Bootstat 2021: Conformal bootstrap and statistical models

Monday 03 May 2021 - Friday 28 May 2021

Institut Pascal, Orsay, France & online

Participants' introductions

Before the start of the programme, each participant was asked to write a short introductory text, in relation with the workshop's themes. These texts allow participants to introduce themselves to one another, and help the organizers build the programme. Participants' introductions may describe their relevant work, recent or not; announce subjects they would be interested in discussing or learning about; and provide suggestions to the organizers.

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The unitary Fermi gas

Participant: Félix WERNER[1]

[1] *LKB, ENS*

The unitary Fermi gas is a non-relativistic conformal field theory, studied experimentally with cold atoms. One wonders whether there are practical consequences of conformal invariance beyond what we already know (see e.g. arXiv:1004.3597 or arXiv:1103.2851).

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Numerical simulations of critical phenomena

Participant: Francesco Parisen Toldin[1]

[1] *University of Wuerzburg*

I am interested in classical and quantum critical phenomena, mostly investigated with Monte Carlo simulations.
In particular, in recent years I have been interested in the fermionic Gross-Neveu-Heisenberg universality class, which is realized in the Hubbard model on the honeycomb lattice (Phys. Rev. B 91, 165108 (2015)), and in surface critical behavior of O(N) models, where I recently showed the existence of a surface transition in the 3D Heisenberg universality class (Phys. Rev. Lett. 126, 135701 (2021))

I am looking forward to learn the bootstrap methods, and to discuss interesting questions that can be tackled also with Monte Carlo simulations.

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Meta-conformal symmetries in non-equilibrium statistical mechanics

Participant: Malte Henkel[1]

[1] *LPCT, Univ. Lorraine Nancy, France*

Can one find critical statistical systems where the naturally occurring global scale-invariance can be generalised towards a large Lie algebra of « local » scale transformations ? It has been recognised since some time ago that this should indeed be possible in certain situations, for example in simple ferromagnets which undergo non-equilibrium phase-ordering kinetics after a quench from a disordered initial state to below the critical temperature. It is known that in these systems, time and space re-scale different which is expressed by the value z=2 of the dynamical exponent. The associated Lie algebra is the Schroedinger algebra, along with its infinite-dimensional extension, the Virasoro-Schroedinger algebra. The underlying dynamics is diffusive.

More recently, analogous ideas have been brought to bear on systems with underlying ballistic transport, such that the underlying dynamical exponent is z=1. A simple physical realisation can be given for the exactly solvable 1D Glauber-Ising model with a directional bias and sufficiently long-range initial correlations. It is found that the associated Lie algebras are isomorphic to the standard « ortho-conformal » Lie algebra in 2D but the representations arising are not angle-preserving. To

signal the relationship with conformal symmetries and at the same time to state clearly the differences, these new transformations care called « meta-conformal ». Infinite-dimensional extensions are known to exist in 2D and 3D, and are isomorphic to the direct sum of two or three Virasoro algebras, respectively. The non-relativistic limit reduces to the conformal galilean algebra.
Further physical applications are under investigation.

1 M. Henkel, S. Stoimenov, Infinite-dimensional meta-conformal Lie algebras in one and two spatial dimensions, J. Stat. Mech. 084009 (2019) [arxiv:1810.09855]

[2] M. Henkel, M.D. Kuczynski, S. Stoimenov, Boundedness of meta-conformal two-point functions in one and two spatial dimensions, J. Phys. A Math. Theor. 53, 475001 (2020)

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Algebraic aspects of Logarithmic CFTs and Topological QFTs

Participant: Azat GAINUTDINOV[1]

[1] *CNRS, Institut Denis Poisson, Université de Tours*

My research interests lie within the intersection of Statistical Physics, Conformal Field Theory, Integrable Models, Representation Theory, Category Theory and Quantum Topology. I am especially interested in algebraic aspects of non-unitary QFTs such as logarithmic models of CFTs: representation theory of logarithmic vertex-operator algebras and their modular tensor categories. My work was mostly concentrated on 2d CFTs but I am also interested in their higher-dimensional generalizations and interplay with scaling limits of statistical physics models. More recently, I began to work on generalizations of 2d loop models based on diagrammatical calculus of high rank quantum algebras. Another branch of my work deals with 3d non-unitary Topological Quantum Field Theory, they are topological cousins of Logarithmic CFTs.

