TUE 3: Quantum Field Theory

Time: Tuesday 14:15–16:00 Location: ZHG003

TUE 3.1 Tue 14:15 ZHG003

Photonic simulation of quantum field dynamics — •Mauro D'Achille[1], Martin Gärttner[1], and Tobias Haas[2] — [1]Friedrich-Schiller-Universität Jena — [2]Universität Ulm

Photonic multimode systems are an emerging quantum simulation platform ideally suited for emulating non-equilibrium problems in quantum field theory.

I will present a new decomposition for the time evolution generated by a large class of field-theoretic quadratic Hamiltonians in terms of optical elements. The peculiarity of this decomposition consists in the way the time parameter is taken into account. Indeed, for such a class, it is always possible to decouple the time evolution in time-dependent phase shifters by means of a proper time-independent symplectic transformation composed by squeezers and beam splitters.

I will conclude with physically relevant examples and applications aimed to analyze and simulate how the entanglement entropy associated to local and non-local theories spreads over time.

TUE 3.2 Tue 14:30 ZHG003

Topologically Charged Vortices at Superconductor/Quantum Hall Interfaces — •Enderalp Yakaboylu and Thomas L Schmidt — Department of Physics and Materials Science, University of Luxembourg, L-1511 Luxembourg

We explore interface states between two paradigmatic mesoscopic many-body quantum phases: a type-II s-wave superconductor (SC) and a Chern insulator in the $\nu = 1$ quantum Hall (QH) regime. We show that effective interactions at the SC/QH boundary give rise to two emergent Abelian Higgs fields, representing paired electrons localized at the interface. These fields couple through a Chern-Simons term originating from the QH sector, which induces a topological mass for photons and imparts a fractional topological charge to the interface vortices. These findings, particularly the emergence of vortices carrying fractional charge, corresponding to Abelian anyons, bridge topological condensed matter physics and quantum information science, suggesting a new platform for engineering anyonic excitations and advancing toward fault-tolerant topological quantum computation.

TUE 3.3 Tue 14:45 ZHG003

Quark confinement due to unified magnetic monopoles and vortices reduced from symmetric instantons with holography — •Kei-Ichi Kondo — Chiba University, Chiba 263-8522, Japan

We present a new rigorous scheme for understanding quark confinement based on the non-perturbative vacuum disordered by some topological defects. We start from the 4-dim. Euclidean Yang-Mills theory and require the conformal equivalence between the 4-dim.Euclidean space and the possible curved spacetimes with some compact dimensions. This requirement forces us to restrict the gauge configurations of 4-dim.Yang-Mills instantons to those with some space symmetries (called symmetric instantons) which are identified with magnetic monopoles and vortices living in the lower-dimensional curved spacetime with non-zero curvature through the dimensional reduction. The new scheme gives the direct built-in equivalence between (3-dim.hyperbolic) magnetic monopoles (of Atiyah type) and (2-dim.hyperbolic) vortices (of Witten-Manton type), which have been assumed without any rigorous proof to be the dominant contributors to quark confinement. This unified treatment of two topological defects is shown to give the semi-classical picture for quark confinement in the sense of Wilson. At the same time, this scheme caused by the dimensional reduction give a holographic description of magnetic monopole dominance on AdS3 in the rigorous way without any further assumptions. Moreover, the asymptotic freedom is also shown to be derived by performing the pertutbative deformation on the vacuum with these topological defects. [Paper in preparation to be submitted to ArXiv]

TUE 3.4 Tue 15:00 ZHG003

Spinorial Superspaces and Supersymmetric Yang-Mills Theories — •Johannes Moerland — University of Göttingen

In physics literature about supersymmetry, many authors refer to "super Minkowski spaces". These spaces are extensions of ordinary Minkowski spaces by spinorial directions. More abstractly, super Minkowski spaces are affine supermanifolds (i.e., locally ringed spaces with a $\mathbb{Z}_2$-graded algebra of functions) with distinguished spin structures.

In this talk, we formalise these spin structures, allowing us to generalise the setup to curved supermanifolds. Apart from the possibility of formulating field theories on topologically non-trivial superspaces, our approach bears two advantages: Firstly, the language of graded geometry allows for a global and inherently coordinate-free formulation of field theories on the superspace. Secondly, the approach to superspaces via graded geometry endows many algebraic manipulations with a concise geometric meaning. For example, the Dirac γ matrices can be identified with the torsion of the superspace along the spinorial directions.

After exploring the geometric properties of spinorial superspaces, we apply the rather general theory to $\mathcal{N} = 1$ super Yang-Mills theories on curved superspaces of space-time dimensions 3 and 4 and show that the effective theory on an embedded ordinary space-time manifold, obtained by integrating over the spinorial directions, reproduces a coupled system of Yang-Mills and twisted Dirac Lagrangians.

TUE 3.5 Tue 15:15 ZHG003

A short review of the worldline approach to strong-field QED — •Christian Schubert — Facultad de Ciencias Físico-Matemáticas, Universidad Michoacana de San Nicolás de Hidalgo, Avenida Francisco J. Mújica, 58060 Morelia, Michoacán, Mexico

The worldline formalism offers an alternative to the standard Feynman diagram approach in QED that has been found particularly efficient for processes in external field, primarily because it avoids the segmenting of fermion lines or loops into individual propagators. Here I will give a short summary of the method and its present range of applications, with examples ranging from Schwinger pair creation in various types of electric fields to photon-graviton conversion in a magnetic field.

TUE 3.6 Tue 15:30 ZHG003

Measurement of the Casimir force during free fall — •Sascha Kulas — International University of Applied Sciences (IU), Hannover, Germany

The Casimir force still has a lot of unknown aspects. Here this force is measured in a tuning fork experiment during free fall and compared with a measurement on ground. It seems like the Casimir force is strongly suppressed during fall. This is a hint that the Casimir force does not have its origin in the Van der Waals force, which would not change in reduced gravity. Independent drop tower experiments have to validate these results. Further conclusions concerning gravity and Dark Energy are raised by establishing a first phenomenological approach based on the measurement results and Verlindes entropic gravity. The main conclusion is that Dark Energy is coupled to baryonic matter.

TUE 3.7 Tue 15:45 ZHG003

Forward Physics at the LHC — •Rainer Schicker — Phys. Institute, Heidelberg University

Quantum-Chromodynamics (QCD) was formulated 50 years ago as a gauge theory for describing the interaction between quarks and gluons. The underlying SU(3) symmetry of the color degree of freedom leads to self-couplings of gluons, which results in two very intriguing features of QCD, confinement and asymptotic freedom. A perturbative treatment of QCD processes is only possible for large momentum transfers Q^2. The nonperturbative sector of QCD still carries many mysteries which are very poorly understood, or not at all. Many of these enigmas reveal their nature in soft interactions which are experimentally accessible in forward and very forward measurements at the LHC.

I will outline how future forward measurements at the LHC could contribute to shed light on the many unsolved mysteries of nonperturbative QCD.