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Magnetic correlations and density ordering in quantum gases

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Quantum gases provide a unique avenue to study fundamental concepts in quantum many-body physics. In our research we go beyond the class of atomic many-body systems that are governed by the interplay between kinetic energy and contact interactions. Using a tunable geometry optical lattice, we create hexagonal, dimerized or anisotropic lattice structures [1]. This allows us to control the exchange energy in a repulsive two-component Fermi gas and study the formation of magnetic correlations. In a different approach, we place a Bose-Einstein condensate into a dynamic lattice potential created by the interaction of the atoms with the vacuum field of an optical cavity. This gives rise to long-range interactions, which result in a transition to a supersolid phase with a broken discrete symmetry, preceded by a mode softening [2]. In the talk I will introduce our experiments and discuss recent results.

[1]: L. Tarruell, D. Greif, T. Uehlinger, G. Jotzu, and T. Esslinger, Nature 483, 302–305 (2012).
[2]: R. Mottl, F. Brennecke, K. Baumann, R. Landig, T. Donner, and T. Esslinger, Science 336, 1570-1573 (2012).