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Disorder and strong correlations in optical lattices

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Remarkable experimental progress has recently allowed the creation of fine-grained optical disorder potentials, where localization effects of ultracold atoms can be clearly observed. Adding an optical lattice gives access to highly tunable quantum many-body systems with disorder. I will focus on the interplay between disorder and strong correlations from a theoretical perspective. Our approach is based on stochastic and dynamical mean-field theories for bosons and fermions. Specifically, I will discuss the following recent results:

1) We are able to describe the highly debated Bose glass phase in three spatial dimensions at any temperature and predict a direct transition between Mott insulator and superfluid [1].

2) Spin-ordering of fermions (e.g. ^{40}K) in an optical lattice is of current interest. We provide a complete phase diagram in the presence of disorder, including a new antiferromagnetic metal [2].

3) We are now able to treat spinful bosons with strong correlations in a unified dynamical mean-field framework. For 2-component bosons (e.g. $^{41}K-^{87}$Rb) mixtures) this yields a rich phase diagram, including anisotropic spin order and supersolid phases [3].

References: [1] U. Bissbort and W. Hofstetter, preprint arXiv:0804.0007 [2] K. Byczuk, W. Hofstetter, and D. Vollhardt, preprint arXiv: 0810.2958 [3] A. Hubener, M. Snoek, and W. Hofstetter, preprint.