Emergent Kardar-Parisi-Zhang phase in quadratically driven condensates

Oriana K. Diessel[1], **Sebastian Diehl** [2], **Alessio Chiocchetta** [2]
1. Max-Planck-Institute of Quantum Optics, Hans-Kopfermann-Strasse 1 , 85748 Garching, Germany
2. Institute for Theoretical Physics, University of Cologne, Zülpicher Strasse 77, 50937 Cologne, Germany

In bosonic gases at thermal equilibrium, an external quadratic drive can induce a Bose-Einstein condensation described by the Ising transition, as a consequence of the explicitly broken $U(1)$ phase rotation symmetry down to Z_2. However, in physical realizations such as exciton-polaritons and nonlinear photonic lattices, thermal equilibrium is lost and the state is rather determined by a balance between losses and external drive. A fundamental question is then how nonequilibrium fluctuations affect this transition. Here, we show that in a two-dimensional driven-dissipative Bose system the Ising phase is suppressed and replaced by a nonequilibrium phase featuring Kardar-Parisi-Zhang (KPZ) physics. Its emergence is rooted in a $U(1)$-symmetry restoration mechanism enabled by the strong fluctuations in reduced dimensionality. Moreover, we show that the presence of the quadratic drive term enhances the visibility of the KPZ scaling, compared to two-dimensional $U(1)$-symmetric gases, where it has remained so far elusive.

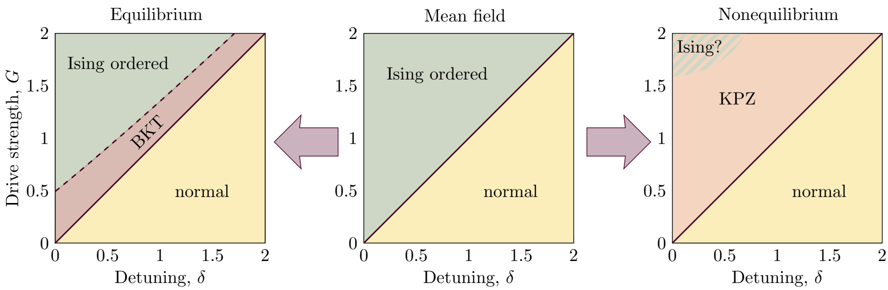

Fig. 1: Effect of fluctuations on the mean-field phase diagram of and, in- and out-of-equilibrium. *Center*— Mean-field phase diagram of a quadratically driven, open condensate, as a function of the imprinted pairing strength G and the detuning δ. *Left*— Equilibrium phase diagram. Fluctuations give rise to an additional intermediate phase featuring BKT scaling. *Right*— Nonequilibrium phase diagram including single and two particle losses. The Ising phase is replaced by a phase which features KPZ scaling.

References

[1] O. K. Diessel, S. Diehl, A. Chiocchetta, arXiv:2103.01947 (2021)