Effective Approximation and Dynamics of Many-Body Quantum Systems

Constructor University Bremen, June 29 – July 3, 2026

Schedule and Abstracts

Time	**Monday**	**Tuesday**	**Wednesday**	**Thursday**	**Friday**
09:00–09:30		Talk Boßmann	Talk Pizzo	Talk Saffirio	Talk Benedikter
09:30–10:00					
10:00–10:30	Coffee + Welcome	Coffee	Coffee	Coffee	Coffee
10:30–11:00	Talk Lemm	Talk Fournais	Talk Griesemer	Talk Nier	Talk Ballesteros
11:00–11:30					
11:30–12:00	Talk Napiórkowski	Talk Bru	Talk Fröhlich	Talk Zanelli	Talk Nguyen
12:00–12:30					
12:30–13:00	Lunch	Lunch	Lunch	Lunch	Lunch
13:00–13:30					
13:30–14:00					
14:00–14:30	Talk Olgiati	Poster Pitch	Free/Discussion	Talk Dietze	
14:30–15:00					
15:00–15:30	Talk Sohinger	Coffee		DFG-ANR: Fantechi	
15:30–16:00		Poster Session		Coffee	
16:00–16:30	Coffee			DFG-ANR: Farhat	
16:30–17:00	Free/Discussion			DFG-ANR: Grasselli	
17:00–17:30			Social Program + Conference Dinner	DFG-ANR: Herdzik	
17:30–18:00					
18:00–18:30	Free/Dinner	Public Lecture		Free/Dinner	
18:30–19:00					
19:00–19:30		Free/Dinner			
19:30–20:00					

Monday, June 29, 2026

Marius Lemm, University of Tübingen

Time: 10:30–11:30

Title: *Transport in disordered quantum many-body models*

Abstract: Disorder drastically affects quantum dynamics by disrupting the coherent ballistic transport of clean systems. The prototype for this phenomenon is the Anderson model, governed by the Hamiltonian $H = -\Delta + V$ with V a suitable random potential, which exhibits complete localization at strong disorder in any dimension. However, adding interactions complicates the picture: Many-body localization (MBL) is expected to persist in 1D and to be unstable over long time scales in higher dimensions. In this talk, I discuss small-velocity Lieb-Robinson bounds, which provide a way to quantify the disorder-induced slowing of dynamics in any dimension on suitable time scales. I present two recent results proving the suppression of many-body transport: first, in the context of strongly disordered quantum spin systems, and second, for the bosonic Anderson model with mean-field interactions. I conclude with a complementary result, establishing delocalization for weakly disordered many-body models on sufficiently short, perturbative time scales. Based on joint work with McDonough & Lucas, Rademacher & Zhang, and Toniolo.

Marcin Napiórkowski, University of Warsaw

Time: 11:30–12:30

Title: *Effective field theory and particle counting in weakly interacting thermal Bose gases*

Abstract: In a recent work we established an approximation of the Gibbs state of the mean-field Bose gas at temperatures of the order of the critical temperature of the BEC phase transition. The effective state is constructed from a one-mode ϕ^4 integral governing the condensate, coupled with a temperature-dependent Bogoliubov Hamiltonian for non-zero momentum particles. In this talk, I will review this result and discuss a semiclassical interpretation of this state via a classical random field. I will present results for probability distributions of particle numbers, localized in either momentum or position space, expressed and proved using the effective field theory. Based on joint works with A. Deuchert (Virginia Tech), P.T. Nam (Munich) and B. Ruba (Warsaw).

