TUE 10: Foundational / Mathematical Aspects – Rigorous Results

Time: Tuesday 14:15–16:15 Location: ZHG103

TUE 10.1 Tue 14:15 ZHG103

Classicality enforced by consistent value assignments — •Giuseppe Antonio Nisticò — University of Calabria, Rende, Italy

The problem of the "emergence of classicality", in rough synthesis, consists in explaining why "macroscopic" systems behave obeying classical laws rather than quantum laws. The present work pursues an approach to this problem alternative to the typical approaches in the literature. The basic step is to identify the deepest origin of non-classicality in the empirically ascertained impossibility of a simultaneous value assignment to all quantum observables. Specific macrosopicity conditions are introduced, which characterize the physical system as rigid homogeneous body. These conditions enforce the possibility of extending the value assignment provided by actually performed measurements to both the position and the velocity of the center of mass of the body, without loosing empirical and quantum theoretical consistency. This made possible by the use of the quantum concept of "evaluation" developed in [Int.J.Theor.Phys., 55 1798 (2016)]. Under regularity conditions for the interaction, it is proved that a center of mass trajectory can be consistently assigned by quantum theory, which satisfies the classical laws of motion.

TUE 10.2 Tue 14:30 ZHG103

In a closed universe, orbital angular momentum has non-integer values — •Daniel Burgarth[1] and Paolo Facchi[2] — [1]Friedrich Alexander University — [2]Bari University

We show that the spectrum of orbital angular momentum in quantum mechanics is the union of two parts when the underlying space has periodic boundaries. While the first part corresponds to the usual textbook integer quantized values, the second is a continuous band arising from the edge of space with respect to the center of rotation. The spectrum thus contains not only half-integer values (often thought impossible for orbital angular momentum), but even irrational ones. This effect is independent of the size of space. We argue that such spectral components would be invisible in the laboratory but might nonetheless have observable consequences on the cosmic scale.

TUE 10.3 Tue 14:45 ZHG103

Proof of the ionization conjecture for Engel-Dreizler atoms — •Heinz Siedentop — Mathematisches Institut, Ludwig-Maximilians-Universität München, Theresienstr. 39, 80333 München

We show that the number of electrons that an atom described by the relativistic density functional introduced by Engel and Dreizler is bounded uniformly in Z. The presentation is based on joined work with Rafael Benguria, Santiago, Chile.

TUE 10.4 Tue 15:00 ZHG103

Robust quantification of spectral transitions in perturbed quantum systems — Zsolt Szabó[1,2], Stefan Gehr[3], Paolo Facchi[4,5], Kazuya Yuasa[6], Daniel Burgarth[3], and •Davide Lonigro[3] — [1]School of Mathematical and Physical Sciences, Macquarie University, NSW 2109, Australia — [2]ARC Centre of Excellence for Engineered Quantum Systems, Macquarie University, NSW 2109, Australia — [3]Department Physik, Friedrich-Alexander-Universität Erlangen-Nürnberg, Staudtstraße 7, 91058 Erlangen, Germany — [4]Dipartimento di Fisica, Università di Bari, I-70126 Bari, Italy — [5]INFN, Sezione di Bari, I-70126 Bari, Italy — [6]Department of Physics, Waseda University, Tokyo 169-8555, Japan

A quantum system subject to an external perturbation can experience leakage between uncoupled regions of its energy spectrum separated by a gap. To quantify this phenomenon, we present two complementary results. First, we establish time-independent bounds on the distances between the true dynamics and the dynamics generated by block-diagonal effective evolutions constructed via the Schrieffer-Wolff and Bloch methods. Second, we prove that, under the right conditions, this leakage remains small eternally. That is, we derive a time-independent bound on the leakage itself, expressed in terms of the spectral gap of the unperturbed Hamiltonian and the norm of the perturbation, ensuring its validity for arbitrarily large times. Our approach only requires the existence of a finite spectral gap, thus accommodating continuous and unbounded spectra.

Based on arXiv:2505.19904.

