Fourty Years of Conformal Field Theory

Galileo Galilei Institute, Florence
February 2, 2024

Schedule

09.00-09.30	*Registration*
09.30-09.55	**Jean-Bernard Zuber** (Paris-Sorbonne University) *Recollections of happy days with Andrea in Saclay*
09.55-10.20	**Lorenzo Maffi** (Niels Bohr Institute, Copenhagen) *Tricritical Ising phase transition in tunable Josephson junction ladders*
10.20-10.45	**Francesco Ravanini** (University of Bologna) *Hagedorn transitions in exact $U_q(su_2)$ S-matrix theories with arbitrary spins*
10.45-11.15	*Coffee break*
11.15-11.40	**Kareljan Schoutens** (University of Amsterdam) *Brick Wall Quantum Circuits with Global Fermionic Symmetry*
11.40-12.05	**Maria Cristina Diamantini** (University of Perugia) *The discovery of electric confinement in condensed matter systems*
12.05-12.30	**Guillermo Zemba** (CNEA, Buenos Aires) *The Effective Field Theory of the Calogero-Sutherland model*
12.30-14.00	*Lunch*
14.00-14.25	**Paul Wiegmann** (University of Chicago) *Emergence of fermions in fluid mechanics*
14.25-14.50	**Denis Bernard** (ENS, Paris) *Playing with random matrices and free probability in many-body systems*
14.50-15.15	**Fabian Essler** (University of Oxford) *Duality in the Lieb-Liniger model*
15.15-15.40	**Carlo Trugenberger** (SwissScientific Technologies, Geneva) *Combinatorial Quantum Gravity: Q-it form Bit*
15.40-16.10	*Coffee break*
16.10-16.35	**Alexander Abanov** (Stony Brook University) *Anomalous fluid dynamics as bosonization*
16.35-17.00	**Jacopo Viti** (INFN, Florence) *The Tracy-Widom distribution in the six-vertex model with DWBC*
17.00-17.25	**Jacopo Sisti** (University of Uppsala) *Weyl anomalies in CFTs with boundaries and defects*
17.25-17.50	**Giuseppe Mussardo** (SISSA, Trieste) *Prime suspects*
20.30	*Social Dinner*

Social Dinner

The dinner will take place at *Ristorante Cafaggi*, Via Guelfa, 35/r. The restaurant is 30 min walk from Porta Romana, through the city center. Follow via Romana, Piazza Pitti, Ponte Vecchio, Duomo, San Lorenzo, via dei Ginori). Otherwise, take bus 11 at Porta Romana, northbound, and get out at Vecchietti (Near Duomo). Then walk 10 minutes through San Lorenzo.

Abstracts

Alexander Abanov (Stony Brook University)
Anomalous fluid dynamics as bosonization

Fluid dynamics emerging from interacting three-dimensional Dirac fermions exhibit chiral anomaly. We consider the anomaly inflow mechanism in fluid terms. We parallel this discussion with the well-known example of bosonization in one spatial dimension.

Denis Bernard (ENS, Paris)
Playing with random matrices and free probability in many-body systems

Maria Cristina Diamantini (University of Perugia)
The discovery of electric confinement in condensed matter systems

Superinsulators are a new state of matter, which we predicted, and which has been experimentally observed on the insulating side of the superconductor-insulator transition in superconducting films. They are the S-dual of superconductors, with infinite resistance below a critical temperature. In the superinsulating state, Cooper pairs and Cooper holes are confined into neutral electric pions by electric strings, with the Cooper pairs playing the role of quarks. The underlying mechanism of superinsulation is, thus, Polyakov's linear confinement of Cooper pairs anti-Copper pairs via instantons in 2d and monopoles in 3d. We present direct experimental evidences of this confining mechanism realised in thin superconducting films.

Fabian Essler (University of Oxford)
Duality in the Lieb-Liniger model

In one dimensional quantum gases there is a well known "duality" between hard core bosons and non-interacting fermions. However, at the field theory level, no exact duality connecting strongly interacting bosons to weakly interacting fermions is known. I discuss the solution to this problem for the case of the Lieb-Liniger model.