Alessandro Olgiati, Politecnico di Milano

Time: 14:00–15:00

Title: *The Lee–Huang–Yang formula for the hard-core dilute Bose gas: an upper bound*

Abstract: The Lee–Huang–Yang formula captures the ground state energy of a dilute Bose gas in the thermodynamic limit. First derived heuristically in 1957, it predicts that, to second order in the dilute limit, the energy depends on the repulsive interaction only through the s-wave scattering length, independently of local integrability of the potential. This prediction has been largely confirmed by mathematical results over the past decades. Yet, while energy lower bounds are known in considerable generality, all upper bounds known so far have relied on local integrability assumptions. We construct a trial state for hard-core bosons whose energy matches the Lee-Huang-Yang asymptotics, thereby establishing the upper bound without requiring local integrability. Based on a joint work with Giulia Basti (Sapienza, University of Rome), Morris Brooks (University of Zurich), Serena Cenatiempo (GSSI L'Aquila), and Benjamin Schlein (University of Zurich).

Vedran Sohinger, University of Warwick

Time: 15:00–16:00

Title: *Almost sure global existence for nonlinear Schrödinger and Hartree hierarchy equations*

Abstract: The nonlinear Schrödinger and Hartree hierarchy equations are systems of infinitely many linear PDEs that arise when deriving the nonlinear Schrödinger (NLS) or Hartree equation (NLH) from the dynamics of many-body quantum systems. We study the almost sure global existence of solutions to these hierarchy equations at low regularities, following the framework pioneered by Bourgain for the NLS and NLH in the 1990s. Working in a general functional setting, we develop an abstract framework that unifies and extends previous results on invariant measures for nonlinear dispersive PDEs. Our main theorem shows that if there exists an invariant measure for the nonlinear (NLS or NLH) flow, then for any initial condition with specific symmetry and regularity properties, there exists a global solution to the hierarchy equations. This result is obtained without requiring direct control of Sobolev norms of the flow of the PDE. Instead, it relies on the Liouville equation perspective and properties of the Malliavin gradient of the nonlinearity. We apply this abstract theorem to several concrete settings of the NLS and NLH. In each case, the associated Gibbs measure serves as the invariant measure, and the almost sure global existence for the hierarchy equations follows from the integrability properties of the nonlinear interaction with respect to the Gaussian measure. This is joint work with Zied Ammari, Nataša Pavlović, and Gigliola Staffilani.

Tuesday, June 30, 2026

Lea Boßmann, University of Erlangen–Nürnberg

Time: 09:00–10:00

Title: *Many-body perturbation theory for interacting Bose gases*

Abstract: We consider Bose gases with singular interactions among the particles. We investigate the question how and to what extent Rayleigh-Schrödinger perturbation theory can be applied, despite the singularity of the interactions, to derive asymptotic expansions for low-energy properties of the system. This is based on joint works with Nikolai Leopold, Sören Petrat, Simone Rademacher, and Robert Seiringer.

Søren Fournais, University of Copenhagen

Time: 10:30–11:30

Title: *TBA*

Abstract: TBA

Jean-Bernard Bru, BCAM – Basque Center for Applied Mathematics

Time: 11:30–12:30

Title: *Studies of Variational Problems on Compact Spaces and Bogoliubov Linearization*

Abstract: Building on key results from convex analysis, we present a method that allows nonlinear variational problems on convex compact spaces to be fully studied using a new linearisation process, which we call the "Bogoliubov linearization." Depending on time constraints, we will discuss connections to optimal transport and game theory, as well as an application to fermionic systems on lattices with mean-field interactions or/and the nonlinear thermodynamic formalism of dynamical systems.

Wednesday, July 1, 2026

Alessandro Pizzo, University of Rome Tor Vergata

Time: 09:00–10:00

Title: *Gap Stability and Boundary Effects in some Spin Chains*

Abstract: I will consider families of quantum lattice systems that have attracted much interest amongst people studying topological phases of matter. Their Hamiltonians are perturbations, by interactions of short range, of a Hamiltonian consisting of strictly local terms and with a (strictly positive) energy gap above its ground-state energy. I will review the main ideas of a novel method to prove gap stability based on local Lie-Schwinger conjugations of the Hamiltonians associated with connected subsets of the lattice. By this method fermions and bosons are treated on the same footing, and our technique does not face a large field problem, even though bosons are involved. If time permits I will outline some recent developments concerning the control of the perturbation of a degenerate ground-state energy. That is, I will report some results regarding the XXZ model coupled to a magnetic field and the AKLT model, with general boundary conditions. (Joint works with S. Del Vecchio, J. Fröhlich, A. Ranallo, and S. Rossi.)