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Conformal bootstrap for emergent supersymmetry

Participant: Aleix Gimenez Grau[1]

[1] *Desy*

I am interested in conformal field theories in general, and more specifically, in the presence of conformal defects and/or supersymmetry. In my research I have applied both analytic and numerical bootstrap methods to study such models. Recently I have been studying models with emergent supersymmetry, the most famous example of which is the Wess-Zumino model. In this workshop I am hoping to learn about the latest developments in numerical bootstrap, and also about some interesting models from statistical physics where these techniques can be applied.

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MonteCarlo Bootstrap

Participant: Uriel Adrian Luviano Valenzuela[1]

[1] *SISSA*

Despite the apparent contradiction in the title, my PhD project consists in searching for approximate solutions to the crossing equations via stochastic optimization. Concretely, we propose an ansatz for the spectrum and then proceed to minimize a functional related to the crossing equations via Metropolis-Montecarlo.

I am very excited to learn about other interesting models that could be solved with the bootstrap, mostly outside unitarity. Learning more about state-of-the-art methods is my secondary goal.

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Lattice models, diagrammatic algebras and logarithmic CFT

Participant: Alexi Morin-Duchesne[1]

[1] *Max Planck Institute for Mathematics, Bonn*

My research focuses on two-dimensional lattice models that have non-local degrees of freedom, and on their description with diagrammatic algebras and logarithmic conformal field theory. I am a newcomer to the conformal bootstrap, so from this conference I hope to get a better understanding of the basics of this technique and to how it can be applied to the non-local models I study.

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Bootstrap, logarithmic CFTs and disordered systems

Participant: Julien Sparel[1]

[1] *ENS Paris*

I am new to the conformal bootstrap and interested in learning this method to study statistical physics systems and phase transitions. I am also interested in its application to logarithmic CFTs and disordered systems.

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Scattering amplitudes and bootstrap

Participant: Tzu-Chen Huang[1]

[1] *California Institute of Technology*

My background is in scattering amplitudes in 3+1 d. Recently I've been interested in applying bootstrap techniques to the study of scattering amplitudes in general dimensions and of 2d CFT with fusion category symmetry. I hope to learn more about new developments in both analytical and numerical aspects of the bootstrap approach.

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1D quantum gases and hydrodynamics

Participant: Jérôme Dubail[1]

[1] *CNRS*

My background in lattice statistical models and 2D CFT, and also in the fractional quantum Hall effect and topological condensed matter physics. In the past four years I have mostly been working on 1D quantum gases, developing hydrodynamic methods for those (especially quantum hydrodynamics in 1D, which takes the form of a perturbed 1+1D CFT), sometimes in connection with experimentalists.

In this workshop I would like to learn about CFT in d>2.

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S-matrix Bootstrap

Participant: João Penedones[1]

[1] *EPFL*

I am interested in bootstrap approaches to Quantum Field Theory, in particular the S-matrix Bootstrap. In this workshop, I would like to learn more about some open problems in statistical physics and the methods developed to attack them.

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Entanglement entropy / Quantum Hall effect

Participant: Benoît Estienne[1]

[1] *Sorbonne Université*

My background is in two-dimensional CFT, applied to statistical physics and condensed matter problems. Recently I have been working on entanglement entropy in 1+1d quantum critical systems, and in trial wavefunctions for the quantum Hall effect. I am interested in learning about :

- recent progress in CFT in d>2,
- the (log) CFT description of loop models in d=2,
- modular tensor categories.

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Solutions explicites / Explicit solutions

Participant: Robert Conte[1]

[1] *ENS Paris-Saclay*

Peu familier des méthodes de "bootstrap", j'espère rencontrer des systèmes physiques variés, régis par des équations différentielles, chaotiques ou intégrables, dont il faut trouver des solutions explicites. Les méthodes fondées sur les singularités donnent souvent de bons résultats. Centres d'intérêt actuels :

- matrices aléatoires (persistance),
- EDP de Ginzburg-Landau cubique-quintique,
- écriture d'une page de Wikipédia issue de "The Painlevé handbook".

Although not familiar with bootstrap techniques, I hope to spot a variety of physical systems governed by differential equations, whether chaotic or integrable, whose explicit solutions are missing. Indeed, singularity based methods often yield quite good results. Current interests:

- random matrices (persistence),
- cubic-quintic Ginzburg-Landau PDE,
- writing a Wikepedia page from "The Painlevé handbook".

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Strong coupling from perturbation theory

Participant: Marco Serone[1]

[1] *SISSA*

I am interested in conformal field theories and resummations of coupling expansions in quantum field theories. I would like to learn more about recent open problems in statistical physics, in particular non-unitary theories.

