 Physics Building

(All are welcome to attend.)

Zi Yang Meng

(Institut fuer Theoretische Physik III, Universitaet Stuttgart, Germany
Center for Computation and Technology, Louisiana State University, USA)

"Quantum Monte Carlo Studies of Correlated Electrons on Honeycomb Lattice and Interacting Topological Insulator"

Abstract:
At sufficiently low temperatures, condensed-matter systems tend to develop order. An notable exception to this behavior is quantum spin-liquids, where fluctuations prevent transition to an ordered state down to the lowest temperatures. Using large-scale quantum Monte Carlo simulations, we found a quantum spin-liquid phase of correlated electrons on the honeycomb lattice, this spin-liquid emerges between the state described by massless Dirac fermions and an antiferromagnetically ordered Mott insulator, and is found to be a short-range resonating valence bond liquid, akin to the one proposed for high temperature superconductors. This was the first unbiased determination of a RVB-liquid in an electronic system [1].

We extend our quantum Monte Carlo study to the Kane-Mele-Hubbard model on the honeycomb lattice. We mapped out the phase diagram at half-filling and determined the phase boundaries between the quantum spin liquid, the topological (quantum spin-Hall) insulator and the antiferromagnetic Mott insulator. At finite Hubbard interaction, the topological insulator is adiabatically connected to the ground state of the Kane-Mele model. The transition from the topological insulator to the antiferromagnetic Mott insulator at large Hubbard U is in the universality class of the three-dimensional XY model. Our numerical data further suggest that the spin liquid to topological insulator and spin liquid to Mott insulator transitions are both continuous. The interaction effect on the helical edge state has also been addressed [2].

References:

[1] Z. Y. Meng, T. C. Lang, S. Wessel, F. F. Assaad and A. Muramatsu, "Quantum spin liquid emerging in two-dimensional correlated Dirac fermions", Nature 464, 847 (2010)

[2] M. Hohenadler, Z. Y. Meng, T. C. Lang, S. Wessel, A. Muramatsu and F. F. Assaad, "Quantum phase transitions in the Kane-Mele-Hubbard model", arXiv:1111.3949 (2011)

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