



TRR 352

in motion

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Issue 2

Welcome to the second issue of the TRR 352 Newsletter!



We're pleased to share another set of updates from our research community. This edition includes news about recent PhDs, international experiences, and career moves. These brief reports offer a glimpse into the diverse paths, activities, and accomplishments of our junior members. We hope you enjoy reading!

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TRR 352: Mathematics of Many-Body Quantum Systems and Their Collective Phenomena



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Recent Doctorates

Duc Viet Hoang successfully defended his PhD thesis on April 22, 2025, at the University of Tübingen

Viet's thesis, titled "*On the Effective Dynamics of Interacting Fermionic Many-Body Systems*", focuses on effective descriptions of the dynamics of interacting fermionic systems. He developed new mathematical methods to rigorously derive mean-field and polaron-type models in strongly interacting and high-density regimes, providing insights into complex quantum many-body dynamics.

Congratulations!



Duc Viet Hoang and Peter Pickl

On March 26, 2025, Vjosa Blakaj successfully passed her PhD defense at the Technical University of Munich



Vjosa Blakaj with Michael Wolf and other members of the thesis committee

Vjosa's thesis "*Transcendental Tools in Quantum Information Theory*" addresses problems in quantum information theory through the lens of transcendental number theory and algebraic geometry, with a particular focus on distinguishing semialgebraic structures from transcendental ones. Specifically, it examines the nature of sets that are central to studying specific tasks in quantum information processing, such as level sets of entropic quantities and sets relevant to optimizing ground-state properties in quantum many-body systems. Furthermore, it analyzes the implications of the transcendental nature of these sets and establishes no-go results for several

entropic quantities. This framework provides insights into when asymptotic settings, infinite resources, or transcendental methods are indispensable for quantum information processing tasks, and when single-letter formulas, finite resources, or algebraic techniques suffice.

Congratulations!

Tim Möbus successfully completed his PhD defense at the Technical University of Munich on February 25, 2025

Tim's doctoral thesis "*Limits of Approximation of Quantum Markov Semigroups in Infinite-Dimensional Systems*" explores the approximation of effective quantum time evolutions in infinite-dimensional quantum mechanical systems, with a particular focus on the quantum Zeno effect and Lie-Trotter's product formula, especially in the context of bosonic systems, including a characterisation of the considered bosonic quantum Markov semigroups through a family of differential equations. The work establishes general, optimal, and explicit error bounds while proving convergence in the strong operator topology. Furthermore, sufficient conditions are derived under which a bosonic initial value problem uniquely defines a quantum time evolution with specific properties, enabling the derivation of error bounds for the aforementioned product formula and ensuring the stability of fixed points. These results find applications in the bosonic error correction cat code, the Ornstein-Uhlenbeck semigroup, and the simulation of local time evolutions.



Tim Möbus

Congratulations!

On May 14, 2025, Cornelia Vogel successfully completed the defense of her PhD thesis at the University of Tübingen



Roderich Tumulka, Cornelia Vogel, and Stefan Teufel

The goal of Cornelia's thesis "*Typical Macroscopic Behavior of Large Quantum Systems*" thesis was to rigorously study the behavior of typical pure states of large quantum systems. In the first part, she generalizes "canonical typicality", a statement regarding the reduced density matrix of typical pure states and small subsystems, and different versions of "dynamical typicality" from the uniform distribution on the sphere as a measure of typicality to the much broader class of GAP measures. The second part is concerned with the long-time behavior of typical pure states from macroscopic Hilbert subspaces and she generalizes von Neumann's "normal typicality" to

more realistic Hamiltonians and also to GAP measures. In the third part, she studies the thermalization of highly degenerate Hamiltonians and in particular of systems of free fermions in arbitrary dimensions.

Congratulations!

International Stays

Three Months in Hokkaidō: A Sapporo Research Adventure – By Marius Wesle



Marius Wesle at the northernmost point of Japan

I spent mid-October 2024 through mid-January 2025 at Hokkaidō University in Sapporo, hosted by Tadahiro Miyao. My visit was timed around a conference in Kyoto last November, organized by Tadahiro, where my supervisor, Stefan Teufel, was invited to speak. Stefan suggested that I come along and enjoy an extended stay in Japan. During those three months in Sapporo, we completed a joint project, which Tadahiro had joined during his sabbatical in Tübingen, proving the validity of linear response theory for interacting infinite-volume quantum Hall systems (the paper will soon appear in *Communications in Mathematical Physics*). We then immediately began generalizing the results to non-periodic systems, removing a key assumption of our first paper. In early December, Tadahiro and I traveled to Kyūshū University in Fukuoka to meet Fumio Hiroshima, where I presented our work in the Mathematical Physics Seminar, sparking fresh ideas for future collaborations.