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2d conformal bootstrap

Participant: Linnea Grans-Samuelsson[1]

[1] *IPhT, CEA Saclay*

My work has been focused on understanding non-unitary 2d CFTs from lattice considerations (e.g. Temperley-Lieb algebra), but this year I have also entered the world of conformal bootstrap – more specifically 2d conformal bootstrap for the Potts and O(n) models.

From this workshop I am hoping to get an overview of what questions people are currently working on within condensed matter theory (e.g. integer quantum Hall effect), and how they use bootstrap techniques in their work.

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Bootstrapping the Landscape of 3d CFTs

Participant: David Poland[1]

[1] *Yale University*

I am interested in both numerical and analytical aspects of the conformal bootstrap. Currently I am focused on 3d bootstrap problems involving external operators with spin and in understanding how to bootstrap gauge theories. From this workshop I'd like to learn more about interesting open problems in statistical models.

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CFT and critical Potts model

Participant: Marco Picco[1]

[1] *LPTHE*

I am interested in various aspects of the Potts model. In particular, I study the influence of disorder on the criticality in 2d. Another aspect is the low temperature dynamics for the Potts model in 2d or higher dimension.

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1+1D CFT and quantum gases

Participant: Jérôme Dubail[1]

[1] *CNRS*

My background is in lattice statistical models and 2D CFT, and also in the fractional quantum Hall effect and topological condensed matter physics. In the past four years I have mostly been working on 1D quantum gases, developing hydrodynamic methods for those (especially quantum hydrodynamics in 1D, which takes the form of a perturbed 1+1D CFT), sometimes in connection with experimentalists. In this workshop I would like to learn about CFT in d>2.

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Boostrap for AdS/CFT and 2D CFTs

Participant: Gabriele Di Ubaldo[1]

[1] *ENS Paris & IPhT Saclay*

Being new to the conformal bootstrap, I look forward to learning about it in general and how to apply it to study phase transitions. Personally, I am interested in the bootstrap in connection with AdS/CFT, in particular for 2D CFTs.

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Bootstrapping Ising, super-Ising, cubic models and QED

Participant: Ning Su[1]

[1] *University of Pisa*

I am interested in developing numerical methods in conformal bootstrap, and applying them to solve problems in condensed matter/statistical physics. Recently I am interested in the Ising, super-Ising, cubic models and QED. From this workshop, I would like to learn more about interesting physics questions in non-unitary CFTs and possible ways to bootstrap them.

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Structural phase transitions, their symmetries and their mechanisms

Participant: Pierre Toledano[1]

[1] *Université de Picardie*

The theoretical investigation of the various classes of structural phase transitions (second-order, first-order, reversible and irreversible, reconstructive, morphotropic, magnetostructural) in solids and soft matter, but also of magnetic and superconducting transitions, are my subject of research.

However, my interest is more on the symmetry properties, the equilibrium physical properties, the transition mechanisms and the phase diagrams, than on the critical behaviour. This is because, even in the assumed pure case of second order transitions, the critical behaviour seems from the experimental data, not reducible to a single theoretical scheme, because of the many controllable and uncontrollable ingredients involved in the symmetry-breaking transition mechanisms of real systems (secondary or hidden order-parameters, defects, etc...).

In the middle of the eighties I collaborated with Louis Michel, my brother Jean-Claude and Edouard Brezin, in the determination of the fixed points associated with effective Hamiltonians relative to phase transitions with four-component order-parameters. I also determined with a student (Emmanuel Meimarakis) the fixed points associated with structural or magnetic phase transitions induced by six and eight dimensional order-parameters.

A detailed comparison of our results with the available experimental data showed that the Renormalization Group approach is in some cases failing in the determination of the critical behaviour of real physical systems.

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Bootstrapping statistical models

Participant: Balt van Rees[1]

[1] *Ecole polytechnique*

I work on the numerical conformal bootstrap, boundaries and defects in conformal field theories, the S-matrix bootstrap and sometimes on superconformal field theories. I like to study QFTs in an AdS background to better understand scattering amplitudes and RG flows. In my free time I read about numerical optimization algorithms. I look forward to learning about interesting statistical models during this program.

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Applications of the bootstrap approach to critical phenomena & to quantum entanglement

Participant: Nina Javerzat[1]

[1] *SISSA*

I have used the conformal bootstrap approach to study the CFTs describing the critical behaviour of percolation models, and in particular of models with long-range correlations such as the Q-state random cluster Potts model and the level-sets of fractional Gaussian surfaces.

I have now shifted to the quantum world and am currently interested in understanding quantities related to entanglement in quantum systems, such as entanglement hamiltonians and entropies. Computing the entanglement entropy is a difficult problem in general, and I would like to investigate to what extent the bootstrap could allow to make progress.