Lorenzo Maffi (Niels Bohr Institute, Copenhagen)
Tricritical Ising phase transition in tunable Josephson junction ladders

Modern hybrid superconductor-semiconductor Josephson junction arrays are a promising platform for analog quantum simulations. Their controllable and non-sinusoidal energy/phase relation opens the path to implement nontrivial interactions and study the emergence of exotic quantum phase transitions. In this talk, I will present the analysis of an array of hybrid Josephson junctions defining a 2-leg ladder geometry for the quantum simulation of the tricritical Ising phase transition. This transition provides the paradigmatic example of minimal conformal models beyond Ising criticality and its excitations are intimately related with Fibonacci non-Abelian anyons and topological order in two dimensions. We study this superconducting system and its thermodynamic phases based on bosonization and matrix-product-states techniques. Its effective continuous description in terms of a three-frequency sine-Gordon quantum field theory suggests the presence of the targeted tricritical point and the numerical simulations confirm this picture. I will briefly indicate which experimental observables can be adopted in realistic devices to probe the physics and the phase transitions of the model. Additionally, our proposal provides a useful

one-dimensional building block to design exotic topological order in two-dimensional scalable Josephson junction arrays.

Giuseppe Mussardo (SISSA, Trieste)
Prime suspects

Does the Fibonacci atom exist? How can we spot a prime number or factorise a composite one? Arithmetic is a noble art based, as true friendship, on simple rules. But to reveal the chest full of its incredible jewels, we may need sophisticated approaches, known for their elegance and precision. As for the infinitely many paths of life, we simply need quantum mechanics.

Francesco Ravanini (University of Bologna)
Hagedorn transitions in exact $U_q(su_2)$ S-matrix theories with arbitrary spins

Generalising the quantum sine-Gordon and sausage models, we construct exact S-matrices for higher spin representations of quantum $U_q(su_2)$ symmetry, which satisfy unitarity, crossing-symmetry and the Yang-Baxter equations. We have derived the thermodynamic Bethe ansatz equations from this S-martrices and found that the universal kernel is associated with graphs related to non-Dynkin diagrams. Furthermore, these equations are showing singularities in the free energies at some finite temperatures, signaling the Hagedorn-type transitions.

Kareljan Schoutens (University of Amsterdam)
Brick Wall Quantum Circuits with Global Fermionic Symmetry

We study brick wall quantum circuits, taking as our building brick a 2-qubit gate that derives from a factorizable S-matrix in integrable, supersymmetric quantum field theory in 1+1D. Using an underlying free fermion structure, we solve the spectral structure of the brick wall circuits. In the Hamiltonian limit of these circuits the global fermionic symmetry protects criticality – breaking that symmetry leads to a variety of topological phases.

Jacopo Sisti (University of Uppsala)
Weyl anomalies in CFTs with boundaries and defects

Conformal field theories are partially characterized by their Weyl anomaly. In this talk, I will first review how the presence of a defect or boundary enriches the structure of such anomalies. I will then present results for four-dimensional defects of arbitrary codimension and discuss examples, such as free and holographic theories, in which the anomaly coefficients can be computed exactly.

Carlo Trugenberger (SwissScientific Technologies, Geneva)
Combinatorial Quantum Gravity: Q-it form Bit

I will review the main results of the combinatorial quantum gravity programme. This is an approach combining Einstein's idea of dynamical geometry and Wheeler's "it from bit" hypothesis in a formulation of general relativity on abstract metric spaces, focusing on the example of random graphs. I will show how geometric manifolds emerge from random graphs in a continuous phase transition due to a condensation of loops. In the 2D case, the emerged manifold is a negative curvature holographic surface with two scales, an ultraviolet Planck scale on which the residual randomness represents matter particles satisfying the trace of the Einstein equations and an infrared radius of curvature above which there is an effective Lorentzian description with spatial spectral dimension 3 and particles governed by 3D quantum mechanics with distances inherited from the holographic screen, representing the gravity interactions.

Jacopo Viti (INFN, Florence)
The Tracy-Widom distribution in the six-vertex model with DWBC

Fluctuations of the extremal lattice path in the six-vertex model with DWBC around the arctic curves are believed to obey the Tracy-Widom distribution. So far, however, evidence for this claim both numerical and analytical has been scarce.

In this talk, I will review the exact solution at the free fermion point and then present a Monte Carlo study at different values of the anisotropy parameter in the disordered phase. The numerical study strongly indicates that fluctuations of the extremal path are indeed described by the Tracy-Widom distribution.

Joint work with: I. Lyberg and V. Korepin. J. Phys. A: Math. Theor. 56 (2023) 495002.

Paul Wiegmann (University of Chicago)
Emergence of fermions in fluid mechanics

Guillermo Zemba (CNEA, Buenos Aires)
The Effective Field Theory of the Calogero-Sutherland model

We review the extended bosonization of the Calogero-Sutherland model on a circle and find its Hilbert space in terms of the $W_{1+\infty}$ irreducible representations. We also find its effective Hamiltonian and the equation of motion of the density field. We compare our results with those based on the hydrodynamics of the model.

Jean-Bernard Zuber (Paris-Sorbonne University)
Recollections of happy days with Andrea in Saclay