Nonequilibrium quantum phase transitions in atom-optomechanical systems

Milan Radonjić

I. Institute of Theoretical Physics, University of Hamburg, Germany

Hybrid atom-optomechanical systems, which combine optomechanics with atom optics, represent one recent promising platform for studying nonequilibrium quantum phase transitions (NQPTs). In these systems, a nanomembrane in a pumped optical cavity is coupled to the motional or to the internal degrees of freedom of a distant gas of cold atoms that are trapped in the optical lattice of the outcoupled light field. We will first study how the center-of-mass motion of the atomic gas in the lattice can be coupled to the membrane (in the so-called *motional coupling scheme*). By varying the pump strength, the effective light-mediated atom-membrane coupling can be tuned. We will present a second-order nonequilibrium quantum phase transition from a localized symmetric state of the atom cloud to a shifted symmetry-broken state. Next, we will analyze the membrane coupled to a transition between two internal states of the atoms (in the so-called *internal coupling scheme*). We will show that this scheme allows both first- and second-order nonequilibrium quantum phase transitions in two different scenarios. Both scenarios have their respective non-trivial phases characterized by a displaced membrane. The order of these phase transitions can be changed by tuning readily accessible experimental parameters.