As a young enthusiastic postdoc I am also looking forward to discover/possibly join/possibly create new projects !

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Conformal bootstrap and S-matrix bootstrap in 4d

Participant: Denis Karateev[1]

[1] *ENS Paris*

I am working in the domain of high energy physics. My main research directions are the conformal bootstrap in higher dimensions (mostly in 4d) and the S-matrix bootstrap. In conformal bootstrap I have been working on constructing general spin 3- and 4-point correlation functions in conformal field theories and on using them to obtain numerical bounds. My dream goal is to discover 4d gauge theories with a non-trivial IR fixed point. On the S-matrix bootstrap side I have been working on developing form factor bootstrap in higher dimensions and on studying S-matrices with generic spin in 4d non-perturbatively.In this conference I would like to get an overview of the main direction in statistical physics (not necessary bootstrap solvable).

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Geometrical critical phenomena and the renormalization group

Participant: Omar Zanusso[1]

[1] *University of Pisa*

My background is on field theory applications of the renormalization group, which I believe to be the fundamental language with which humans should approach the understanding of reality, but I have taken increasing interest towards conformal symmetry, mostly because of its elegance and power. For this reason I like to say "conformal field theories of gods, renormalization group flows of men" paraphrasing the title of a book that I once read. I have been guilty (several times actually) of talking about CFT related topics, even though I don't know nearly enough about them. Hopefully with this meeting I can amend. I am looking forward to geometrical critical phenomena, but all other topics interest me as well.

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Analytic and numerical aspects of the conformal bootstrap

Participant: Petr Kravchuk[1]

[1] *IAS, Princeton*

I'm working on analytic and numerical aspects of conformal bootstrap. On the numerical side, I have been interested in extending the existing techniques to local operators with spin, as well as in performing numerical studies using said techniques. On the analytic side, I've been working on light-ray operators and their applications to observables such as event shapes. From this workshop I'm most interested in learning about bootstrap targets which are of interest to researchers outside of the conformal bootstrap community.

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Bootstrap and Critical Dynamics

Participant: Louie Hong Yao[1]

[1] *Virginia Tech*

I am working in non-equilibrium statistical mechanics, especially in universality of critical dynamics. My current research is based on RG and I am extremely interested in how bootstrap techniques can be applied to study the non equilibrium universality classes.

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Exact results at and near criticality

Participant: Gesualdo Delfino[1]

[1] *SISSA*

I worked on different facets of the statistical bootstrap. One of my recent interests has been to find access to aspects of criticality that had remained out of reach for 2D exact methods, e.g. cluster connectivities and random critical points.

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Numerical simulations on the q-states Potts model

Participant: Lourdes Bibiana Merino Solís[1]

[1] *Universidad de Guanajuato, México*

I am currently developing an algorithm for critical temperature calculation in the q-states Potts model in 2D.

I have experience in the implementation of the Monte Carlo algorithm for study of phase transition of the Ising model in 2D, also I've working in the numerical resolution of non-linear partial differential equations using the Runge-Kutta Discontinuous Galerkin method.

I'm very interested in the resolution of physics models using numerical methods. My goal during this congress is to expand my knowledge of numerical methods used in statistical mechanics, focusing mostly on those similar to the Potts model.

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Critical geometry approach to three-dimensional percolation

Participant: Alessandro Galvani[1]

Co-authors: Giacomo Gori ; Andrea Trombettoni

[1] *SISSA*

In the first part of the talk, I will describe a theory of bounded critical phenomena based on a geometric approach [https://arxiv.org/abs/1904.08919]: a curved metric, conformal to the euclidean one, is added to a bounded domain, with the requirement of constant curvature, to enforce homogeneity. This leads to the so-called Yamabe equation, which is then modified, with the introduction of a fractional Laplacian, to account for the anomalous dimension of the fields. Solving this equation provides a point-dependent scale for the system, which can be used to determine one-point and two-point spin correlations functions. After briefly reviewing results for the Ising and XY models, we compare the Yamabe predictions with numerical simulations of continuum percolation in three dimensions, and we present a high-precision estimate of its anomalous dimension η.

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Boundary bootstrap and perturbative fixed points

Participant: Connor Behan[1]

[1] *University of Oxford*

Lately I have been working on an approach to the boundary bootstrap which takes advantage of bulk equations of motion.

I am also interested in perturbative fixed points. Especially those where the primary motivation comes from structural considerations of the operator algebra.

One thing I would like to learn more about in this workshop is the family of logarithmic CFTs that arise as limits of generalized minimal models.