Outside the office, I explored Hokkaidō's winter beauty: the Ishikari River delta where it meets the sea, a mountain onsen just outside Sapporo (soaking in steaming water while snow fell around me), and a three-day stay in Wakkanai at Japan's northernmost tip. Christmas in Sapporo meant fried chicken and a Munich-style Christmas Market downtown, while New Year's Day began with hatsumōde (the first shrine visit of the year) at Hokkaidō Jingū (the island's largest Shintō shrine), which offered a striking contrast to celebrations back home. Closer to campus, I made it my mission to sample every nearby ramen shop, quickly falling for the Sapporo-style miso ramen. I also spent time with several of Tadahiro's students, who were very welcoming and even gave me Japanese lessons. I hope to further increase my language skills so that on my next visit I can absorb even more of Japan's amazing culture and atmosphere.

I would like to thank SFB TRR 352 and Stefan for making this stay possible, and Tadahiro for his generous hospitality and our many enjoyable discussions.

New Career Moves

Mathematical Physics Between Molecules and Parks: A New Chapter at KIT – By Siegfried Spruck

During my Ph.D. at the universities of Tübingen and Dijon, with Peter Pickl and Jonas Lampart, I investigated the effective dynamics of the Bose polaron – a quasi-particle formed by an impurity interacting with a Bose-Einstein condensate. This work contributed to a better mathematical understanding of many-body quantum systems with impurities.

In April, I joined the Karlsruhe Institute of Technology (KIT), where I am now working with Dirk Hundertmark and Ioannis Anapolitanos. Our research interests lie in the mathematical aspects of atomic and molecular physics. Among the topics we focus on are van der Waals interactions between neutral molecules – a quantum mechanical effect mediated by induced dipoles – as well as the Casimir-Polder effect, molecular isomerization, and the Born-Oppenheimer approximation. These phenomena lie at the interface of mathematical physics and quantum chemistry and pose a variety of interesting analytical challenges.



Karlsruhe Palace, a view from the office

The mathematics building at KIT is located next to Karlsruhe Palace and the adjacent park, providing a beautiful and peaceful environment for research. The setting is well suited for reflective walks or a quiet moment of thought at the office window.



A squirrel in the palace park

Thanks to temporary accommodation provided by the KIT Guesthouse, my relocation to Karlsruhe went very smoothly. I was particularly impressed by the abundance of squirrels in the surrounding palace park, which I can observe directly from my balcony – a small but welcome perk of living on the third floor.

Outside of work, Karlsruhe offers many opportunities for relaxation, including a number of scenic lakes accessible by bike, and cultural venues such as Gottesau Palace, where one can enjoy classical music performances in the heart of the city.

From Munich to Milan: A Postdoctoral Journey – By Emanuela Laura Giacomelli

I joined LMU Munich in October 2019. From the outset, I found the environment to be welcoming, collaborative, and intellectually stimulating. I truly felt part of a genuine scientific community.

My years at LMU were intense and fulfilling, filled with meaningful exchanges, collaborations, and personal growth, a deeply formative experience. I learned a great deal from all the members of the community, including professors, postdoctoral researchers, and PhD students. I also appreciated the many scientific events organised within the SFB TRR 352 community, which broadened my perspective on related and complementary research areas.

The main project I worked on during my time at LMU, carried out in collaboration with Christian Hainzl, Phan Thành Nam, and Robert Seiringer, focused on rigorously deriving the Huang-Yang formula for the energy density of a dilute system of spin-1/2 fermions in the thermodynamic limit.



Emanuela L. Giacomelli at her farewell dinner with the LMU research group

Beyond the academic sphere, it was the genuinely warm atmosphere and the many shared moments — meals, conversations, and laughter — with the group that made this time special on a personal level. These moments added depth to an already engaging academic experience. Overall, my time at LMU was both scientifically stimulating and personally meaningful.

Since February 2025, I have been working at the University of Milan as a tenure-track

Assistant Professor, bringing with me everything I have learned and experienced in Munich.

New Office, Still Numerics – By Dominik Sulz

After finishing my PhD in Tübingen in December, my journey now continues at the TU Munich. This May, I started a post-doc position in Caroline Lasser's group "Numerics of Partial Differential Equations". Thus, I will remain connected to the TRR, which I am very happy about.

I will continue to focus on exciting topics related to numerics of quantum dynamics – from semi-classical methods to high-dimensional tensor techniques, I am trying to develop and analyze efficient numerical methods for quantum dynamics. My main focus lies on Gaussian wave packets and on low-rank approximations of long-range interacting quantum spin systems.

I'm looking forward to the new environment, the professional exchange and, last but not least, the beautiful hikes in the mountains on my doorstep!



Dominik Sulz hiking near Munich
