

Mathematical Physics in the Heart of Germany VI

Workshop Program

All talks take place at Constructor University in R.1-53 Lecture Hall (main lecture hall of Research I building). Each talk is 50 minutes followed by 5 minutes of questions.

Friday, November 21, 2025

Time	Event / Speaker
09:30–10:00	<i>Coffee and snacks</i>
10:00–11:00	David Mitrouskas (IST Austria)
11:00–12:00	Morris Brooks (University of Zürich)
12:00–13:00	<i>Lunch break</i>
13:00–14:00	Janik Kruse (University of Paderborn)
14:00–15:00	Itaru Sasaki (Shinshu University)
15:00–15:30	<i>Coffee and snacks</i>
15:30–16:30	Christiaan Van de Ven (University of Erlangen–Nürnberg)
16:30–17:30	Christian Fleischhack (University of Paderborn)
18:30	<i>Conference Dinner</i>

Titles and Abstracts

10:00–11:00

David Mitrouskas (IST Austria)

On the Stability–Instability Transition in Large Bose–Fermi Mixtures

Abstract: In this talk, we study the low-energy spectrum of a large Bose–Fermi mixture. In the chosen scaling regime, the fermions induce an effective attraction among the bosons, which competes with their intrinsic repulsive interaction. Our main result shows the convergence of the eigenvalues towards those of an effective Bose Hamiltonian. For short-range potentials, we apply this result to derive a stability–instability transition in the bosonic subsystem, driven by the Bose–Fermi coupling strength g . For small values of $|g|$, the bosons form a stable Bose–Einstein condensate with the energy per particle uniformly bounded from below. For large $|g|$, the energy per particle is no longer uniformly bounded from below, signalling the collapse of the condensate.

Based on joint work with E. Cárdenas, J.K. Miller, and N. Pavlović.

11:00–12:00

Morris Brooks (University of Zürich)

The Effective Mass of the Fröhlich Polaron at Strong Coupling

Abstract: In this talk we investigate the Fröhlich polaron in the strong coupling limit, which is a model describing the interactions of a charged particle, e.g., an electron, with a polarizable environment. Notably, the model is simple enough to allow for rigorous mathematical proofs, while giving rise to a multitude of interesting and non-trivial phenomena, such as an effectively increased mass of the electron. In particular, we will discuss a recent proof concerning the validity of the celebrated Landau–Pekar formula for the effective mass of the Fröhlich polaron at strong couplings, which has been an outstanding open problem in mathematical physics conjectured by Spohn in 1987.

13:00–14:00

Janik Kruse (University of Paderborn)

Scattering Theory and Asymptotic Completeness: From Many-Body Quantum Systems to Quantum Field Theory

Abstract: The goal of scattering theory is to describe the asymptotic evolution of systems of interacting particles. A central concept in this framework is asymptotic completeness, which asserts that every state can be decomposed into bound and scattering states. In this talk, I will review the scattering theory of many-body quantum mechanical systems and explain how key ideas from quantum mechanics can be adapted to the study of asymptotic completeness in quantum field theory. In quantum mechanics, asymptotic completeness has been established under fairly general conditions. I will explain essential analytic tools, such as propagation estimates and the convergence of the asymptotic velocity, and their role in proving asymptotic completeness. In quantum field theory, asymptotic completeness remains an open problem due to additional conceptual and mathematical challenges. I will outline how techniques inspired by spectral theory and Mourre’s conjugate operator method can be adapted to the algebraic framework of QFT and the Haag–Ruelle scattering theory, which led to recent progress on the convergence of Araki–Haag particle detectors. These asymptotic observables play a role in QFT analogous to that of the asymptotic velocity in quantum mechanics and their convergence is a key prerequisite towards asymptotic completeness.

References: doi:10.1007/s00220-024-05091-7, doi:10.1007/s11005-024-01859-z

14:00–15:00

Itaru Sasaki (Shinshu University)

Holomorphy of the Ground State in the Pauli–Fierz Model with Dipole Approximation

Abstract: We study the analytic properties of the ground state in the Pauli–Fierz model in the dipole approximation, focusing on its dependence on the electric charge e . By applying a Bogoliubov transformation, we obtain partially explicit representation of the ground state, which enables a detailed analysis of its regularity. It is shown that both the ground state and its energy can be analytically continued as holomorphic functions of e in a complex strip containing the real axis. When the ultraviolet cutoff is

taken to be of the order of mc^2 , the physical value of the charge e lies within this strip, implying that the ground state and its energy admit a Maclaurin expansion in e .

15:30–16:30

Christiaan Van de Ven (University of Erlangen–Nürnberg)

Large Deviations in the Semi-Classical Limit of Quantum Spin Systems

Abstract: The continuous C^* -bundle generated by Berezin–Toeplitz quantization on a symplectic manifold provides a rigorous framework for describing the semiclassical limit of quantum systems. The rate of convergence in this limit, often quantified by a rate function or entropy, is naturally formalized through the theory of large deviations. In this work, I investigate the specific case of the 2-sphere, which serves as the phase space for a single quantum spin system. The spin, which characterizes the system’s quantum nature, defines the semiclassical parameter and corresponds to the dimension of the associated Hilbert space. More precisely, we establish a full large deviation principle for the local Gibbs state and explicitly characterize the corresponding rate function. This is done by using a sophisticated argument based on a generalization of Fekete’s Lemma.

Joint work with Matthias Keller (Uni Potsdam).

16:30–17:30

Christian Fleischhack (University of Paderborn)

States on Holonomy–Flux Algebras

Abstract: About 20 years ago, Lewandowski, Okolow, Sahlmann and Thiemann showed that there is a unique diffeomorphism-invariant state on the holonomy–flux algebra underlying the kinematics of loop quantum gravity. Unfortunately, the original proof was very technical. In our talk, we are going to present a much shorter proof. Moreover, the new result even covers related cases in homogeneous loop quantum cosmology, namely, the flat Friedmann–Robertson–Walker model and the Bianchi I model.