MP 4: Quantum field theory, AdS/CFT, non-equilibrium and quantum dynamics

Time: Tuesday 16:15–18:35 Location: MP-H5

MP 4.1 Tue 16:15 MP-H5

Wormholes from Berry phases in AdS_3/CFT_2 — Souvik Banerjee, Moritz Dorband, Johanna Erdmenger, René Meyer, and •Anna-Lena Weigel — Institute for Theoretical Physics and Astrophysics and Würzburg-Dresden Cluster of Excellence ct.qmat, Julius-Maximilians-Universität Würzburg, Am Hubland, 97074 Würzburg, Germany

The AdS/CFT correspondence states that certain CFTs admit a description in terms of a gravitational theory in asymptotically AdS geometries of one dimension more. A central question in understanding the mechanism behind the duality is how the geometry in the bulk spacetime is encoded in the dual CFT state. Berry phases present a useful tool for understanding this. In their most general form, Berry phases are geometric phases acquired by states due to the presence of holonomies when parallel transported around a closed loop in parameter space. The AdS/CFT correspondence admits the description of bulk geometries with semi-classical spacetime wormholes in terms of two entangled CFTs. Wormholes are a topological feature of the bulk spacetime that presents as a holonomy and thus can be probed with Berry phases. The entanglement induced by the wormhole in the bulk geometry implies the dual CFTs no longer factorize. We show that non-factorization in the dual entangled CFTs is evident in Berry phases for such systems. We briefly discuss further applications of Berry phases for probing spacetime holonomies in geometries without wormholes and their CFT interpretation.

MP 4.2 Tue 16:35 MP-H5

Quantum Complexity as Hydrodynamics — •Pablo Basteiro[1,2], Johanna Erdmenger[1,2], Pascal Fries[1], Florian Goth[1,2], Ioannis Matthaiakakis[1,2], and René Meyer[1,2] — [1]Institut für Theoretische Physik und Astrophysik, Julius-Maximilians-Universität Würzburg, 97074 Würzburg, Germany — [2]Würzburg-Dresden Cluster of Excellence ct.qmat

In recent years, many concepts of quantum information theory have been introduced to the AdS/CFT correspondence and have lead to several meaningful insights. In particular, quantum computational complexity has been suggested as a candidate to describe the late-time behavior of black hole interiors. We contribute to its understanding by considering Nielsen's geometric approach to operator complexity for the $SU(N)$ group. We develop a tractable large N limit which leads to regular geometries on the manifold of unitaries. To achieve this, we introduce a particular basis for the $\mathfrak{su}(N)$ algebra and define a maximally anisotropic metric with polynomial penalty factors. We implement the Euler-Arnold approach to identify incompressible inviscid hydrodynamics on the two-torus as a novel effective theory for the evaluation of operator complexity of large qudits. We discuss the resulting complexity geometry in view of essential properties of holographic complexity measures, such as ergodicity and conjugate points.

MP 4.3 Tue 16:55 MP-H5

The free energy of the two-dimensional dilute Bose gas — •Andreas Deuchert[1], Simon Mayer[2], and Robert Seiringer[2] — [1]Institute of Mathematics, University of Zurich — [2]Institute of Science and Technology Austria (IST Austria)

We prove bounds for the specific free energy of the two-dimensional Bose gas in the thermodynamic limit. We show that the free energy at density ϱ and inverse temperature β differs from the one of the non-interacting system by the correction term $4\pi\varrho^2|\ln(a^2\varrho)|^{-1}(2-[1-\beta_c/\beta]_+^2)$. Here a is the scattering length of the interaction potential, $[x]_+ = \max(0,x)$ and β_c is the inverse Berezinskii–Kosterlitz–Thouless critical temperature for superfluidity. The result is valid in the dilute limit $a^2\varrho \ll 1$ and if $\beta\varrho \gtrsim 1$.

