Quantum dynamics of Dissipative Kerr solitons

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Dissipative Kerr solitons arising from parametric gain in ring microresonators are usually de- scribed and understood within a classical mean-field framework. In this work, I develop a quantum-mechanical model of dissipative Kerr solitons in terms of the Lindblad master equation formalism and study the model via the truncated Wigner order in $\hbar$.

This work shows that, within this open quantum system framework, the soliton experiences a finite coherence time due to quantum fluctuations originating from losses. Reading the results in terms of the theory of open quantum systems, allows to estimate the Liouvillian spectrum of the system. It is characterized by a set of eigenvalues with finite imaginary part and vanishing real part in the limit of vanishing quantum fluctuations. This arrangement emerges asymptotically in the limit of large input power, and the Liouvillian gap vanishes as a power law of the total photon occupation in the microring modes. We have therefore shown that DKSs are a specific manifestation of a dissipative time crystal – a general phenomenon which can arise in open quantum systems and has been extensively studied in recent times. Establishing the link between DKSs and dissipative time crystals is an important step in the study and characterization of spontaneous time-translational symmetry breaking in quantum systems out of equilibrium. While being a theoretical work per se, special consideration will be given to the experimental implementations of the system under investigation.

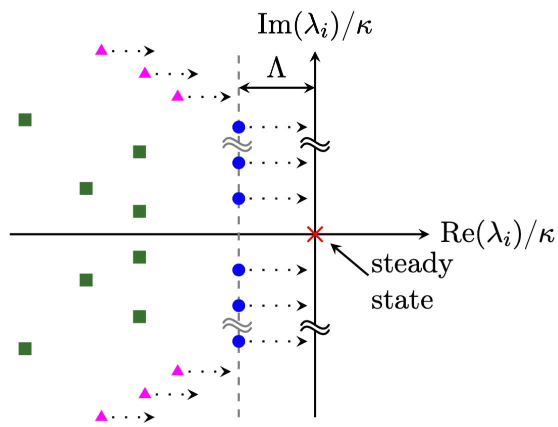

Fig. 1: *Schematic representation of the spectrum of the Liouvillian.*

References:
[1] K. Seibold et al, *Phys. Rev. A* **105**.053530 (2022).
[2] K. Seibold et al, *Phys. Rev. A* **101**.033839 (2020).