Quantum Mathematics
Book of Abstracts for Scientific Talks

March 5-6, 2026

Abstract

The aim of the scientific meeting is to present recent developments in quantum mathematics, with a particular focus on many-body quantum problems and PDEs, seen as effective models. This meeting is being held to mark the creation of the new "BCAM Severo Ochoa Strategic Lab" on Quantum Mathematic in September 2025, headed by Niels Benedikter (University of Milan), Chiara Boccato (Università di Pisa) and Jean-Bernard Bru (BCAM and EHU). The workshop will in particular present associated research groups, with Serena Cenatiempo and her collaborators as special guests from Gran Sasso Science Institute (GSSI).

Contents

1 *March 5, Thursday*

Luis Vega, Basque Center for Applied Mathematics

Title: *Talbot effect and fractional dispersion.*
Schedule: 11h00-12h00
Abstract: We will explore how the energy of matter waves is transported according to the Quantum Talbot effect. Fin particular, we will also address issues related to the dispersive quantization in periodic media and how the energy is propagated. This is the so-called fractional Talbot effect, a phenomenon in which matter waves, such as electrons or atoms, exhibit periodic self-imaging when they pass through a periodic structure like a diffraction grating. It turns out that the energy concentrates at rational times with an intensity that depends on the rational, while at irrational times seems to be spread continuously. We will analyze the energy transport through fixed spatial intervals using regularized Dirac combs. The expected conjecture is that the statistics of the corresponding time series is governed by a compensated jump Levy process.

Nguyen Ngoc-Nhi, Université de Lille

Title: *Dynamics of fermions and semiclassical commutators estimates.*
Schedule: 12h00-12h45
Abstract: In this talk, we will discuss some recent results on the effective dynamical properties for interacting fermionic systems. I will try to emphasis the advances of the magnetic field case, based on a joint work with Niels Benedikter (Milan), Chiara Boccato (Pisa) and Domenico Monaco (Rome).

Sascha Lill, University of Copenhagen

Title: *Ground State Energy of a 2D Mean-Field Fermi Gas*
Schedule: 14h45-15h30
Abstract:We present recent work with Gregorio Casadei on a two-dimensional mean-field Fermi gas. For sub-Coulomb potentials, we prove an upper and lower bound for the correlation energy, which is the two-dimensional equivalent of the Gell-Mann–Brueckner formula, recently established by Benedikter, Porta, Schlein and Seiringer, as well as by Christiansen, Hainzl and Nam. Moreover, we provide an upper bound for a larger class of potentials that includes the Coulomb potential. While our general proof strategy follows the 3D case, we now face a larger relative coupling in two dimensions, which makes a more careful analysis of excitations at different momentum scales around the Fermi ball necessary.

Edoardo D'angelo, Università degli Studi di Milano

Title: *Vertex perturbations for the Luttinger model*
Schedule: 15h30-16h15
Abstract: The Luttinger model plays a central role in condensed matter physics, as it is believed that it captures universal features of a wide class of interacting, one-dimensional Fermi systems. It was solved by Mattis and Lieb in 1965 using bosonization, and its exact solvability makes

the model a natural starting point for studying perturbations of interacting one-dimensional systems. In this talk I discuss vertex perturbations of the Luttinger model, expressed as exponentials of bosonic fields. The main focus is on constructing a convergent perturbative expansion for the partition function. The expansion is formulated directly in terms of bosonic correlation functions, and relies on a thermal Wick theorem for vertex operators. Moreover, by adapting the iterated Mayer expansion to this setting, we establish the existence of the thermodynamic limit for the pressure.

Alan Ramer dos Santos, Mathematisches Institut der Universität München

Title: *Joule's Law for Free Fermions in Periodic Potentials*
Schedule: 16h45-17h30
Abstract: In this work we analyse the dynamics of non-interacting lattice fermions subjected to periodic static potentials and compactly supported time-dependent electromagnetic fields. In the limit of infinitely large supported electromagnetic fields (macroscopic limit), we derive Joule's law in the AC–regime. An important outcome is the extension of the notion of macroscopic AC–conductivity measure to free fermions in periodic potentials, known so far only for fermions within disordered media. Such excitation measures result from Bochner–Schwartz theorem together with the 2nd law of thermodynamics, where the latter corresponds to the passivity of thermal equilibrium states. We conclude by studying the properties of these measures.

Cornelia Vogel, Ludwig-Maximilians-Universität München

Title: *Normal Typicality and Dynamical Typicality for a Random Block-Band Matrix Model*
Schedule: 17h30-18h15
Abstract: We consider a closed macroscopic quantum system in a pure state evolving unitarily and take for granted that different macro states correspond to mutually orthogonal subspaces ("macro spaces") of the system's (high-dimensional) Hilbert space. We are interested in what the time evolution of the system's wave function looks like macroscopically, in particular, how much of it lies in a certain macro space. Two important related phenomena are the ones of normal typicality (a type of long-time behavior) and dynamical typicality (a type of similarity of the time evolution for initial states from a certain macro space). Here, we prove normal as well as dynamical typicality for a (centered) random block-band matrix model with block-dependent variances. A key feature of our model is that we achieve intermediate equilibration times, an aspect that has not been proven rigorously in any model before. Our proof builds on recently established concentration estimates for products of resolvents of Wigner-type random matrices and an intricate analysis of the deterministic approximation. This talk is based on joint work with László Erdős, Joscha Henheik, Stefan Teufel and Roderich Tumulka.

