Non-equilibrium Quantum Matter

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Optical pulses allow steering strongly correlated quantum matter far away from thermal equilibrium on short time scales. In this talk I will highlight important aspects of the novel physics that becomes accessible in this non-equilibrium setting.

I will first give examples of experiments that have found striking physical properties in strongly driven quantum materials that are still poorly understood. I will then use a simple paradigm physical model to illustrate how strong periodic driving can induce a phase change and focus on a transition from a metallic to an exotic superconducting phase that is not accessible in thermal equilibrium [1].

When driving is switched off, quantum systems are expected to return to a stationary equilibrium state. Continuous driving is expected to cause heating until a featureless infinite temperature state is attained. I will challenge both assumptions by identifying simple and generic conditions for dissipation to prevent a quantum many-body system from ever reaching a stationary state [2]. This will go beyond dissipative quantum state engineering approaches and 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 this picture may lead to driving induced long-range off-diagonal η-pairing order [3].

[1] J.R. Coulthard, S.R. Clark, S. Al-Assam, A. Cavalleri and D. Jaksch, Phys. Rev. B **96**, 085104 (2017); J.R. Coulthard, S.R. Clark and D. Jaksch, Phys. Rev. B **98**, 035116 (2018).

[2] B. Buca, J. Tindall, and D. Jaksch, Complex coherent quantum many-body dynamics through dissipation, Nature Communications **10**, 1730 (2019).

[3] J. Tindall, B. Buca, J.R. Coulthard, D. Jaksch, Heating-Induced Long-Range η-Pairing in the Hubbard Model, arXiv:1902.05012 (2019).