Colloquium

Dissipation induced non-stationary complex quantum dynamics

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The assumption that physical systems relax to a stationary state in the long-time limit underpins statistical physics and much of our intuitive understanding of scientific phenomena. For isolated systems, this follows from the eigenstate thermalization hypothesis. When an environment is present the expectation is that all of phase space is explored, eventually leading to stationarity.In this talk, I will identify and discuss simple and generic conditions for dissipation to prevent a quantum many-body system from ever reaching a stationary state [1]. These “dynamical symmetries” go beyond dissipative quantum state engineering approaches towards controllable long-time non-stationary dynamics typically associated with macroscopic complex systems. The resulting coherent and oscillatory evolution constitutes a dissipative version of a quantum time-crystal.I will show how such dissipative dynamics can be engineered and studied with fermionic ultracold atoms in optical lattices using current technology. Furthermore, I discuss how dissipation leads to long-range quantum coherence, complexity, and η-pairing indicating a superfluid state in these setups [2] and the potential connection to driving induced superconductivity [3, 4]. Finally, I will connect these ideas to a more general theory of synchronization in quantum systems [5] and quantum dynamics on graphs with long-ranged interactions [6]References1. B. Bua, J. Tindall, and D. Jaksch, Complex coherent quantum many-body dynamics through dissipation, Nature Communications 10, 1730 (2019)2. J. Tindall, B. Bua, J. R. Coulthard, and D. Jaksch, Heating-Induced Long-Range η-Pairing in the Hubbard Model, Physical Review Letters 123, 030603 (2019)3. J. Tindall, F. Schlawin, M. Buzzi, D. Nicoletti, J. R. Coulthard, H. Gao, A. Cavalleri, M. Sentef and D. Jaksch, Dynamical Superconductivity in a Frustrated Many-Body System, Physical Review Letters 125, 137001 (2020)4. J. Tindall, F. Schlawin, M. Sentef and D. Jaksch, Analytical Solution for the Steady States of the Driven Hubbard model, Phys. Rev. B 103, 035146 (2021)5. B. Buca, C. Booker and D. Jaksch, Algebraic Theory of Quantum Synchronization and Limit Cycles under Dissipation, SciPost Phys. 12, 097 (2022).6. Joseph Tindall, Amy Searle, Abdulla Alhajri, Dieter Jaksch, Quantum Physics in Connected Worlds, Nature Communications 13, 7445 (2022).

Monday, March 11, 2024 11:30am - 12:30pm

Raiffeisen Lecture Hall

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