**C. Morais Smith**
**Institute for Theoretical Physics, Utrecht University, the Netherlands**

**Artificial Staggered Magnetic Field for Ultracold Atoms in Optical Lattices**

**Location:** Hörsaal A (1.3.14)
**Time:** Monday, February 14th, 2011, 14 h s.t.

**Abstract:**

Uniform magnetic fields are ubiquitous in nature, but this is not the case for staggered magnetic fields. In this talk, I will discuss an experimental set-up recently proposed by us [1], which allows for the realization of a "staggered gauge field" in a 2D optical lattice loaded with cold atoms. If the lattice is loaded with bosons, the effective Hamiltonian of the system is a Bose-Hubbard one, with complex and anisotropic hopping coefficients. A very rich phase diagram emerges from the model: besides the usual Mott-insulator and zero-momentum condensate, a new phase with a finite momentum condensate becomes the ground-state at high-rotation [2]. By using the technique of Feshbach resonance, it is possible to realize bosonic molecules and observe a coherent superposition of a vortex-carrying atomic condensate and a conventional zero-momentum molecular condensate [3].
On the other hand, if the lattice is loaded with fermions, the system allows us to emulate graphene under uniaxial pressure [4]. When the system is loaded with a mixture of bosons and two-species fermions, several features of the high-Tc phase diagram can be reproduced. Starting from a DDW phase, with a staggered pi-flux traversing each plaquette, unconventional superconductivity with features of the RVB state is obtained for a certain range of parameters. Even more interestingly, the complexity of the normal phase surrounding the superconducting dome emerges naturally in this system, and the evolution from a non-Fermi liquid to a Fermi-liquid behavior with increasing doping can be naturally understood. The evolution of the Fermi-surface upon doping also shows that CDW and SDW instabilities could easily occur, due to nesting [5].
Finally, I will discuss a completely different set-up, which allows for the realization of an effective staggered Zeeman field for fermions in a 2D optical lattice [6]. The resulting band structure is quite exotic; fermions in the third band have an unusual rounded picture-frame Fermi surface (essentially two concentric squircles), leading to imperfect nesting. We develop a generalized SO(3,1) X SO(3,1) theory describing the spin and charge degrees of freedom simultaneously, and show that the system can develop a coupled spin-charge-density wave order.

[1] A. Hemmerich and C. Morais Smith, Phys. Rev. Lett. 99, 113002 (2007).
[2] Lih-King Lim, A. Hemmerich, and C. Morais Smith, Phys. Rev. Lett. 100, 130402 (2008).
[3] Lih-King Lim, T. Troppenz, and C. Morais Smith, arXiv:1009.1471.
[4] Lih-King Lim, A. Hemmerich, and C. Morais Smith, Phys. Rev. A 81, 023404 (2010).
[5] Lih-King Lim, A. Lazarides, A. Hemmerich, and C. Morais Smith, EPL 88, 36001 (2009) and Phys. Rev. A 82, 013616 (2010).
[6] D. Makogon, I. B. Spielman, and C. Morais Smith, arXiv: 1007.0782.