TUE 10.5 Tue 15:15 ZHG103

Lie symmetries and ghost-free representations of the Pais-Uhlenbeck model — •Alexander Felski — Max Planck Institute for the Science of Light, Erlangen, Germany

Ghost-ridden quantum systems manifest in various forms. Typically, this means that parts of their spectra are not bounded from below or that they contain non-normalisable states, leading to a violation of unitarity. We investigate the Pais-Uhlenbeck model, a prominently ghost-ridden system and paradigmatic example of a higher time-derivative theory, by identifying the Lie symmetries of its associated fourth-order dynamical equation. Exploiting these symmetries in conjunction with the model's Bi-Hamiltonian structure, we construct distinct Poisson bracket formulations that preserve the system's dynamics. This allows us to recast the Pais-Uhlenbeck model in a positive definite manner, offering a solution to the long-standing problem of ghost instabilities. Furthermore, we systematically explore a family of transformations that reduce the Pais-Uhlenbeck model to equivalent first-order, higher-dimensional systems. Our approach yields a unified framework for interpreting and stabilizing higher time-derivative dynamics through a symmetry analysis.

TUE 10.6 Tue 15:30 ZHG103

Macroscopic Hall-Current Response in Infinite-Volume Systems — •Marius Wesle[1], Giovanna Marcelli[2], Tadahiro Miyao[3], Domenico Monaco[4], and Stefan Teufel[1] — [1]Universität Tübingen, Germany — [2]Università di Roma Tre, Italy — [3]Hokkaido University, Japan — [4]Sapienza Università di Roma, Italy

Given a 2-dimensional system of interacting fermions, the Hall-conductivity is defined as the linear response coefficient that is associated to the current induced in one direction when applying a homogeneous electric field in the perpendicular direction.

In this talk I will explain how in infinitely-extended periodic systems of interacting lattice fermions with a spectral gap, one can rigorously realise the linear response definition of the Hall-conductivity described above. By using the NEASS (Non-Equilibrium Almost-Stationary State) approach to linear response theory we can rigorously control the induced Hall-current, despite the fact that even a very small homogeneous electric field closes the spectral gap. Our proof recovers a many-body version of the double-commutator formula for the Hall-conductivity and shows, that the current response is purely linear with no polynomial corrections. It also allows for a simple argument that shows that the Hall-conductivity is constant within topological phases. This talk is based on arXiv:2411.06967.

TUE 10.7 Tue 15:45 ZHG103

Particle propagation bounds for bosonic lattice systems with long range interactions — •Carla Rubiliani[1], Marius Lemm[1], and Jingxuan Zhang[2] — [1]University of Tübingen, Germany — [2]Tsinghua University, China

We study the quantum time evolution of a system of bosons on a lattice generated by a long-range Hamiltonian with power-law decaying terms. We establish the first thermodynamically stable particle propagation bound in this setting, thus showing the finiteness of the speed of boson transport across the lattice. The main novelty in our proof is a multi-scale adaptation of the adiabatic space-time localisation observable method, which allows removing the dependence of the error term from far-away particles. Following this strategy, we were also able to control higher moments of the number operator. This opens the door to proving the first thermodynamically stable Lieb-Robinson bounds for bosonic systems with long-range hopping. This talk is based on arxiv:2310.14896

TUE 10.8 Tue 16:00 ZHG103

Quantum Incompatibility in Parallel *vs* Antiparallel Spins — Ram K Patra[1], •Kunika Agarwal[1], Biswajit Paul[2], Snehasish R Chowdhury[1], Sahil G Naik[1], and Manik Banik[1] — [1]Department of Physics of Complex Systems, S. N. Bose National Center for Basic Sciences, Block JD, Sector III, Salt Lake, Kolkata 700106, India — [2]Department of Mathematics, Balagarh Bijoy Krishna Mahavidyalaya, Balagarh, Hooghly-712501, West Bengal, India

We investigate the joint measurability of incompatible quantum observables on ensembles of parallel and antiparallel spin pairs. In parallel configuration, two systems are identically prepared, whereas in antiparallel configuration each system is paired with its spin-flipped counterpart. We demonstrate that the antiparallel configuration enables exact simultaneous prediction of three mutually orthogonal spin components*an advantage unattainable in the parallel case. As we show, this enhanced measurement compatibility in antiparallel configuration is better explained within the framework of generalized probabilistic theories, which allow a broader class of composite structures while preserving quantum descriptions at the subsystem level. Furthermore, this approach extends the study of measurement incompatibility to more general configurations beyond just the parallel and antiparallel cases, providing deeper insights into the boundary between physical and unphysical quantum state evolutions. To this end, we discuss how the enhanced measurement compatibility in antiparallel configuration can be observed on a finite ensemble of qubit states, paving the way for an experimental demonstration of this advantage.