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CFTs of geometric critical phenomena

Participant: Yifei He[1]

[1] *ENS Paris*

Recently I have been studying 2d CFTs of critical geometrical models (Potts and O(n) for example). In general I am interested in using the conformal bootstrap approach to study geometrical type of phase transition in general dimensions.
From this workshop, I would like to learn more about open questions in statistical and condensed

matter physics (integer quantum hall transition for example), as well as advanced numerical bootstrap techniques in d>2 especially the potential of a systematic non-unitary bootstrap program.

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Boundaries and defects in CFTs

Participant: Edoardo Lauria[1]

[1] *Ecole Polytechnique*

My research has to do with studying 'boundaries' and 'defects' in CFTs. These deformations typically introduce some complexity in the theory, for example new 'defect' critical exponents. An interesting question to ask is about the dynamics of a CFT in the presence of a defect: the new critical exponents, the interplay between bulk and defect data, the emergent dualities of the system. Another question is about the space of defects in a given CFT, for example the set of allowed unitary and conformal boundary conditions for the free Maxwell field, or for a free massless scalar. I am interested in addressing these questions using a combination of numerical and analytic bootstrap techniques.

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Bootstrap and extended operators

Participant: Marco Meineri[1]

[1] *CERN*

I am mainly interested in the properties of extended operators in quantum field theory. I have worked in applying the numerical and the analytic bootstrap to boundaries and defects in conformal field theory. I am also interested in the more recent targets of the bootstrap, like QFT in Anti de Sitter space and the two-to-two S-matrix in flat space.

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Wick rotating conformal field theory in d>2

Participant: Jiaxin Qiao[1]

[1] *Ecole Normale Supérieure*

I'm recently interested in the axiomatic aspects of CFT in d>2. I would like to understand the relation of the basic assumptions of the numerical bootstrap (Euclidean CFT axioms) to other Euclidean or Lorentzian quantum field theory axiomatizations, e.g. Wightman axioms.

I'm looking forward to learn various stat-phys/bootstrap techniques and ideas from this conference.

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Conformal bootstrap for Anderson transitions?

Participant: Martin Zirnbauer[1]

[1] *University of Cologne*

I have recently proposed a 2D conformal field theory description, by a deformed $gl(1|1)$ current algebra, of the Anderson localization-delocalization transition between plateaus of the integer quantum Hall effect. Circumventing no-go results by Chamon-Mudry-Wen (1996) and Read-Saleur (2001), the proposal involves a novel scenario of spontaneous symmetry breaking for a theory with noncompact target space (where the Mermin-Wagner-Coleman theorem does not apply). My interest is to see whether conformal bootstrap could help to establish a similar scenario for Anderson transitions in 3D.

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Numerical bootstrap and positive geometry

Participant: Wei Li[1]

[1] *National Taiwan University*

I'm interested in all aspects of numerical bootstrap. Recently I've been working on using positive geometry to interpret the optimal functional from various numerical bootstrap problem.

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Realization of generalized symmetries in CFT

Participant: Ying-Hsuan Lin[1]

[1] *Harvard University*

I'm recently interested in the open question of whether every generalized symmetry (fusion category) can be realized in a 2D CFT. While this question is difficult to answer in general, one can try to hunt down exotic symmetries whose realizations are yet to be known. I am attacking this question with two approaches, (1) finding CFT phases in the Aasen-Fendley-Mong statistical model, and (2) studying conformal bootstrap with topological defect lines.

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Bootstrapping entanglement entropy

Participant: Filiberto Ares [1]

[1] *International Institute of Physics, Natal, Brazil*

I am interested in strongly correlated low-dimensional quantum systems.

I have studied different aspects of these systems such as entanglement in spin chains and gauge field theories or the role of Painlevé transcendents when a system is close to a quantum critical point. In this program, I wish to learn bootstrap methods in order to employ them in quantum many-body problems.

Right now, I am investigating the application of bootstrap techniques in the analysis of entanglement entropies in conformal minimal models. This problem boils down to computing the partition function of the model on compact Riemann surfaces.

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Aspects of CFTs and QFT in AdS

Participant: Xiang Zhao[1]

[1] *Ecole Polytechnique*

My research interest covers various aspects of CFTs, including the flat-space limit of QFT in AdS, supersymmetric CFTs and defect CFTs. Currently I'm interested in learning analytic structure of the S-matrix from the flat-space limit of the conformal correlation functions.

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Multiple correlators bootstrap

Participant: Zechuan Zheng[1]

[1] *ENS paris*

Recently I'm interested in bootstrap involving multiple correlators. In most bootstrap problems we've met so far, most of them are of single correlator or very few correlators. But some recent progress on random matrices bootstrap shows that there may exist abundant information in higher operators, and this may provide us with some clues for multiple correlators bootstrap in CFT and S-matrix.