Marcel Griesemer, University of Stuttgart

Time: 10:30–11:30

Title: *On Rayleigh scattering in the massless Nelson model*

Abstract: Asymptotic completeness of Rayleigh scattering in models of atoms and molecules of non-relativistic QED is expected, but to prove it, we still lack sufficient control over the number of emitted soft photons. So far, this obstacle has only been overcome for the spin-boson model. In a general class of models, asymptotic completeness holds provided the expectation value of the photon number N remains bounded uniformly in time. This was shown a few years ago by Faupin and Sigal. We review and simplify their work, and, more importantly, we replace the bound on N by a weaker assumption on the distribution of N that is both necessary and sufficient for asymptotic completeness. This is joint work with Valentin Kußmaul.

Jürg Fröhlich, ETH Zürich

Time: 11:30–12:30

Title: *Events, States and Evolution in Quantum Mechanics*

Abstract: TBA

Thursday, July 2, 2026

Chiara Saffirio, University of Basel

Time: 09:00–10:00

Title: *TBA*

Abstract: TBA

Francis Nier, Université Sorbonne Paris Nord

Time: 10:30–11:30

Title: *Derivation of the Bistritzer-MacDonald model for the twisted bilayer graphene*

Abstract: I will explain the several issues and the strategy for the justification and the quantitative validation of the simplified Bistritzer-MacDonald model for the twisted bilayer graphene, by starting from a more realistic 3-dimensional Schrödinger Hamiltonian. This is a work still in progress, in collaboration with Eric Cancès.

Lorenzo Zanelli, University of Padova

Time: 11:30–12:30

Title: *Semiclassical Wick operators and many body dynamics*

Abstract: We discuss some results on time propagation of Wick operators defined on Bargmann-Fock space and related semiclassical asymptotics of symbols. The target is to improve the known results on the quantum propagation of Pseudodifferential operators by using here the setting and the properties of many body dynamics on Bargmann-Fock. As a byproduct we apply such results to get a mean field estimate for the quantum fluctuation around the Hartree flow.

Charlotte Dietze, Sorbonne University - Laboratoire Jacques-Louis Lions

Time: 14:00–15:00

Title: *Focusing dynamics of 2D Bose gases in the instability regime*

Abstract: We consider the dynamics of a 2D Bose gas with an interaction potential of the form $N^{2\beta-1}w(N^{\beta}\cdot)$ for $\beta \in (0, 3/2)$. The interaction may be chosen to be negative and large, leading to the instability regime where the corresponding focusing cubic nonlinear Schrödinger equation (NLS) may blow up in finite time. We show that to leading order, the N-body quantum dynamics can be effectively described by the NLS prior to the blow-up time. Moreover, we prove the validity of the Bogoliubov approximation, where the excitations from the condensate are captured in a norm approximation of the many-body dynamics. This is joint work with Lea Boßmann and Phan Thành Nam.

DFG–ANR Session (Thursday)

Michele Fantechi, University of Lorraine

Time: 15:00–15:30

Title: *Existence of Solutions for time-dependent fractional Kohn–Sham Equations*

Abstract: We consider time-dependent Kohn–Sham equations in dimension 3 with a fractional dispersion relation $(1-\Delta)^s$, $s \in (0, \frac{3}{2})$, and a class of long-range interaction terms including, in particular, external potentials, internal potentials associated to Hartree-type non-linearities, and exchange terms described by energy subcritical pure-power non-linearities. We prove the local existence of weak solutions in H^s using an approximation procedure regularizing the non-linearities. Assuming that the interaction energies can be controlled by the kinetic energy, we show that the solutions can be extended to global solutions using energy estimates. If $s \in [1, \frac{3}{2})$, we establish in addition the well-posedness of the time-dependent Kohn–Sham equations using Strichartz estimates.

