FRI 10: Foundational / Mathematical Aspects – Unconventional Approaches

Time: Friday 10:45–12:45 Location: ZHG103

FRI 10.1 Fri 10:45 ZHG103

Particle-wave duality and quantization: Self-organisation of particle movement in zero-point field — •Christian Jooss — Institute of Materials Physics, University of Goettingen, Friedrich-Hund-Platz 1, 37077 Goettingen, Germany

The Göttingen physicist Friedrich Hund gave a fitting definition of quantum theory, namely as 'The theory of the role that h plays in nature'.[1] In this contribution, I discuss the Planck constant h as being an emergent quantity, reflecting the threshold between energy and momentum conserving random motions of particles in the Lorentz-invariant zero-point field and the lasting energy / momentum changes of quantum states. The analysis builts up on the analysis of the stochastic effects of a real zero-point field on particle motion[2], distinguishing reversible fluctuations which underly detailed energy balance and abrupt lasting changes in quantum state determined by h. Based on simple models of these processes, the emergence of particle-wave duality can be understood in terms of a self-organization effect, where the effect of the zero-point field on particle motion and its back reaction on zero-point fluctuations gives rice to the emergence of matter waves. Thus, existence of the quantum of action is interpreted as an expression of an organizational law[3]. The impact of this analysis on the realistic interpretation of quantum mechanics is discussed. References: [1] F. Hund, Geschichte der Quantentheorie, BI Wissenschaftsverlag 1975. [2] L. de la Pena and A. M. Cetto, The quantum dice: An introduction to stochastic electrodynamics, Kluwer Academic Publishers, 1996. [3] Ch. Jooss, Self-organization of Matter, de Gruyter 2020.

FRI 10.2 Fri 11:00 ZHG103

Quantum randomness revisited: simulating quantum measurement as a unitary time evolution — •Thomas Dittrich, Oscar Rodríguez, and Carlos Viviescas — Departamento de Física, Universidad Nacional de Colombia, Bogotá D.C., Colombia

Quantum measurement is usually regarded as incompatible with unitary time evolution, since the collapse of the wave packet breaks time reversal invariance. We challenge this view, studying quantum measurement as a unitary time evolution of the measurement object coupled to an environment that represents the meter and the apparatus. Modelled as a heat bath comprising only a finite, if large, number of boson modes, it is fully included in the time evolution of the entire system. We perform unitary numerical simulations of projective measurements of σz in spin-1/2 particles. They are prepared in a neutral pure state, the environment in a product of coherent states with centroids chosen at random from a thermal distribution. Initially, the spin gets entangled with the heat bath and loses coherence, reproducing the collapse. For large times and most of the initial states of the environment, the spin returns to a pure state, either spin up or spin down with equal probability, as definite outcome of the measurement. Unitarity allows us to run the simulations backwards from final state to preparation, undoing the measurement and tracing its result back to those initial conditions of the heat bath that entailed this result. That reveals the observed randomness as amplified quantum and thermal noise of the macroscopic environment. Extending our approach to an EPR setup is sketched as work in progress.

FRI 10.3 Fri 11:15 ZHG103

A heuristic solution to the time of arrival problem via mathematical probability theory — •Maik Reddiger — Anhalt University of Applied Sciences

There does currently not exist any scientific consensus on how to predict the probability that a single quantum particle impinges on an ideal detector in a given interval of time. The apparent simplicity of the problem is overshadowed by the deep conceptual discrepancies, which are exposed by the multitude of solutions proposed so far. Ab initio approaches need to model the ideal detector in such a manner, that it is compatible with quantum dynamics. A corresponding boundary condition for the Schrödinger equation was suggested by Werner in the 1980s, yet there is reason to question the physical validity of this detector model. In this talk I present an approach via mathematical probability theory and a physically natural adaption of the Madelung equations, which assures that the detector is perfectly absorbing. The presented solution is heuristic in the sense that a full solution would require a well-posedness result for the Cauchy problem of the corresponding system of PDEs for sufficiently regular initial data.

This solution of the time of arrival problem is obtained within the more general framework of geometric quantum theory. Geometric quantum theory is a novel adaption of quantum mechanics, which makes the latter consistent with mathematical probability theory.

