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Synthetic quantum many-body systems with local and global interactions

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The challenge for the research field of quantum gases is to gain distinctive and new insights into quantum many-body physics – and, if possible, to answer long-standing questions of an underlying model or to create many-body systems of an entirely new character. The talk will report on quantitative experiments with fermions in optical lattices and a quantum phase transition in an open many-body system with global interactions. Recent measurements on the Fermi-Hubbard model and comparison with theoretical calculations allow us to quantify the entropy and temperature in the approach to magnetic order. Studying a Bose-Einstein condensate in an ultrahigh-finesse optical cavity under transverse pumping, we observe that the superfluid self-organizes into an emergent checkerboard pattern above a critical pump power. When entering this self organized phase, the gas initially maintains phase coherence and can thus be regarded as a supersolid. The underlying quantum phase transition is described by the Dicke model. Over a wide range of parameters, the phase boundary is mapped out.