7th SwissMAP General Meeting

6-9 September 2020 – Golfhotel "Les Hauts de Gstaad"
(Saanenmöser)

Colloquium Talks

Nicolas GISIN (University of Geneva)

Title : *Indeterministic Physics and Intuitionistic Mathematics*

Abstract : *Physics is formulated in terms of timeless axiomatic mathematics. However, time is essential in all our stories, in particular in physics. For example, to think of an event is to think of something in time. A formulation of physics based of intuitionism, a constructive form of mathematics built on time-evolving processes, would offer a perspective that is closer to our experience of physical reality and may help bridging the gap between static relativity and quantum indeterminism.*

Historically, intuitionistic mathematics was introduced by Brouwer with a very subjectivist view where an idealized mathematician continuously produces new information by solving conjectures. Here, in contrast, I'll introduce intuitionism as an objective mathematics that incorporates a creative time and an open future. Standard mathematics appears as the view from the "end of time" and the usual real numbers appear as the hidden variables of classical physics.

Grigory MIKHALKIN (University of Geneva)

Title : *Ellipsoid of golden section and its symplectic geometry*

Abstract : *Symplectic varieties naturally appear as phase spaces of mechanical dynamical systems. The question of embeddability of one open symplectic variety into another is one of the central symplectic problems initially advanced from scratch by Gromov's symplectic non-squeezing theorem of 1985 (providing us with the Gromov-Witten invariants as a byproduct). It is also known as the symplectic packing problem.*

In 2012 McDuff and Schlenk have obtained a breakthrough result completely solving the symplectic packing of a 4-dimensional ellipsoid into a 4-ball revealing a beautiful and unexpected answer now known as the Fibonacci staircase going back to the Diophantine equation discovered by Markov in 1879. The answer has a phase transition precisely at the golden section ellipsoid, the one obtained from the ellipses with the semi-major axis \tau and the semi-minor axis 1/\tau. Recent research has shown that ellipsoids of smaller eccentricity are particularly interesting since they are responsible for various symplectic and Lagrangian exotic phenomena (intrinsically linked to Markov's triples of integers).

Alba GRASSI (CERN /University of Geneva)

Title : *A geometric approach to black holes spectral theory*

Abstract : *In general, it is difficult to find analytic solutions in spectral theory of quantum mechanical operators. Nevertheless it has been recently recognised that a geometric perspective of spectral theory often provides us with many useful tools, developed in supersymmetric gauge theories and topological string theory, to obtain exact solutions for new families of quantum spectral problems.*

In the first part of the talk I will review the main ideas beyond such geometric approach to spectral theory, while in the second part I will present some applications to black holes physics. More precisely, I will focus on black holes quasinormal modes. These correspond to resonance states (or dissipative modes) in quantum mechanics and are responsible, for example, for the damped oscillations appearing the ringdown phase of two merging black holes.

Vincent TASSION (ETH Zurich)

Title : *Russo-Seymour-Welsh theory for planar percolation*

Abstract : *Originally introduced to describe porosity, percolation models have found applications in many branches of statistical mechanics. For example, percolation connectivity properties can be used to analyze correlations in Ising model. In the eighties, Russo, Seymour and Welsh obtained general bounds on crossing probabilities for planar Bernoulli percolation, one of the most studied percolation model. These inequalities rapidly became central tools to analyze the critical behavior of the model in dimension 2. For many years, the Russo-Seymour-Welsh theory only applied to a very restricted class of models with strong independence properties.*

In this talk, I will first discuss the known theory for Bernoulli percolation, and then present recent progress extending the theory to a large framework, and leading to the rigorous resolution of long-standing open problems in percolation theory and spin systems. This talk is based on joint works with Hugo Duminil-Copin, Laurin Köhler-Schindler and Vladas Sidoravicius.

