Technische Universität Berlin

Description of PhD project: "Driven-dissipative quantum state preparation"
(see job offer for a Research assistant / PhD student, 75% TV-L E13, until 31.12.2026)

Quantum Non-Equilibrium Dynamics group (Prof. André Eckardt, www.tu.berlin/quantum), Technical University Berlin, Institute for Theoretical Physics

The project "driven-dissipative quantum state preparation" concerns the design and theoretical investigation of protocols for the preparation of correlated target states in engineered quantum systems, such as photonic systems of superconducting circuits or ultracold atoms in optical lattices and tweezers. The focus lies on topologically ordered states, like fractional Chern insulators and spin liquids, which have fascinating properties such as anyonic excitations and are of interest both for quantum simulation and quantum error correction. For that purpose, two rather different control strategies shall be combined: Floquet engineering on the one hand, where strong time-periodic driving is used to effectively modify the properties of a quantum system, and reservoir engineering on the other, where a dissipative environment is controlled in order to guide the system into a desired state. This combination is motivated by the fact that the former is rather powerful but plagued by unwanted heating, which shall be suppressed by engineered dissipation. Both driving and dissipation are predicted to lead to a complex interplay the investigation of which requires the treatment of the system beyond the limit of ultraweak coupling between system and reservoir (as it is often considered).

For the project both analytical calculations and numerical simulations need to be performed. In particular, the implementation of numerical methods for the simulation of open driven systems beyond ultraweak system-reservoir coupling, will be crucial. Further tasks comprise the work on scientific publications, the presentation of the results on international conferences and the collaboration with other scientists and students in the research group.

The project lies at the border between theoretical quantum optics and many-body theory, with the focus lying on open, driven, and topological quantum systems. Experience in one or several of these research fields is desirable.

For further information, please, contact Prof. André Eckardt (Email: eckardt@tu-berlin.de, Tel.: +49 30 314 23034).

Related References:

- *Colloquium: Atomic quantum gases in periodically driven optical lattices*, André Eckardt, Rev. Mod. Phys. **89**, 011004 (2017), arXiv:1606.08041;
- *Floquet-heating-induced non-equilibrium Bose condensation in an open optical lattice,* Alexander Schnell, Ling-Na Wu, Artur Widera, André Eckardt, arXiv:2204.07147;
- *Non-perturbative Floquet engineering of the toric-code Hamiltonian and its ground state*, Francesco Petiziol, Sandro Wimberger, André Eckardt, Florian Mintert, arXiv:2211.09724;
- *Cavity-Based Reservoir Engineering for Floquet-Engineered Superconducting Circuits*, Francesco Petiziol, André Eckardt, Phys. Rev. Lett. **129**, 233601 (2022), arXiv:2205.15778;
- *Cooling and state preparation in an optical lattice via Markovian feedback control*, Ling-Na Wu, André Eckardt, Phys. Rev. Research **4**, L022045 (2022), arXiv:2106.03883.