Shahnaz Farhat, University of Tübingen

Time: 16:00–16:30

Title: *Mean-field regimes of the Bose–Hubbard Model*

Abstract: In the first part, I will talk about the many-body quantum Gibbs state for the Bose–Hubbard model on a finite graph at positive temperature. We scale the interaction with the inverse temperature, corresponding to a mean-field limit where the temperature is of the order of the average particle number. We prove an expansion to any order of the many-body Gibbs state with inverse temperature as a small parameter. In the second part, I will talk about the validity of a mean-field approximation for the dynamics of quantum systems in high dimension, using the Bose–Hubbard model on a square lattice. We prove a trace norm estimate between the one-lattice-site reduced density of the Schrödinger dynamics and the mean-field dynamics in the limit of large dimension.

Viviana Grasselli, University of Lorraine

Time: 16:30–17:00

Title: *Speed of propagation for solutions of the boson star equation*

Abstract: We consider the boson star equation, which is an effective equation of Hartree-type with a semirelativistic kinetic energy, obtained as the mean-field limit of a large system of gravitating bosons. We study its dispersive properties, in particular the speed of propagation of the particle. We prove that the particle's speed can not exceed that of light and that the particle can not escape the cone of propagation, up to exponentially small errors. Moreover, we prove a minimal velocity bound depending on the kinetic energy of the particle at time $t = 0$. These results are a joint work with Sébastien Breteaux and Jérémy Faupin.

Matthias Herdzik, Technical University Braunschweig

Time: 17:00–17:30

Title: *Microscopic model of electrons and phonons*

Abstract: Rigorous mathematical discussions of crystalline solids and the effective models used in physics are few in the literature. We introduce a microscopic model of a crystalline solid, which fills the entirety of a box with periodic boundary conditions, where the ion positions are dynamical variables and the valence electrons are modelled by an electron gas. Each ion exerts an attractive force on each electron which is modelled by a smooth bump potential. We present relative bounds on the interaction and discuss some of the findings and challenges of our ongoing project of modeling crystals.

Friday, July 3, 2026

Niels Benedikter, University of Milan

Time: 09:00–10:00

Title: *TBA*

Abstract: TBA

Miguel Ballesteros, Universidad Nacional Autónoma de México

Time: 10:30–11:30

Title: *Time Evolution and Spectral and Scattering Theories for Matrix-Valued Lattice Schrödinger Operators (Tight-Binding Models)*

Abstract: Tight-binding models are effective single-particle frameworks derived from many-body quantum systems that approximate the low-energy dynamics via a single-particle operator on a discrete lattice. In this work, we study the spectral theory, scattering theory, and time evolution for such models, focusing on matrix-valued Schrödinger operators defined on lattices.

We emphasize the analytic properties of the scattering matrix and its topological relation to the spectral properties of the underlying operator, in particular through Levinson's theorem, which relates the number of bound states of the operator to the total phase variation of the scattering matrix across the spectrum, together with correction terms arising from the presence of threshold resonances or half-bound states at band edges.

We establish results for several classes of models, including periodic systems in one dimension and in dimensions $d \geq 3$. We obtain results on the asymptotic behavior of the scattering matrix near band edges.

- In one dimension, the Green's function exhibits a square-root singularity, which plays a central role in the analysis.
- In higher dimensions, we study critical points on the Fermi surface, which correspond to saddle points of the dispersion relation. These points give rise to nontrivial contributions to the spectral and scattering behavior.

We further discuss extensions to matrix-valued operators, where refined estimates of the Green's function near Weyl points are essential.

Ngoc Nhi Nguyen, Université de Lille

Time: 11:30–12:30

Title: *Fermions in a magnetic field*

Abstract: In this talk, we will discuss some recent results on the spectral properties and effective dynamical for interacting fermionic systems in a magnetic field, in the mean-field regime. This is a joint work with Niels Benedikter (Milan), Chiara Boccato (Pisa) and Domenico Monaco (Rome).