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Innovator Prize Winner's Talks

Fiona Seibold (ETH Zurich)

Title : *Advances in integrable eta deformations*

Abstract : *Integrable models, whose dynamics are constrained by the presence of many conserved charges, are important tools in theoretical physics as they can be solved exactly. The superstring sigma models appearing in instances of the AdS/CFT correspondence are such integrable theories. Deformations of these superstring sigma models preserving integrability have been proposed, among which eta deformations. Several puzzles associated to integrable eta deformations of superstrings have been recently resolved. In this talk I will introduce the salient features of eta deformations and discuss these recent advances.*

Pierrick BOUSSEAU (ETH Zurich)

Title : *Strong positivity for the four-punctured sphere.*

Abstract : *I will present a result on the topology of curves on topological surfaces: the positivity of the structure constants of the bracelets basis of the skein algebra of the four-punctured sphere. The proof uses algebro-geometric techniques coming from mirror symmetry.*

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Short Talks

Gabriel CUOMO (EPFL)

Title : *CFTs at large non-Abelian charge*

Abstract : *Recently, it was pointed out that in a generic conformal field theory (CFT) the spectrum of operators carrying a large internal U(1) charge can be analyzed semiclassically in an expansion in inverse powers of the charge. The key is the operator state correspondence, by which such operators are associated with a finite density superfluid phase, whose low energy dynamics is dominated by a single hydrodynamic Goldstone mode. The same picture holds in theories invariant under non-Abelian symmetries, in which case however the superfluid spectrum of Goldstones includes both gapless and gapped modes, whose gap is generically of the order of the strong coupling scale of the system. In this talk, I will explain the consequences of the existence of gapped Goldstones for the CFT data of the theory.*

Matthew WALTERS (EPFL)

Title : *QFT from CFT*

Abstract : *I will discuss a new nonperturbative method which uses data from UV fixed points (i.e. CFTs) to numerically compute dynamical observables in more general strongly-coupled QFTs. This approach uses low-dimension operators from the UV CFT to approximate the low-energy eigenstates of the full QFT Hamiltonian, allowing us to study dynamics even at strong coupling. After presenting a general framework which can be applied to QFTs in any number of dimensions, I will then discuss its application to some 2D and 3D examples, as well as recent ideas for applying this framework in higher dimensions and to gauge theories, including QCD.*

Pranjal NAYAK (University of Geneva)

Title : *Thermalisation and Ergodicity in Low Dimensional theories*

Abstract : *In this talk, I will obtain the one-dimensional Schwarzian theory, the low energy effective field theory that arises from SYK model in the IR limit, by dimensionally reducing two-dimensional Liouville theory on an open string. Different boundary conditions at the ends of the open string give rise to different states in the one-dimensional Schwarzian theory. I will discuss the construction of these states and study the correlation functions of bilocal operators in these states to study thermalisation. When the pure states are energy eigenstates, expectation values of non-extensive operators are thermal. On the other hand, in coherent pure states, these same operators can exhibit ergodic or non-ergodic behavior, which is characterized by elliptic, parabolic or hyperbolic monodromy of an auxiliary equation; or equivalently, which coadjoint Virasoro orbit the state lies on. This provides a renewed understanding of the role of coadjoint orbits in the low dimensional holography. Chaos in quantum theories is also defined in terms of their Wigner-Dyson spectral statistics. Ergodic limit of a theory is defined as one in which this universal behavior becomes relevant. I will discuss our work on the analysis of operator correlation functions in the SYK model in ergodic limit, without having to take the IR limit.*

Daniele DIMONTE (University of Basel)

Title : *Dynamics of a Bose-Einstein Condensates in the Thomas-Fermi Regime*

Abstract : *We discuss the time evolution for a many-body system of interacting bosons in the mean-field regime with scaled potential with shrinking support. Under appropriate assumptions the many-body Schrödinger dynamics for N particles is expected to be approximated by a one-particle nonlinear Schrödinger equation.*

The pure mean-field or GP limits have already been studied in detail, and the approximation proven to be correct on suitable time scales. On the opposite, in spite of its relevance in experimental physics, the Thomas-Fermi (TF) regime has not been fully investigated: in this regime the support of the interaction potential shrinks as the scattering length diverges with N. We show that the dynamic approximation is more subtle in this case, in particular at large time scales, but the effective description is still correct.

