Sebastian Diehl

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Research profile: Driven open quantum matter is characterized by an interplay of coherent quantum dynamics with external driving, dissipation, and quantum measurement. This scenario emerges in platforms ranging from ultracold atomic gases over light-driven quantum materials to the first quantum computing architectures. What are the universal principles and phenomena governing such systems? We construct novel theoretical frameworks to understand this question, bringing together concepts from quantum optics, solid state- and quantum field theory.

Qualifications and Career

1999 - 2003	Physics Studies at Heidelberg University (with distinction)
2003 - 2006	PhD with Prof. Christof Wetterich, Heidelberg University (summa cum laude)
2006 - 2011	Postdoc at the Institute for Quantum Optics and Quantum Information, Innsbruck
2011 - 2014	Independent Junior Research Group leader (START grant), Innsbruck University
2014	Habilitation in Theoretical Physics at Innsbruck University
2014 - 2015	Full Professor (W3), Technical University Dresden
2015 -	Full Professor (W3), University of Cologne

Professional Activities

2016 -	Project leader in: CRC1238 (Control and Dynamics of Quantum Materials), CRC183 (Entangled States of Matter)
2016 - 2017	Head of the Institute for Theoretical Physics, University of Cologne
2019 -	Project leader in the Cluster of Excellence ML4Q
2020 -	Member of the selection committee of the Humboldt foundation (Feodor Lynen stipends)
2019 - 2023	Project leader in DFG Priority Program 1929 (Gigantic Interactions in Rydberg Systems)
2022 - 2023	Head of the Department of Physics, University of Cologne
2023 - 2024	Head of the Institute for Theoretical Physics, University of Cologne
2024 -	Member of the editorial board, Physical Review X

Academic Distinctions

1999 -2006	Student/PhD scholarship of Studienstiftung des Deutschen Volkes (German Academic Scholarship Foundation)
2003	Otto-Haxel-Prize, Physics Department, Heidelberg University
2011	START prize of the Austrian Science Fund
2015	Consolidator grant of the European Research Council

Selected publications

1. M. Buchhold, Y. Minoguchi, A. Altland, S. Diehl, *Effective theory for the measurement-induced phase transition of Dirac fermions*, Phys. Rev. X **11**, 041004 (2021), arxiv:2102.08381
   An analytical replica field theory approach is constructed to capture measurement induced phase transitions in monitored fermion systems.
2. A. Chiocchetta, D. Kiese, F. Piazza, S. Diehl, *Cavity-induced quantum spin liquids*, Nature Communications **12**, 5901 (2021), arxiv:2009.11856
   It is shown that the coupling of magnetic systems, such as ordinary Heisenberg magnets, to the quantized light of a cavity generates frustration and results in robust spin liquid phases.
3. A. Altland, M. Fleischhauer, S. Diehl, *Symmetry classes of open fermionic quantum matter*, Phys. Rev. X **11**, 021037 (2021), arxiv:2007.10448
   A first-principles classification for open fermion systems in terms of discrete symmetries is developed, revealing a fine structure of equilibrium vs. non-equilibrium evolutions.
4. O. Alberton, M. Buchhold, S. Diehl, *Entanglement transition in a monitored free-fermion chain: from extended criticality to area law*, Phys. Rev. Lett. **126**, 170602 (2021), arxiv:2005.09722
   A new measurement induced transition from a critical to an area law entangled phase is discovered.
5. S. Mathey, S. Diehl, *Absence of criticality in the phase transitions of open Floquet systems*, Phys. Rev. Lett. **122**, 110602 (2019) , arxiv:1807.02146
   Rapid Floquet drive of an open system cuts off scaling behavior, which is only recovered in the limit of infinitely rapid drive, providing a counterpart to the Kibble-Zurek scenario for slowly driven systems.
6. J. Marino, S. Diehl, *Driven Markovian quantum criticality*, Phys. Rev. Lett. **116**, 070407 (2016), arxiv:1508.02723
   An analog of quantum criticality is established in driven open quantum systems, constituting a new non-equilibrium universality class.
7. L. M. Sieberer, M. Buchhold, S. Diehl, *Keldysh field theory for driven open quantum systems*, Rep. Prog. Phys. **79**, 096001 (2016), arxiv:1512.00637
   We review and further develop the Keldysh field theory approach to driven open many-body systems.
8. L. Sieberer, S. Huber, E. Altman, S. Diehl, *Dynamical critical phenomena in driven-dissipative systems*, Phys. Rev. Lett. **110**, 195301 (2013), arxiv:1301.5854
   This paper reveals new universality induced due to the breaking of equilibrium conditions.
9. S. Diehl, E. Rico Ortega, M. Baranov, P. Zoller, *Topology by dissipation in atomic quantum wires*, Nature Physics **7,** 971 (2011), arxiv:1105.5947
   This paper shows how topological states in fermion systems can be reached by engineered dissipation.
10. S. Diehl, A. Micheli, A. Kantian, B. Kraus, H. Büchler, P. Zoller, *Quantum states and phases in driven open quantum systems with cold atoms*, Nature Physics **4,** 878 (2008), arxiv:0803.1482
    The concept of dissipation engineering in many-body systems is introduced.