Poster Abstracts

Tamim Al-Qaiwani, Constructor University Bremen

Title: *Exponential Decay in Discrete Systems with Application to Spontaneous Emission in Large Cavities*

Abstract: We study a class of Friedrichs Hamiltonians, that is, operators describing an excited state coupled to a bath through a rank-one perturbation, in the case where the bath Hamiltonian has purely discrete, yet "dense", spectrum. Under favourable conditions, we prove that the survival probability of the excited state decays in an approximately exponential manner. As an application, we treat a two-level atom coupled to a massless bosonic field in a large cavity in the rotating wave approximation.

Gandeeb Bhattarai, Gran Sasso Science Institute (GSSI)

Title: *Uniform Convergence of Spectral Distribution Functions for Mean-Field Quantum Dynamics*

Abstract: We consider fluctuations of bounded self-adjoint one-particle observables under the mean-field dynamics of bosonic N body systems, which define a self-adjoint operator-valued process $D_t^{(N)}$. The fluctuations D_t^N satisfy a CLT in the limit with variance of the limiting Gaussians given by Bogoliubov dynamics. We improve the CLT, which is a convergence in distribution result, to a type of uniform convergence in distribution result with uniformity in the time parameter.

Marco Bianchini, Gran Sasso Science Institute (GSSI)

Title: *Bose-Einstein condensation for two dimensional bosons beyond the Gross-Pitaevskii regime*

Abstract: We study Bose–Einstein condensation for interacting bosons on the two-dimensional torus, in regimes between Gross–Pitaevskii and the thermodynamic limit. Using a Schur-complement diagonalization, we separate microscopic and macroscopic correlations and prove condensation for ground and approximate ground states for $\kappa \in [0, 1/7)$, with optimal or quasi-optimal convergence rates and bounds on excitation numbers. Joint work with C. Brennecke, C. Caraci, S. Cenatiempo.

Alessandro Boldrini, University of Copenhagen

Title: *Dimensional Reduction and Low-Energy Excitations in Rotating Bose–Einstein Condensates*

Abstract: Bose–Einstein condensates under strong transverse confinement or cylindrical symmetry are expected to exhibit an effective lower-dimensional behavior. We study the dimensional reduction of three-dimensional Gross–Pitaevskii models in the presence of rotation and in the Thomas–Fermi regime, with the aim of deriving effective two-dimensional descriptions for both ground states and low-energy excitations. The main focus is the interplay between confinement, rotation, and interaction strength. In particular, the project aims to understand whether low-energy excitations are energetically more likely to produce vortices in the condensate profile or to populate Bogoliubov modes.

Pietro Falzoni, University of Genova

Title: *Probabilistic methods in the construction of Fermionic Euclidean free fields*

Abstract: Euclidean QFT offers powerful tools, yet Fermions pose challenges: anticommutation prevents classical interpretations and the link to Minkowskian theory via Wick rotation is less transparent. This work presents a rigorous Euclidean construction of Fermionic fields via non-commutative probability. Extending Osterwalder-Schrader and Nelson frameworks, it introduces a conditional expectation handling anticommutation, recovering Minkowskian covariance and offering a pathway to interacting models.

Daniele Ferretti, Ludwig-Maximilians-Universität München (LMU)

Title: *Effective Dynamics for Weakly Interacting Bosons in an Iterated High-Density Thermodynamic Limit*

Abstract: We investigate the dynamics of weakly interacting Bosons on a 3D torus of increasing volume. The coupling constant is supposed to be inversely proportional to the density, which is considered to be large. We take into account a class of initial states exhibiting quasi-complete Bose-Einstein condensation. We prove the convergence of the one-particle reduced density matrix towards the projection onto the order parameter describing the BEC in the iterated limit where volume and density are large.

