MAR17-2016-030159

Abstract for an Invited Paper
for the MAR17 Meeting of
the American Physical Society

**Spatial Charge and Spin Correlations in the Fermi-Hubbard Model**

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Strong electron correlations lie at the origin of transformative phenomena such as colossal magneto-resistance and high-temperature superconductivity. Already near room temperature, doped copper oxide materials display remarkable features such as a pseudo-gap and a "strange metal" phase with unusual transport properties. The essence of this physics is believed to be captured by the Fermi-Hubbard model of repulsively interacting, itinerant fermions on a lattice. I will describe our recent experiments on two-dimensional Fermi gases of $^{40}K$ atoms under a Fermi gas microscope [1], where metallic, Mott insulating and band insulating states of the Fermi-Hubbard model were observed with single-site, single-atom resolution [2]. The microscope allows for the site-resolved observation of charge and spin correlations in this system [3]. It directly reveals anti-ferromagnetic spin correlations, the Pauli and correlation hole in the metallic regions, and strong doublon-hole bunching in the region near half-filling. The latter is expected in the presence of singlet bonds forming between adjacent lattice sites and should play an important role for transport in the Fermi-Hubbard model.

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[2] Lawrence W. Cheuk, Matthew A. Nichols, Katherine R. Lawrence, Melih Okan, Hao Zhang, Martin W. Zwierlein, Phys. Rev. Lett. 116, 235301 (2016).
[3] Lawrence W. Cheuk, Matthew A. Nichols, Katherine R. Lawrence, Melih Okan, Hao Zhang, Ehsan Khatami, Nandini Trivedi, Thereza Paiva, Marcos Rigol, Martin W. Zwierlein, Science 353, 1260-1264 (2016)