I'm interested in learning some recent analytic and mathematical progress on CFT.

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CFTs and critical phenomena in d>2

Participant: Gian Paolo Vacca[1]

[1] *INFN - Bologna*

I am generally interested in improving the knowledge, especially at non perturbative level, of critical theories and CFTs in $d > 2$ (unitary and non unitary), both at an analytical and numerical level.
For example:
1. Find routes to improve the understanding of the (theory) space of all possible CFTs (and eventually scale invariant theories) in multi field systems without imposing symmetries a priori. Therefore see also the pattern of emergent symmetries. Our knowledge is essentially given by few RG analysis. Also establish links to possible physical realisations of critical phenomena related to some CFTS with specific novel emergent symmetries.
2. Devise effective paths to deal with the huge set of non unitary theories for $d \geq 3$, which are expected to exist, few of them mostly investigated with RG techniques. Understand their physical significance.

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Universal bootstrap results for critical phenomena

Participant: Amnon Aharony[1]

[1] *Tel Aviv University*

I have worked on the RG for critical phenomena for the last 50 years. I am interested in various universality classes, and I have used both real space, epsilon-expansions and 1/n-expansions for calculating critical exponents and universal amplitude ratios. In my talk I shall specifically discuss the cubic problem and its implications for structural phase transitions.

In addition, I would be interested to see how bootstrap methods can yield universal equations of state, correlation functions and universal amplitude ratios. I have also worked on random exchange and random field systems, issues of self-averaging, percolation and spin glasses. Looking forward to discussions of all these problems.

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Using the conformal bootstrap to study critical phenomena

Participant: Benoit Sirois[1]

[1] *École Normale Supérieure / IHES*

Since I am new to the bootstrap community, I am excited to learn about all the different ways the bootstrap can be used to study phase transitions.

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Renormalization group and CFTs

Participant: Dario Benedetti[1]

[1] *CPHT, Ecole Polytechnique and CNRS*

I am interested in better understanding how conformal field theories arise as fixed points of the renormalization group, and possibly find new useful ways to combine renormalization and conformal methods in order to study interesting statistical models. I have recently begun touching upon this topic in the context of some multiscalar models whose large-N limit, dominated by melonic diagrams, allows to solve old-bootstrap equations (conformal limits of Schwinger-Dyson and Bethe-Salpeter equations). In the process I have also become interested in long-range models in general, and the associated non-local CFTs.
By participating in this meeting I hope to learn as much as possible about the modern conformal bootstrap, with or without the assumption of unitarity, and to discuss about promising directions with the other participants.

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Inner workings of conformal field theories

Participant: Johan Henriksson[1]

[1] *Università di Pisa*

I am interested in understanding the "inner workings" of conformal field theories, such as the interdependence of CFT-data and the relation between perturbative and non-perturbative descriptions. CFTs with applications to statistical physics constitute a good testing ground for studying these questions, and my goal is to learn more about all the different theories and methods within this framework.

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RG flows in two-dimensional models

Participant: Bernardo Zan[None]

I'm in general interested in RG flows in a general number of dimensions, but recently I've been studying two-dimensional models which exhibit peculiar RG flows (to the eyes of a high energy theorist, at least), such as $O(n)$ loop models. I'd like to find out more about open problems or interesting models in this field, whether a bootstrap approach can somehow overcome their lack of unitarity, and about some of the techniques used by statistical physicists to study them (let me mention as an example the (affine) Temperley-Lieb algebra).

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CFTs and various critical phenomena

Participant: Stefanos Robert Kousvos[1]

[1] *University of Crete*

My current research focuses on bootstrapping various multi-scalar theories relevant to physical systems undergoing phase transitions. With respect to this workshop, I would be very interested in learning about several statistical physics targets and their phenomenology. Another topic I want to learn about is the possibility of bootstrapping non-unitary CFTs, somewhat systematically, i.e. a generic formalism that would work for any non-unitary CFT (or alternatively a large class of them).

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Minimal bootstrap solutions in d>2

Participant: Wenliang Li[1]

[1] *Okinawa Institute of Science and Technology Graduate University*

In 2d, the most well-understood bootstrap solutions of correlators (not necessarily the full CFTs) are associated with truncated OPEs. I am interested in their d>2 counterparts.

The unitary solutions at numerical bootstrap kinks are characterized by decoupled operators. I have been thinking about their analytic origin. I believe that they are closely related to the resolution of trajectory mixing, which leads to significant repulsion at low spin and thus potential decoupling and non-unitarity.

