CO.CO.MAT

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Bose-Einstein condensate in an optical cavity: exploring the Dicke-type quantum phase transition

The coherent coupling of a single mode of the resonator with motional excitations of a Bose–Einstein condensate driven by a laser perpendicular to the cavity axis was shown to be a formal realization of the Dicke model. This system led to the first observation of the phase transition in the Dicke model which is, in fact, the zero temperature limit of the atomic self-organization in a cavity. Beyond the mapping of the phase diagram, the spontaneous symmetry breaking as well as the mode softening in the excitations spectrum at the critical point have been demonstrated experimentally. The cavity-based realization is an open system, therefore the Dicke-type Hamiltonian does not provide for a complete description. The critical behavior has been reinvestigated for the stationary state of the driven and damped system. We will show that the non-equilibrium system exhibits a dynamical quantum phase transition. The critical point as well as the mean field solution are only slightly modified with respect to the equilibrium phase transition in the ground state. However, the correlation functions describing the quantum fluctuations differ significantly in the two, equilibrium and non-equilibrium, cases. Recent experiments revealed the importance of the atom-atom s-wave scattering in quantitative description of data. Here we will show that the damping of motional excitations is very sensitive to the coupling to a photon field and the Beliaev damping rate can be resonantly tuned by the external laser drive strength.

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