FRI 10.4 Fri 11:30 ZHG103

Simultaneous processes in mechanics and quantum physics — •Grit Kalies[1] and Duong D. Do[2] — [1]HTW University of Applied Sciences, Dresden, Germany — [2]The University of Queensland, Brisbane, Australia

Processes change the properties of objects. Using examples such as the lifting, acceleration or displacement of a body as well as of a quantum object, we substantiate the plausibility and advantages of replacing 'force is action' with 'process is action'. Since each process with energy transfer describes the change in one property of a macroscopic or microscopic object, simultaneous processes allow for a more detailed energetic analysis than forces. The notion of acting forces and the current general definition of work are interpreted as helpful geometric substitute concepts, which conceal the actual dynamic processes such as the momentum work that takes place at the macroscopic and quantum levels.

FRI 10.5 Fri 11:45 ZHG103

Plasma-like description for quantum particles — •Andrey Akhmeteli — LTASolid Inc., Houston, Texas, USA

A scalar complex wave function can be made real by a gauge transformation (Schrödinger, Nature, 1952). Similarly, one real function is also enough to describe matter in more realistic theories, such as the Dirac equation in an arbitrary electromagnetic (Akhmeteli, J. Math. Phys., 2011, Eur. Phys. J. C, 2024) or Yang-Mills (A., Quantum Rep., 2022) field. As these results suggest some "symmetry" between positive and negative frequencies and, therefore, particles and antiparticles, one-particle wave functions can be described as plasma-like collections of a large number of particles and antiparticles (A., Eur. Phys. J. C, 2013, Entropy, 2022). The similarity of the dispersion relations for the Klein-Gordon equation and a simple plasma model provides another motivation for the plasma-like description of quantum particles.

The criterion for approximation of continuous charge density distributions by discrete ones with quantized charge is based on Gaussian smoothing (A., arXiv:2503.10667). A discrete distribution satisfying this criterion can be found for any smooth distribution. An example mathematical model of the interpretation is proposed.

The plasma-like description can offer an intuitive picture of the uncertainty principle, the double-slit experiment, and negative probabilities. Wave function spreading is not problematic for the model. Any experimental results that can be described using one-particle wave functions can be emulated using the plasma-like description.

FRI 10.6 Fri 12:00 ZHG103

Pinning quantum particles to surfaces and curves: a momentum operator- based approach — •Mohammad Shikakhwa — Department of Basic Sciences, TED University, Ziya Gökalp Caddesi No.48, 06420, Kolej - Çankaya, Ankara, Turkey

A physical, intuitive approach is proposed to confine a spin zero particle in 3D to arbitrary surfaces and curves embedded in the 3D space through the introduction of strong confining potential(s). The idea is to start from the onset with the Hamiltonian expressed in terms of the Hermitian *components* of the momentum operator and achieve confinement to the lower dimensional manifolds by dropping these Hermitian components that are normal to these manifolds along with setting the corresponding normal coordinates to zero. The resulting Hamiltonian, expressed now in terms of the manifold momenta along with a geometrical potential is a Hermitian operator. The resulting manifold momenta are at the kinematical ones proportional to the velocity of the particle on these manifolds.

FRI 10.7 Fri 12:15 ZHG103

Two quantum analogies — •Ryszard Wojnar — Institute of Fundamental Technological Research PAS

In the first analogy, the diffusion equation with an imaginary diffusion coefficient D=ih/2m is considered. The solutions are harmonic functions decaying in time. The disappearance time of a wave packet is proportional to m/h: for an electron of the order of seconds, for a mass of 1 g of the order of 10^10 years.

The second analogy refers to the hexatic transformation. The change in the contact of the particles participating in the transformation leads to either the creation or annihilation of dislocations 5-7, formations distinguished against the background of the hexagonal lattice.

FRI 10.8 Fri 12:30 ZHG103

Volume Portions Provide the Quantum Postulates and Exact Quantum Frames For Space Navigation — •Hans-Otto Carmesin — Universität Bremen, Fachbereich 1, Postfach 330440, 28334 Bremen — Studienseminar Stade, Bahnhofstr. 5, 21682 Stade — Gymnasium Athenaeum, Harsefelder Straße 40, 21680 Stade

A space paradox shows that space is an average of microscopic volume portions. These imply the quantum postulates, as well as gravity and curvature in spacetime. It is very valuable and insightful that the volume portions show how the quantum postulates are derived from spacetime and how they are applied to spacetime: In this manner, exact quantum frames of spacetime are derived and exact space navigation is enabled for the first time (Carmesin 2025). Predictions are derived, have been tested empirically, and can additionally be tested by space flights in various manners.

[1] Carmesin, H.-O. (2025): On the Dynamics of Time, Space and Quanta - Essential Results for Space Flight and Navigation. Berlin: Verlag Dr. Köster.