TRR 352 Junior Meeting

Herrsching/Ammersee.

December 13-15 2023

Long-time dynamical behavior of weakly interacting lattice fermions

Peter Madsen, LMU

Describing the long-time dynamical behavior of fermionic systems is a long-standing open problem. When the coupling constant λ of the interaction is small, the dynamics of the system up to kinetic time $t \sim \lambda^{-2}$ is conjectured to be effectively governed by a Boltzmann-Nordheim kinetic equation. In this talk I will introduce the model and state a result which we expect to be true, but have not yet proven. I will also describe some of the methods we are using to try to tackle the problem.

Hydrodynamic equations for integrable many-body systems

Alberto Brollo, TUM

Hydrodynamics is one of the possible approach to the study of non-equilibrium physics. While during the last century, physicists manage to understand the principles of the equilibrium behavior of many-body system, which have a solid mathematical foundation on large deviation theory, the out-of-equilibrium physics is one of the most compelling problem in modern physics. Integrable systems are characterized by having an extensive number of conserved quantities. This make them not only exactly solvable, but due to this extremely constrain dynamics they display peculiar thermodynamical properties. The study of their hydrodynamic can give new insight into hydrodynamics and non-equilibrium statistical mechanics.

Computing spectra of infinite-volume aperiodic operators

Paul Hege, University of Tübingen

Studying the spectra of infinite-volume operators is a central problem in mathematical physics. For periodic operators, the Bloch decomposition can be used to compute the spectrum as a union of bands and gaps. Quasicrystals are solids which have strong long range order and behave like normal crystals in many respects. But their atomic structure is aperiodic, which means that Bloch theory cannot be applied. In this talk, we present an approach to compute to the spectra of aperiodic systems from finite patches. It turns out that the local information can be combined to obtain rigorous error control in Hausdorff distance. In particular, we can for the first time prove the existence of spectral gaps in some two-dimensional infinite-volume aperiodic systems.

Effective polaron dynamics for an impurity particle interacting with a Fermi gas

Viet Hoang, University of Tübingen

We study the quantum dynamics of a homogeneous ideal Fermi gas coupled to an impurity particle on a 3-dimensional box with periodic boundaries. For large Fermi momentum k_F, we prove that the effective dynamics is generated by a Fröhlich-type polaron Hamiltonian, which linearly couples the impurity particle to an almost-bosonic excitation field. Our method applies to the case of an interaction coupling $\lambda = 1$ and time scales of order k_F^{-1}, allowing us to compare our results with experimental observations.

Third order corrections to the ground state energy of a Bose gas in the Gross-Pitaevskii regime

Diane Saint Aubin, University of Zürich

In recent decades, substantial progress has been made in understanding Bose gases, from both experimental and theoretical realms. In this talk, we consider a system of N bosons in the Gross-Pitaevskii regime, moving on the unit torus and interacting through a repulsive potential with scattering length $1/N$. We present the derivation of the ground state energy of such a system. While the leading order (of order N) and second order (of order 1) of the ground state energy have been established in recent years, this approach resolves the next order term of order $\log N/N$. The correction to the energy is consistent with predictions of the ground state energy per particle in the thermodynamic limit. This talk is based on joint work with Cristina Caraci, Alessandro Olgiati and Benjamin Schlein.

Weighted CLR type bounds for a magnetic Schrödinger operator in two dimensions

Larry Read, LMU

The Cwikel-Lieb-Rozenblum (CLR) inequality establishes an upper limit for the number of negative eigenvalues of the classical Schrödinger operator in three or more dimensions. However, in lower dimensions, these bounds fail since even minimally attractive (electric) potentials produce at least one bound state. In this talk, I will show that introducing a nontrivial Aharonov-Bohm magnetic field in two dimensions enables the derivation of both strong and weak weighted versions of the CLR inequality.

The generalized capacity of a quantum channel

Zahra Khanian, TUM

The transmission of classical information over a classical channel gave rise to the classical capacity theorem with the optimal rate in terms of the classical mutual information. Despite classical information being a subset of quantum information, the rate of the quantum capacity problem is expressed in terms of the coherent information, which does not mathematically generalize the classical mutual information. Additionally, there are multiple capacity theorems with distinct formulas when dealing with transmitting information over a noisy quantum channel. This leads to the question of what constitutes a mathematically accurate quantum generalization of classical mutual information and whether there exists a quantum task that directly extends the classical capacity problem. In this paper, we address these inquiries by introducing a quantity called the generalized information, which serves as a mathematical extension encompassing both classical mutual information and coherent information. We define a transmission task, which includes as specific instances both classical information and quantum information capacity problems, and show that the transmission capacity of this task is characterized by the generalized information.

Some open (and closed) problems in probability and statistical mechanics

Quirin Vogel, TUM

In order to introduce his research to the group, the speaker will talk about some problems and past research he's been involved with over the past years. In particular, the speaker will focus on the Bose gas and the random walk on the lattice.

Simulation of long-range quantum spin systems using tree tensor networks

Dominik Sulz, University of Tübingen

In many applications, it is of interest to numerically solve high-order tensor differential equations, e.g. the many-body Schrödinger equation in quantum physics or discretized high-dimensional time-dependent partial differential equations. Tree tensor networks (TTNs) turned out to be a promising ansatz to overcome the so-called 'curse of dimensionality' as they are an efficient hierarchical data sparse format to approximate tensors. Based on the dynamical low-rank approximation, several novel time integration methods for TTNs have been proposed in the last few years. In a recursion from the leaves up to the root, all nodes are updated by only solving small matrix-/tensor differential equations. The proposed methods are robust even in the presence of small singular values. Further properties like rank-adaptivity, norm and energy preservation and error behavior are mathematically well understood for these methods. The talk intends to give an overview of the latest results for dynamical low-rank approximations. Further, the different time integration methods and their applicability to many-body quantum systems are discussed. Numerical experiments validate the theoretical results and show several applications from quantum physics.

The free energy of dilute Bose gases at low temperatures

Florian Haberberger, LMU

I will start by presenting the key idea of Bogoliubovs paper "On the Theory of Superfluidity" from 1947 followed by a rigorous derivation of the Free Energy of the Bogoliubov Hamiltonian. I will then present our result: A perturbative expansion of the Free energy, that refines the Bogoliubov expression by providing the correct constants. Finally, I will elucidate methods and ideas involved in the proof of the lower and upper bound of the expansion. This is joint work with: C.Hainzl, P.T.Nam, B.Schlein, R.Seiringer, A.Triay.