2 *March 6, Friday*

Théotime Pierrot, Gran Sasso Science Institute

Title: *Non-linear Landau levels of the almost-bosonic anyon gas.*
Schedule: 9h00-9h45
Abstract: In this talk I will introduce the topic of the anyon gas within its almost-bosonic extended framework. I will then focus on the usual N-body ground state and describe how to approximate it with the use of an effective magnetic Gross-Pitaevskii functional. The second part of the talk will be dedicated to the study the stability and the minimizers of the above mentioned functional. I will show that they belong to non-linear Landau levels and contain vortices. Overall, this talk will perform a review of recent mathematical results related to the almost-bosonic anyon gas.

Stefano Marcantoni, Gran Sasso Science Institute

Title: *Dynamics of open quantum systems under strong coupling*
Schedule: 9h45-10h30
Abstract: We consider the prototypical example of an open quantum system, that is a finite-level quantum system linearly coupled to a bosonic reservoir, and we study the dynamics of the finite system when the coupling constant tends to infinity. In particular, under mild assumptions on the interaction, we prove that the dynamics corresponds to a nonselective projective measurement followed by a unitary evolution generated by an effective (Zeno) Hamiltonian. The proof can be generalized to the case of a small system interacting with two reservoirs, when one of the couplings is finite and the other one tends to infinity. In this second scenario the reduced dynamics is richer and possibly non-Markovian. Joint work with Marco Merkli, Quantum 9, 1656 (2025).

Nathan Metraud, University of the Basque Country

Title: *Non-commutative evolution equation and application in many-body quantum theory.*
Schedule: 11h00-11h45
Abstract: We study the Brocket-Wegner flow, an evolution equation on non-commutative spaces of operators. It defines a nonlinear, operator-valued dynamics that is particularly delicate in the presence of unbounded operators. We discuss the main analytical difficulties arising from non-commutativity and unboundedness and show how they can be overcome in a specific class of intial data: quadratic fermionic Hamiltonians. In this case, despite unbounded initial data, intrinsic structures ensure well-posedness of the flow. Using this flow as a dynamical tool, we obtain new diagonalization results in many-body quantum theory (joint work with Jean-Bernard Bru).

Daniele Ferretti, Gran Sasso Science Institute

Title: *Effective dynamics of weakly interacting bosons at high density*
Schedule: 11h45-12h30
Abstract: We discuss the time evolution of weakly interacting Bose gases on a three-dimensional torus of arbitrary volume. The coupling constant is chosen to be the inverse of the density of

the system, which is considered to be large (and independent of the particle number). We focus on a class of initial states endowed with a coherent structure exhibiting quasi-complete Bose-Einstein condensation. For each fixed time in a finite interval, we prove the convergence of the one-particle reduced density matrix towards the projection onto the normalized order parameter describing the condensate – evolving according to the Hartree equation – in the iterated limit where the volume (and therefore the particle number), and subsequently the density go to infinity.

Umberto Morellini, Università di Pisa

Title: *Norm approximation of bosonic mean-field dynamics by quasifree evolution.*
Schedule: 14h30-15h15
Abstract: In this talk, I will consider the quantum many-body evolution of a homogeneous Bose gas in three dimensions in the mean-field scaling regime. I will study a class of initial data describing finitely many excitations over a quasi-stationary Bose-Einstein condensate. Using a rigorous version of Bogolyubov's theory, I will prove that the many-body evolution can be approximated in Fock space norm by a quasifree bosonic evolution of the excitations with an error which grows linearly in time. This talk is based on an ongoing work with Niels Benedikter (University of Milan) and Chiara Boccato (University of Pisa).

Jacob L. Barnett, Basque Center for Applied Mathematics

Title: *Conserved quantities in non-Hermitian many-body physics*
Schedule: 15h30-16h15
Abstract:

Non-Hermitian Hamiltonians are a ubiquitous feature of the linearized dynamics of open and dissipative systems. Even without the spectral theorem, qualitative aspects of the dynamics may be unveiled by determining the conserved quantities. Pauli found that conserved quantities correspond to solutions of a case of Sylvester's equation [0], which is a linear equation on the space of operators. A computational tool that reduces the number of elementary operations required to solve this equation when the Hamiltonians are of a Lie algebraic type was found in [1-4]. In this talk, I examine applications of this tool to four physically motivated settings and I discuss the extent to which it can be generalized to Leibniz algebraic contexts. These settings are: (i) Zeeman Hamiltonians, (ii) Heisenberg's picture, (iii) paraFermionic bilinear Hamiltonians, (iv) Translationally invariant systems.

[0] W. Pauli. Rev. Mod. Phys. 15.3 (1943): 175.
[1] C. M. Bender. Czech. J. Phys. 54 (2004) 1027.
[2] P. E. G. Assis and A. Fring. J. Phys. A 42 (2008) 015203.
[3] C. Quesne. J. Phys. A 40 (2007) F745.
[4] A. Mostafazadeh. Int. J. Geom. Methods Mod. Phys. 7.07 (2010): 1191.

Diwakar Naidu, Università degli Studi di Milano

Title: *Momentum distribution of a Fermi gas with the Coulomb interaction under the Random Phase Approximation.*
Schedule: 16h45-17h30
Abstract: I will talk about the momentum distribution of an interacting Fermi gas on a 3D torus in the mean field regime. The key tool for deriving the distribution is a rigorous bosonization method. I will start with the construction of a natural trial state and then show the implementation of the bosonization procedure. Finally, I will sketch how we obtain the momentum distribution in the mean field approximation, along with the novel bootstrap technique. The expression for the momentum distribution contains the contributions of collective excitations above the Fermi-surface going beyond the precision of Hartree-Fock theory. This result is an extension of the previous result for the momentum distribution by Benedikter-Lill.