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Probing and controlling quantum magnetism with ultra-cold atoms

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By loading spinor atoms in optical lattices it is now possible to experimentally implement quantum spin models in a controlled environment, and to investigate quantum magnetism in strongly correlated systems. In this talk we will describe a novel approach to prepare, detect and control super-exchange interactions in ultracold spinor atoms loaded in optical superlattices [1]. Recently this approach was used for the first experimental observation of super-exchange interactions in ultra-cold atoms [2]. The many-body dynamics arising from the coherent coupling between singlet-triplet pairs in adjacent double-wells will be also discussed, in particular how it can lead to the formation of spin states with a high degree of multi-particle entanglement. Finally, we will present an extension of this approach to prepare and detect in a controllable way d-wave superfluidity in an array of weakly coupled plaquettes loaded with fermionic atoms.

[1] A. M. Rey, V. Gritsev,I. Bloch, E. Demler, and M. D. Lukin, PRL 99, 140601 (2007)
[2] S. Trotzky, P. Cheinet, S. Folling, M. Feld, U. Schnorrberger, A.M. Rey, A. Polkovnikov, E. Demler, M. D. Lukin, and I. Bloch, Science 319, 295 (2008)