Decoherence in quantum active particles: towards classical active particles?

Keyword:
*Non-equilibrium
*Quantum walk
*Active matter

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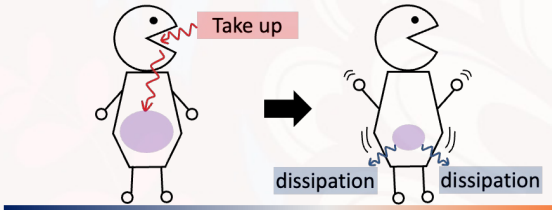
? How to define active matter (well studied in classical systems) in a quantum system?



Our "Quantum active matter"
1. System without energy nor momentum conservation
2. Particle moves depending on its internal state

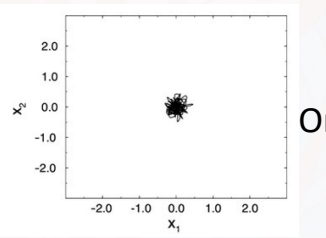
! In a quantum system,
✓ Obtain similar results with a previous research in a classical system
✓ Observe unique features

New research field

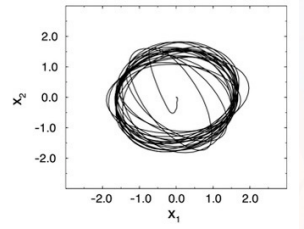
Systems w/o energy conservation

	Momentum conserved	Momentum not conserved
Classical	Dissipative system	Active matter
Quantum	Non-Hermitian physics	**Quantum active matter**

Previous research



Ordinary

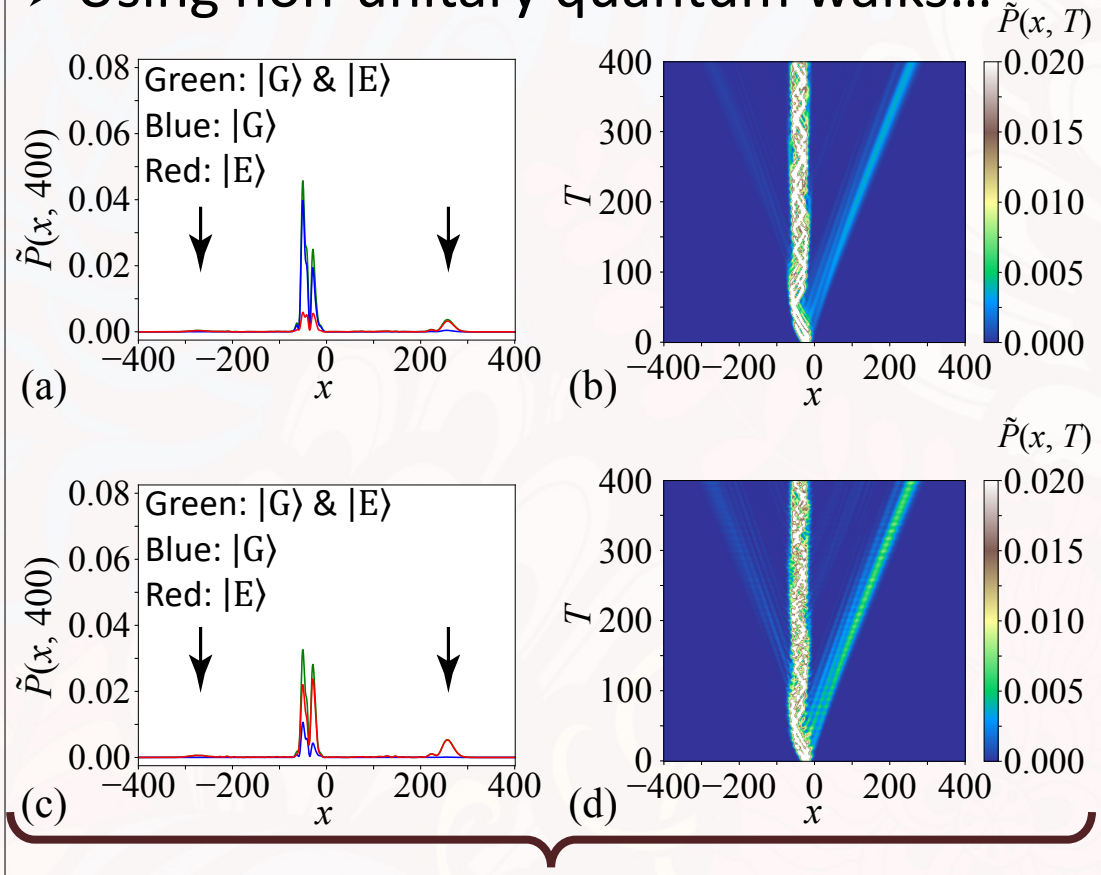


Active

F. Schweitzer *et al.*, PRL. **80**, 5044-5047 (1998).

- M. Yamagishi, N. Hatano and H. Obuse, arXiv:2305.15319 (2023).

➢Using non-unitary quantum walks…



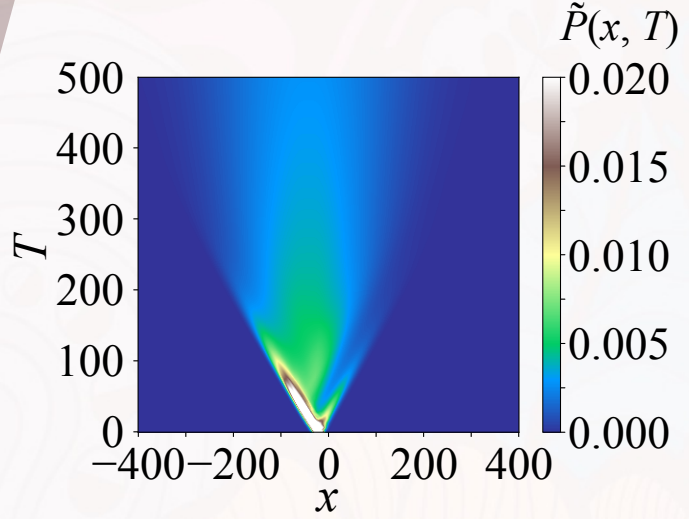
Under effective harmonic potential

(a)&(b): Ordinary ($g = 0$),
(c)&(d): Active ($g = 1$)

🤔 Classical limit?

➢Numerically introduce decoherence in the form of

$$\rho^{\text{new}} = (1-p)U\rho U^{\dagger} + p\,\text{diag}\left(U\rho U^{\dagger}\right)$$



$p = 0.1$
$g = 1$