The OPE truncation helps eliminate non-unitarity, but unitarity is not essential to minimal solutions. (See Lee-Yang.) In the absence of positivity related to vector directions, it seems natural to consider vector norms/lengths that measure the complexity of a bootstrap solution. The corresponding minimization problem extracts minimal solutions and generalizes Gliozzi's method.

For statistical physics targets, I am curious about the following question: As non-unitary minimal solutions are dense, can we view a non-minimal solution, such as a logarithmic correlator, as the limit of a discrete sequence of minimal solutions with increasing complexity?

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Progress in analytic calculations in CFT and beyond

Participant: Mykola Shpot[1]

[1] *ICMP Lviv*

I come from statistical physics, field-theoretic approach to critical phenomena. Recently I was fascinated by collaboration with Parijat Dey and Tobias Hansen, combining Feynman-graph expansions and Renormalization Group with methods of the Conformal Field Theory. For sure, diverse interactions of these quite different "worlds" are very promising.

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The 3-state Potts model upper critical dimension

Participant: Shai Chester[1]

[1] *Weizmann Institute*

The 3-state Potts model has a unitary second order phase transition in spacetime dimension d=2, which is defined by an exactly solvable minimal model called the critical Potts model. There is also another 2d minimal model called the tricritical Potts model which has the same symmetries but one extra relevant operator. As d increases, these two fixed points are expected to merge and go off into the complex plane, so that the unitary second order phase transition disappears. I would like to use the conformal bootstrap to observe this behavior, and see if it occurs below d=3, as commonly believed. Preliminary results show that that the 2d theories can be successfully numerically bootstrapped, but further strategies are needed for going above 2d.

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Quantization of a self-dual conformal theory in $(2+1)$ dimensions

Participants: Andrea Cappelli[1]; Lorenzo Maffi[2]

[1] *INFN*

[2] *University of Florence*

(These are the title and abstract of the article arXiv:1912.04125)

Compact nonlocal Abelian gauge theory in $(2+1)$ dimensions, also known as loop model, is a massless theory with a critical line that is explicitly covariant under duality

transformations. It corresponds to the large N_F limit of self-dual electrodynamics in mixed three-four dimensions. It also provides a bosonic description for surface excitations of three-dimensional topological insulators. Upon mapping the model to a local gauge theory in $(3+1)$ dimensions, we compute the spectrum of electric and magnetic solitonic excitations and the partition function on the three torus T^3. Analogous results for the $S^2 \times S^1$ geometry show that the theory is conformal invariant and determine the manifestly self-dual spectrum of conformal fields, corresponding to order-disorder excitations with fractional statistics.

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Mostly supersymmetric CFTs

Participant: Agnese Bissi[None]

I am interested in conformal field theories in general. I worked mostly on supersymmetric theories.

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Conformal invariance at Anderson transitions and other disordered critical points

Participant: Ilya Gruzberg[1]

[1] *Ohio State University*

I am interested in critical phenomena at Anderson transitions, including the multifractality of critical wave functions. An important example is the integer quantum Hall transitions, which has been actively studied for a long time, and recently has seen very interesting developments, including Martin Zirnbauer's proposal of an exact CFT describing the transition.
I would like to see if the conformal bootstrap program can be applied to Anderson transitions other disordered critical points.

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Advances in numerical bootstrap in order to study phase transitions.

Participant: Marten Reehorst[1]

[1] *Institute des Hautes Études Scientifique*

I am interested in advancing numerical conformal bootstrap techniques (e.g. the Navigator function bootstrap that will be presented here by one of my Collaborators Ning Su, and the bootstrap of spinning external operators) in order to study 3D CFTs describing interesting phase transitions appearing in statistical physics. I believe that these technical advances in the numerical bootstrap techniques will enable us to answer new and interesting physical questions. I would love to learn more about what the statistical physics community finds to be the important questions relating to conformal field theories.

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Applications of the bootstrap to critical phenomena

Participant: Andreas Stergiou[1]

[1] *Los Alamos National Laboratory*

Three-dimensional CFTs beyond Ising and O(N) have important applications in a variety of physical systems, most notably frustrated magnets and crystals undergoing structural phase transitions. Experimental and theoretical results pertaining to these systems have produced puzzles that have remained unresolved for decades. I am interested in forming well-defined plans for resolving these puzzles, which will likely involve experimental efforts as well as theoretical bootstrap studies.