MP 4.4 Tue 17:15 MP-H5

Analytical and numerical methods for nonlinear diffusive transport and shock acceleration — •Dominik Walter[1], Horst Fichtner[1], Frederic Effenberger[1], and Yuri Litvinenko[2] — [1]Ruhr-Universität-Bochum; Institut theoretische Physik IV — [2]University of Waikato, Department of Mathematics, New Zealand

We explore a nonlinear diffusive type of particle/cosmic ray transport. A special focus will be put on particles/cosmic rays, escaping from a shock or other localized acceleration sites and their acceleration process. Instead of solving coupled differential equations, as is the more common method of describing the interaction of diffusing particles with the backgrond medium, we analyse a single nonlinear advection-diffusion equation. In a first step we analyse the effect of the nonlinear model on particle transport, we apply an analytical expansion technique to cartesian and spherical symetrical geometries, to derive approximate solutions to the resulting equations and establish numerical models to compare and expand on this results. As a foundation for the numerical models we use the grid based Code VLUGR3, to provide numerical solutions, when there is no analytical way of solving distinct models. As a second step we construct a model for shock acceleration, to investigate the impact of nonlinear diffusion on shock acceleration, again using VLUGR3. We recreate a linear cartesian case of reference and use it as a groundwork to investigate the effects of nonlinearity.

MP 4.5 Tue 17:35 MP-H5

Electrons and their interactions: A deduction from Quantum Field Theory — •Nadine Cetin and Nils Schopohl — Institut für Theoretische Physik, Universität Tübingen, Auf der Morgenstelle 14, 72076 Tübingen

We suggest a new unitary transformation of the fundamental electron-positron field theory Hamiltonian of Quantum Electrodynamics (QED), that brings with help of Wegner's flow equation method this Hamiltonian to a block-diagonal form, each block labeled by an eigenvalue of the operator $\hat{N} = \hat{N}^{(e)} + \hat{N}^{(p)}$, with $\hat{N}^{(e)}$ counting the number of electrons and $\hat{N}^{(p)}$ counting the number of positrons, while keeping all interactions with with long wavelength photons $\lambda_{ph} \gg \frac{h}{m_e c}$ intact. A representation of that block-diagonal Hamiltonian as a perturbation series with regard to the fine structure constant $\alpha_{FS} \approx \frac{1}{137}$ establishes to order α_{FS}^2 the well known gauge invariant and particle number conserving Hamiltonian for nonrelativistic electrons and positrons in its second quantized guise. Our derivation of the effective two-particle interactions between particles carrying mass, charge and spin while moving at nonrelativistic speed arises directly from QED throughout treating electron fields and positron fields in an entire symmetrical fashion. Similarities and salient contrast with related early work of Cohen-Tannoudji et al., Takashi Itoh and I. Bialynicki-Birula are discussed in detail.

MP 4.6 Tue 17:55 MP-H5

Recenr Results on Quantum Spin Glasses — •Chokri Manai[1], Simone Warzel[1], Hajo Leschke[2], and Rainer Ruderer[2] — [1]Department of Mathematics, TU München, Garching bei München, Germany — [2]Institut für Theoretische Physik, FAU Erlangen, Erlangen, Germayn

In the past few decades, the theory of spin glasses has become a major field of interest in condensed matter physics, mathematical physics and proabbility theory. While in the classical spin glass theory many problems remain unsolved, at least a rough understanding of the underlying physics has been established. The milestone so far has been the derivation of a formula for the free energy in the classical Sherrington-Kirkpatrick model by this year's Nobel price winner Giorgio Parisi based on his replica method and its rigorous proof by Guerra and Talagrand.

The situation is vastly different for quantum spin glasses, where quantum effects are for example incorporated via a transversal field. In this case no closed formula has been found for the Quantum SK-model; and most physical results are based on numerical simulations. In this talk, I will give an introduction to the topic of quantum spin glasses. I will discuss recent results on hierarchical Quantum spin glasses, where one can rigorously prove a formula for the free energy. Moreover, we will have a quick look on the Quantum SK model, where one can at least prove the existing of replica symmetry breaking.

MP 4.7 Tue 18:15 MP-H5

Local composite operators in the Sine-Gordon model — Daniela Cadamuro and •Markus B. Fröb — Institut für Theoretische Physik, Universität Leipzig

The Sine-Gordon model is a widely studied two-dimensional quantum field theory, which depending on the value of the coupling β is finite (for $\beta^2 < 4\pi$), super-renormalizable ($4\pi \leq \beta^2 < 8\pi$) or just renormal-

izable ($\beta^2 = 8\pi$). However, local composite operators have not been studied in the theory, apart from a few simple examples. We show that even in the finite range $\beta^2 < 4\pi$ composite operators need additional renormalization beyond the free-field normal-ordering at each order in perturbation theory, and prove convergence of the renormalized perturbative series.