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Bose Condensation Phenomena in Driven Open Quantum Systems

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Abstract:

In experimental platforms such as exciton-polariton systems, coherent and dissipative dynamics appear on an equal footing, giving rise to new non-equilibrium scenarios in stationary state.

Here we report on dynamical critical phenomena of the non-equilibrium Bose condensation transition in many-body ensembles subject to particle loss and pumping. Using two complementary renormalization group approaches, in three spatial dimensions we establish an effective thermalization mechanism of the low frequency dynamics. Still, the microscopic drive conditions are witnessed even on the largest scales via a new, independent universal critical exponent. Such systems thus define an out-of equilibrium universality class beyond the classification scheme of equilibrium dynamical transitions.

Furthermore, we address the fate of non-equilibrium Bose condensation in two dimensions. We show that such driven Bose systems cannot exhibit algebraic superfluid order, unless being strongly anisotropic. Our result implies, in particular, that Bose condensation in currently investigated exciton-polariton systems must be an intermediate scale crossover phenomenon, while the true long distance correlations fall off exponentially. We obtain these results through a mapping of the long-wavelength condensate dynamics onto the Kardar-Parisi-Zhang equation.