MP 8: Poster Session

Time: Wednesday 18:00–18:45 Location: Redoutensaal

MP 8.1 Wed 18:00 Redoutensaal

Newton Revisited: Modifications and Practical Insights into Classical Mechanics — •Amritpal Singh Nafria — IEC University

This paper challenges the foundational principle of applied force in classical mechanics by systematically addressing the limitations of Newton's second law in real-world scenarios. It demonstrates that the standard formulation is insufficient for accurate prediction when non-conservative forces are present.

Through a series of innovative experiments and detailed theoretical analyses, the work quantitatively reveals significant discrepancies between ideal theoretical predictions and empirical observations. The investigation meticulously accounts for the effects of friction and air resistance, and extends the analysis to consider celestial variations across different planetary environments.

The study employs advanced methodologies, including the use of weighing scales for the direct measurement of resistance forces. It integrates calculations across a wide spectrum of contexts, from terrestrial conditions to the low-gravity environment of Pluto, thereby providing a comprehensive and nuanced view of force dynamics.

The findings underscore the critical necessity for refined mechanical models that explicitly incorporate resistance effects. This work establishes a framework for more accurately predicting and managing force interactions in practical engineering and physics applications, paving the way for more effective force measurement and application techniques in both terrestrial and extraterrestrial environments.

MP 8.2 Wed 18:00 Redoutensaal

Addition of relativistic velocities with arbitrary directions in four-dimensional space — •Roland Alfred Sprenger — Herford, Germany

A vectorial construction method for adding relativistic velocities with arbitrary directions is presented and justified. Without using oblique Minkowski diagrams with scale changes, but using an additional auxiliary dimension, vector addition is performed purely geometrically in a four-dimensional Euclidean space and projected back into three-dimensional real space. This forces all velocities to be limited to the speed of light purely geometrically. The auxiliary dimension represents the time component of the motion geometrically and has no independent physical dynamics. The approach is completely equivalent to special relativity and offers an alternative geometric perspective on the role of time in relativistic motions.

MP 8.3 Wed 18:00 Redoutensaal

Testing Non-Commutative Spacetime and Dark Matter Coupling via X-Ray Binary QPO Observations — •Batuhan Çil[1,2] and Ertan Güdekli[3] — [1]Faculty of Sciences and Literature, Department of Mathematics, Haliç University, Istanbul 34060, Turkey — [2]Graduate School of Engineering and Science, Istanbul University, Istanbul 34134, Turkey — [3]Department of Physics, Istanbul University, Istanbul 34134, Turkey

This study investigates the orbital dynamics and quasi-periodic oscillations (QPOs) of test particles around a charged non-commutative Schwarzschild black hole immersed in perfect-fluid dark matter (PFDM). Using the effective-potential formalism, we derive the specific energy, angular momentum and ISCO radii as functions of α, β and Q. PFDM introduces logarithmic corrections to the metric, while non-commutativity smooths the near-horizon geometry and shifts the epicyclic frequency profiles inward. We also compare the model with QPO data from four X-ray binaries via MCMC, obtaining bounds on α, β and Q and showing that PFDM and non-commutative effects leave observable signatures in strong-field QPO behaviour.

MP 8.4 Wed 18:00 Redoutensaal

Symmetry-breaking constraints from higher-group structure in axion electrodynamics — •Timo Schulze — II. Institut für Theoretische Physik, Universität Hamburg

Over the past decade, generalised symmetries have opened a new perspective on global symmetries by describing them in terms of higher categorical structures. In a d-dimensional QFT, a q-form symmetry is generated by topological defects supported on closed $(d-q-1)$-manifolds, acting on q-dimensional charged operators. In axion electrodynamics, electric and magnetic 1-form symmetries as well as axionic 0- and 2-form symmetries can combine into a higher-group structure. Building on previous work by Brennan and Cordova, we study and attempt to formalise how higher-group data constrain the order of emergence of these symmetries along RG flows. We suggest further constraints on explicit breaking terms for both electric and magnetic 1-form symmetries below the breaking scale of the axionic 0-form shift symmetry. In particular, this implies that magnetically charged probe particles below that scale must also be electrically charged.

