Turing Mechanisms in a Multimode Quantum System

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Turing instabilities provide a fundamental mechanism for pattern selection in classical reaction–diffusion systems, yet their extension to genuinely quantum settings remains limited and only partially explored. Existing approaches typically rely on semiclassical reductions or mean-field analogies, with only a few works addressing pattern formation in open quantum systems and limited one-two mode lattices [1, 2].

In this talk, we investigate a multimode quantum system governed by a Lindblad master equation, where local and nonlocal dissipative processes give rise to Turing-like instabilities. By employing the phase-space formulation based on the Wigner function, we show how in the semi-classical limit the quantum dynamics can be recast into an effective Fokker–Planck framework, allowing a systematic analysis of linear instabilities and mode selection.

Different classes of spatial patterns can be selectively determined depending on the intensity of the dissipators. This approach provides a framework to connect classical Turing theory with genuinely quantum effects, highlighting both its potential and its current limitations in the quantum regime.

References

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