Sascha Lill, University of Copenhagen

Title: *Momentum Distribution in a Dilute Fermi Gas - and Fermi Liquid Theory*

Abstract: Fermi Liquid Theory is an effective model conceived by Landau to predict the physical behavior of a fermionic gas using quasiparticles. Curiously, a mathematical proof of the existence of quasiparticles in a 3d Fermi gas is an open conjecture since decades, although the physics literature widely agrees on many predictions made via quasiparticles. This poster reports on recent findings on the momentum distribution of a Fermi gas, which are in support of the existence of quasiparticles.

Julien Malartre, Université Sorbonne Paris Nord

Title: *Coherent State Dynamics for the Spatially Cutoff $P(\phi)_2$ Model*

Abstract: We study the propagation of coherent states in self-interacting bosonic quantum field theories in the semiclassical regime for the spatially cutoff $P(\phi)_2$ model, under standard assumptions ensuring essential selfadjointness of the Hamiltonian. The classical field equation is a nonlinear Klein-Gordon equation, whose well-posedness constitutes the first step of our analysis. We then apply Hepp's method to obtain an asymptotic expansion of arbitrary order for the propagation of coherent states.

Diwakar Naidu, Univ. degli Studi di Milano

Title: *Momentum distribution of a Fermi gas with Coulomb interaction in Random Phase approximation.*

Abstract: I will talk about the momentum distribution of an interacting Fermi gas on a three dimensional torus in mean field regime in a trial state that reproduces the Gell-Mann-Brueckner prediction for the correlation energy for Coulomb potential. We show that the momentum distribution is a step function corrected by the random phase approximation as predicted by

Bohm-Pines for a class of potentials including the Coulomb potential. The key tool for deriving the distribution is a rigorous bosonization.

Filippo Perani, Politecnico di Milano (POLIMI)

Title: *Classical Limit of The Heisenberg Model*

Abstract: In this paper we study the Heisenberg model in a bosonic framework by means of the Holstein-Primakoff representation. In particular, we studied its classical regime (proved by Lieb in 1973 by means of Bloch coherent states). In the framework we used, the large spin limit behaviour of the dynamical interaction and the kinematical interaction has been studied. A geometric link between the classical phase that we obtained and the standard classical spin phase space has been derived too.

Denis Périce, Constructor University Bremen

Title: *Mean field limit of the Bose–Hubbard model with large coordination number*

Abstract: The Bose–Hubbard model effectively describes bosons on a lattice with on-site interactions and nearest-neighbour hopping, useful for understanding the superfluid-to-Mott-insulator phase transition. This poster will present results about the mean-field theory of this model, which is obtained in the large coordination number limit. Unlike the conventional many-body mean-field limit, this framework is compatible with strongly interacting particles.

Dominic Shillingford, University of Toronto

Title: *Weyl laws for interacting particles at positive temperature*

Abstract: We prove a positive-temperature semiclassical Weyl law for the grand-canonical reduced Hartree-Fock model. For confined fermions in $\mathbb{R}^3$ with repulsive positive-type interactions and general concave entropy, the rescaled grand potential converges to a positive-temperature Thomas-Fermi grand potential as $\hbar \to 0$.

Anne van Grinsven, University of Copenhagen

Title: *The ground state energy of dilute Bose gases on the cubic lattice: A second order upper bound*

Abstract: We study the dilute limit of a Bose gas on a cubic lattice with repulsive two-body interactions. We show the existence, uniqueness, and asymptotic expansion of the zero-energy scattering solution. Using a Gaussian trial state, we then prove an upper bound for the ground state energy density to Lee-Huang-Yang order in the thermodynamic limit for symmetric, summable potentials with compact support. Additionally, we outline progress towards the matching lower bound using von Neumann localisation.

Qiyun Yang, ENS de Lyon

Title: *Dimensional reduction for anyons in the average-field approximation*

Abstract: We study abelian anyons in the almost-bosonic regime, governed by the Chern–Simons–Schrödinger system. Introducing a strongly anisotropic trapping potential, we rigorously derive an effective 1D model from the original 2D dynamics by tracing out the tightly confined direction. The resulting dynamics is described by a defocusing quintic nonlinear Schrödinger equation. The derivation is justified for both ground state energies and time-dependent solutions.