MP 8.5 Wed 18:00 Redoutensaal

An Algorithm with Positive Geometry and Polynomials $P(2\pi)$ for Elementary Particle Physics — •Helmut Schmidt — Grasbrunn, Germany

The new field of positive geometry draws on algebraic geometry, which describes shapes and spaces by solving systems of polynomial equations. The neutron mass $m_{Neutron}/m_e = (2\pi)^4 + (2\pi)^3 + (2\pi)^2 - (2\pi)^1 - (2\pi)^0 - (2\pi)^{-1} + 2(2\pi)^{-2} + 2(2\pi)^{-4} - 2(2\pi)^{-6} + 6(2\pi)^{-8} = 1838.6836611$ is accurate to 10 decimal places. The formula can be divided into 3 objects, each with 3 spatial coordinates and a common time. The first term corresponds to 3 gluons. The second term contains two electrons and a superposition of the quarks u and d. The third term contains the detection in the measuring device in the form of a cascade with streams of electrons. The proton mass m_P/m_e differs from that of the neutron $E_{C+} = -\pi^1 + 2\pi^{-1} - \pi^{-3} + 2\pi^{-5} - \pi^{-7} + \pi^{-9} - \pi^{-12} - 2\pi^{-14}$ and contains the binding energy, or charge. The electron is weightless with $(2\pi) = 1$ and is the center for a circular inversion of all other particles. For each of the three spatial dimensions, the torque and angular momentum are conserved with $2\pi c$. From this, an algorithm is developed that describes the rest masses and standard deviations of all elementary particles, with the symmetries for matter/antimatter, attraction/repulsion, and creation and annihilation. The Earth's diameter, sidereal time, and synodic time are the required parameters. $2\pi c\ m\ day = D_{equatorial\ Earth\ diameter}{}^2$

MP 8.6 Wed 18:00 Redoutensaal

Modeling and simulation of diffraction efficiency growth during holographic grating recording — •Alexei Meshalkin, Elena Achimova, Vladimir Abaskin, Veronica Cazac, Constantin Losmanschii, and Vladislav Botnari — Institute of Applied Physics, Moldova State University, Chisinau, Moldova

This work presents theoretical and numerical studies on the modeling of wave propagation and light matter interaction during the recording of holographic diffraction gratings. The simulations focus on the evolution of diffraction efficiency as a function of the grating profile, spatial period, and phase-relief depth. Numerical modeling was implemented in MATLAB using the Angular Spectrum Method for light propagation, where all grating parameters were defined based on corresponding experimental data. The obtained simulation results were compared with experimental measurements for holographic gratings recorded in thin films of azopolymers and chalcogenide amorphous materials. A good correlation between the simulated and measured diffraction efficiencies confirms the applicability of the proposed numerical model for describing holographic recording processes. Moreover, the developed approach enables solving the inverse problem: determining grating parameters from measured diffraction efficiency.

MP 8.7 Wed 18:00 Redoutensaal

Speed Limits from Symmetries in Quantum Control — •Marco Weidmann[1], Santana Lujan[1,2], and Daniel Burgarth[1] — [1]Friedrich-Alexander Universität Erlangen-Nürnberg — [2]German Aerospace Center (DLR)

We present lower bounds on the time needed to implement any given unitary operation in a given control system. The bound crucially depends on the size of the minimal perturbation to the control system that renders the target operation unreachable. This reachability analysis is carried out using the tools of geometric control theory, which are deeply rooted in the theory of Lie Algebras and their commutants. Using Semidefinite programming (SDP) and gradient optimization techniques, we calculate the smallest perturbation that increases the dimension of the commutant of the tensor-square representation.

MP 8.8 Wed 18:00 Redoutensaal

Self-adjoint extensions of the higher order Rabi model — •Felix Knapp and Davide Lonigro — Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU), Erlangen, Germany

The quantum Rabi model is a paradigmatic system for studying light–matter interactions, describing the linear coupling between a two-level system and a single bosonic mode. In this work, we investigate higher-order quantum Rabi models of the form

$$\omega a^\dagger a + g\big((a^\dagger)^k + a^k\big)\sigma_x + \Delta\sigma_z,$$

where the interaction term is nonlinear in the bosonic creation and annihilation operators. The operator is defined on a natural dense domain given by finite photon-number states tensored with the two-level system. By analyzing the deficiency indices, we show that for $k \geq 3$ the operator is not essentially self-adjoint on this domain and explicitly characterize its self-adjoint extensions. Moreover, we prove that the spectrum of this operator is purely discrete.