Michael Bleher, Dr.

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Academic Positions

2024 - Present **Postdoctoral Researcher**, *STRUCTURES Cluster of Excellence, Heidelberg University*.
Exploratory Project: New methods for single cell data analysis?

- Geometric Neighbour Embeddings
- Cell Differentiation as Magnetic Systems
- Stochastic Models of Cell Differentiation from Topological Data Analysis

Education

2017 - 2023 **PhD Physics and Mathematics (Interdisciplinary)**, *Heidelberg University*.
Advisor: Prof. Dr. Johannes Walcher
'Haydys-Witten Instantons and Symplectic Khovanov Homology'

2013 - 2016 **M.Sc. Physics**, *Heidelberg University*.
Advisor: Prof. Dr. Johannes Walcher
'A Survey of Defects in $\mathcal{N} = 4$ Supersymmetric Yang-Mills Theory'

2014 - 2015 **Graduate Course**, *University of Durham, UK* (Student Exchange).
M.Sc. in Particles, Strings and Cosmology at the Centre for Particle Theory.

2010 - 2013 **B.Sc. Physics**, *Heidelberg University*.
Advisor: Dr. Werner Rodejohann
'Neutrinoloser Doppelbeta-Zerfall – Untersuchung einer Methode zur Auswahl eines Nuklearen Matrix-Elements'

Scholarships

2017 - 2020 **Distinguished Doctoral Fellowship**, *Heidelberg Graduate School of Fundamental Physics*.

Publications

1. Michael Bleher (2025). 'Adiabatic Solutions of the Haydys-Witten Equations and Symplectic Khovanov Homology'. arXiv: 2501.01365 (preprint).
2. Michael Bleher (2024). 'A Family of Instanton-Invariants for Four-Manifolds and Their Relation to Khovanov Homology'. arXiv: 2412.13285 (preprint).
3. Johannes Bleher and Michael Bleher (2024). 'An Algebraic Framework for the Modeling of Limit Order Books'. arXiv: 2406.04969 (preprint).

4. Michael Bleher (2023). 'Haydys-Witten Instantons and Symplectic Khovanov Homology' PhD thesis, Ruprecht-Karls Universität Heidelberg. DOI: 10.11588/HEIDOK.00034010.
5. Michael Bleher (2023). 'The Decoupled Haydys-Witten Equations and a Weitzenböck Formula'. arXiv: 2307.15056 (preprint).
6. Michael Bleher (2023). 'Growth of the Higgs Field for Kapustin-Witten Solutions on ALE and ALF Gravitational Instantons'. arXiv: 2306.17017 (preprint).
7. Maximilian Neumann, Michael Bleher, Lukas Hahn, Samuel Braun, Holger Obermaier, Mehmet Soysal, René Caspart and Andreas Ott (2022). 'MuRiT: Efficient Computation of Pathwise Persistence Barcodes in Multi-Filtered Flag Complexes via Vietoris-Rips Transformations'. arXiv: 2207.03394 (preprint).
8. Michael Bleher, Lukas Hahn, Juan Angel Patino-Galindo, Mathieu Carriere, Ulrich Bauer, Raul Rabadan and Andreas Ott (2021). 'Topology Identifies Emerging Adaptive Mutations in SARS-CoV-2'. arXiv: 2106.07292 (preprint).
9. Johannes Bleher, Michael Bleher and Thomas Dimpfl (2020). 'From Orders to Prices: A Stochastic Description of the Limit Order Book to Forecast Intraday Returns'. arXiv: 2004.11953 (preprint).

Presentations

1. *Persistence and Coarse-Graining in Dynamical Biological Systems*. TDA Symposium at MPI-MCG, Dresden. 12th Dec. 2024.
2. *Fast Computation of Pathwise Persistence in Pandemic-Scale SARS-CoV-2 Genome Data*. 4th Workshop on Computational Persistence, TU Graz. 23rd Sept. 2024.
3. *Haydys-Witten Instantons and the Gauge Theoretic Approach to Khovanov Homology*. Gauge Theory and Mathematical Physics Seminar, Morningside Center of Mathematics, Beijing (invited talk). 3rd July 2024.
4. *RNA Velocity Embeddings in Curved Spaces - Exploring Cellular Dynamics*. Seminar 24122, Dagstuhl. 20th Mar. 2024.
5. *On Haydys-Witten Instantons and the Gauge Theoretic Approach to Khovanov Homology*. HU Gauge Theory Research Seminar, Berlin (invited talk). 31st Jan. 2024.
6. *Haydys-Witten Instantons in the Gauge Theoretic Approach to Khovanov Homology*. ULB Geometry Seminar, Brussels (invited talk). 4th Dec. 2023.
7. *Topological Signatures of Convergence in Viral Evolution*. CompTopNN Meeting 2023, Sevilla (invited talk). 8th Nov. 2023.
8. *Feature Representation of scRNA Data in Symmetric Spaces*. Structures Symposium, Heidelberg (poster). 20th July 2023.
9. *Learning Representations of Symbolic Data in Symmetric Spaces*. TDA Research Seminar, Heidelberg. 13th July 2023.
10. *Haydys-Kapustin-Vafa-Witten Floer Theory*. Physical Mathematics Seminar, Heidelberg. 10th Feb. 2023.
11. *Persistent Homology Detects Emerging Adaptive Mutations*. TDA Journal Club, Heidelberg. 7th June 2021.
12. *Welcome Notes and an Introduction to Mapper*. Heidelberg TDA Workshop 2020, Heidelberg (organizer). 26th Oct. 2020.

Scientific Engagement and Outreach

2023 **4th Heidelberg TDA Workshop**, *Co-Organizer*.

2019–2022 **Topics in TDA**, *Journal Club, Co-Organizer*.

2021 **2nd Heidelberg TDA Workshop**, *Co-Organizer*.

2020 **1st Heidelberg TDA Workshop**, *Co-Organizer*.

Software Development

gNE **geometric Neighbour Embeddings**, *https://github.com/subthaumic/gne*.
Python package.

MuRiT **Multiparameter Rips Transform**, *https://github.com/tdalife/murit*.
A Ripser add-on for exploration of persistence in multi-filtered metric spaces.

Teaching Experience

2019 **Research Seminar: Seiberg-Witten Theory**, *Heidelberg University*.

2017–2022 **Teaching Assistant**, *Universities of Heidelberg, Mannheim, and Hohenheim*.

- Mathematics Refresher for Master Students in Economics (available on Youtube)
- Helpdesk for First-Year Math Students (Winter 2020 – Spring 2022)
- Theoretical Physics I, II, and IV
- Höhere Mathematik für Physiker III
- Applied Topology I