Joint work in progress with M. Correggi, E. Giacomelli and P. Pickl

Géraldine HAACK (University of Geneva)

Title :

Energy-based observables for assessing the presence of quantum correlations in dissipative open quantum systems

Abstract : *Models for dissipative open quantum systems constitute ideal platforms to better understand energy exchanges at the quantum scale. Generic setups are made of characterized by several out-of-equilibrium environments interacting with one or multiple quantum systems. Their investigation is triggering the development of novel theoretical tools to assess their time-dependent and steady-state dynamics, the search for energy-based signatures of quantum effects and the connection to state-of-the-art experiments. These questions are part of the motivations for the emergent and growing research field "quantum thermodynamics".*

In this context, I will present a specific model for an open dissipative quantum system, made of interacting qubits, each of them being coupled to its own thermal environment. Following the spirit of thermal machines, a thermal out-of-equilibrium situation can be exploited to generate bipartite and multipartite entanglement amoung the qubits in the steady-state regime. These systems are now known as "entanglement engines". Whereas it was phenomenologically shown that a heat current is

necessary to achieve steady-state entanglement, the existence of an exact relation between the observable, a heat current, and quantum information measures for entanglement, i.e. negativity, was not known. In a recent work [1], we demonstrated a lower bound for the heat current for successful operation of the engine, i.e. to achieve steady-state entanglement in the weak and strong inter-qubit interacting regimes. This result was derived from an analytical understanding of the dynamics and entanglement measures. It clarifies for the first time the role of an energy-based observable in a quantum transport experiment for achieving quantum correlations. It also establishes a novel connection between quantum thermodynamics and quantum information theory, providing an alternative to tomography protocols to certify the presence of entanglement.

[1] S. Khandelwal, N.Palazzo, N. Brunner, and G. Haack, New J. Phys. 22, 073039 (2020)

Kaloyan SLAVOV (ETH Zurich)

Title :

What is the probability that a (sparse) polynomial of degree d over a finite field is irreducible?

Abstract :

A classical result of Gauss states that among all monic polynomials of degree d over a finite field, approximately 1/d are irreducible. Extending previous results, we prove that under a mild assumption, the proportion of irreducible polynomials does not change even if only the last two coefficients are allowed to vary. The talk will be non-technical.

Nikolai LEOPOLD (University of Basel)

Title : *Landau-Pekar equations and quantum fluctuations for the dynamics of a strongly coupled polaron*

Abstract : *The Fröhlich model describes the interaction between an electron and the quantized phonons of a ionic crystal. In this talk, I will discuss its time evolution in the limit of large coupling constant α. For initial data of Pekar product form with coherent phonon field and with the electron minimizing the corresponding energy, I will present a norm approximation of the evolution, valid up to times of order α^2. The approximation is given in terms of a Pekar product state, evolved through the Landau-Pekar equations, corrected by a Bogoliubov dynamics taking quantum fluctuations into account. This is joint work with David Mitrouskas, Simone Rademacher, Benjamin Schlein, and Robert Seiringer.*

Nicolo DEFENU (ETH Zurich)

Title :

Complex networks with tuneable dimensions as a universality playground

Abstract :

Universality is one of the key concepts in understanding critical phenomena. However, for interacting inhomogeneous systems and complex networks a clear understanding of the relevant parameters for universality is often missing. To explore the role of dimension, we construct a complex network model where the probability of a bond between two nodes is proportional to a power law of the nodes' distance. By explicit computation we prove that the spectral dimension for this model can be tuned continuously from 1 to infinity, and we discuss related network connectivity measures. We present a platform to explore universal critical behavior in fractional dimension on inhomogeneous structures, which can be realized experimentally in atomic, molecular and optical devices.

Pietro LONGHI (ETH Zurich)

Title : *BPS counting with exponential networks*

Abstract : *Spectral networks compute certain enumerative invariants associated with Hitchin systems, by focusing on the interplay of certain geometric and combinatorial data within them.*

In physics, spectral networks count BPS states of class S theories through 2d-4d wall crossing. I will describe a 3d-5d uplift of this based on exponential networks, that computes generalized Donaldson-Thomas invariants of toric Calabi Yau threefolds.

Nikita NIKOLAEV (University of Geneva)

Title :

Existence of Exact WKB Solutions of Schrödinger Equations

Abstract :

Given a Schrödinger equation in the complex domain, it is not difficult to construct a formal power series solution in the Planck constant ħ, the so-called formal WKB solutions. Such power series solutions are generically divergent series, and the question of whether they are the asymptotic expansions as ħ->0 of exact solutions (the so-called exact WKB solutions) has in general remained open. I will advertise my recent work (to appear) which gives an affirmative answer to this question in large class of problems using methods from the theory of Borel-Laplace transformations.

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