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CFTs applied to to statistical mechanics and many-body quantum systems

Participant: Jacopo Viti[1]

[1] *INFN Florence and IIP Natal*

I work on low-dimensional systems and 2d Conformal Field Theories (CFTs).
An important part of my research is devoted to the construction of the field theories that describe critical random clusters in 2d statistical mechanics. These are
$hrefhttps://en.wikiversity.org/wiki/Non-unitary_conformal_field_theory$non-unitary CFTs, where states with zero norm may appear in the spectrum.

Recently, I also applied CFT techniques to non-equilibrium quantum systems and studied how to build partition functions of minimal models on genus two
$hrefhttps://en.wikipedia.org/wiki/Riemann_surface$Riemann surfaces.

I am looking forward to learn numerical and analyical bootstrap techniques and try to apply them to statistical mechanics problems.

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Non-positive bootstrap especially for boundary CFT

Participant: Shumpei Iino[1]

[1] *ISSP*

I'm generally interested in numerical methods to investigate CFTs.
Recently I have been working on 2d boundary CFT and its application to surface critical behavior on lattice models using tensor network techniques.
Since I've started to study the surface criticality in 3d classical systems.
I would like to understand how to extract the BCFT data by the non-positive bootstrap.
I'm also interested in studying non-unitary CFTs by the non-positive conformal bootstrap, such as the percolations and self-avoiding walks.

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Critical phenomena and Conformal bootstrap

Participant: Parijat Dey[1]

[1] *Uppsala University*

I am interested in various aspects of critical phenomena and conformal bootstrap. I work on analytic conformal bootstrap techniques to explore critical systems. At this workshop I would like to learn how statistical physics systems in higher dimensions (e.g. Q-state critical Potts model, percolation) can be studied using conformal bootstrap.

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Analytic bootstrap

Participant: Marc Gillioz[1]

[1] *SISSA*

I am a high-energy physicist interested in analytical approaches to the conformal bootstrap. I am currently working on developing conformal field theory in Minkowksi momentum space. At this workshop I am looking forward to hearing about open problems and about the role played by unitarity in statistical physics.

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Phase transitions that defy the Landau-Ginzburg paradigm

Participant: Andrea Manenti[1]

[1] *Department of Physics and Astronomy, Uppsala University*

I am interested in the application of the conformal bootstrap aimed at better understanding deconfined quantum critical points, mainly in three dimensions. These are phase transitions that defy the Landau-Ginzburg paradigm in that they do not have a disordered phase in either side of the phase diagram.

From the literature it seems that building lattice models that display this phenomenon is not easy at all. So the bootstrap has the potential of being a very effective tool for studying these critical points.

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Bootstrap for statistical mechanics models, and disordered systems

Participant: Kay Wiese[1]

[1] *LPENS*

The bootstrap program is very successful for unitary CFTs. On the other hand, there are many systems in statistical mechanics which are not described by a unitary field theory, such as self-avoiding polymers or loop-erased random walks. While these models are accessible via standard perturbative RG, disordered systems are even more challenging, as they demand to use a functional RG. I wish to explore their foundations in the bootstrap approach.

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Conformal random geometry

Participant: Jesper Jacobsen[1]

[1] *Laboratoire de Physique de l'Ecole Normale Supérieure*

Generally my research concerns conformal field theory and exactly solvable models. Most of my past activity concerns two dimensions, but I am currently trying to move into higher dimensions as well.

One of my main interests is conformal random geometry, that is, the study of conformally invariant models of geometric critical phenomena, such as percolation, the FK cluster model, self-avoiding walks and loop models with various symmetries. I am working on bringing the corresponding non-unitary field theories under control from the bootstrap perspective.

I am also interested in the corresponding algebraic aspects, both in two dimensions (affine Temperley-Lieb algebra and generalisations) and in higher dimension (join-detach algebra and other partition algebras). The goal is to understand operators that insert extended geometric objects from a representation theoretical perspective.

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Percolation models with long-range correlations

Participant: Raoul Santachiara[1]

[1] *CNRS*

I work on 2D conformal field theories. I am interested in studying their properties, in particular the ones that allows their application to statistical models and condensed matter problems.

In the last few years I focused my attention on a wide range of interesting percolation model with long-range correlation.
For instance, the random cluster Potts model is a percolation model where the bonds are not activated independently one to the other but two distant bonds are activated with a correlation which decays algebraically with the distance. The study of CFT describing its percolation critical point has been an 30 y.o. open problem that now bootstrap techniques has almost solved.

There are other long range percolation model that seem to challenge our comprehension of CFT, two examples in particular: the level-set of fractional Gaussian surface (including the celebrated 2D Gaussian free field) and the Potts spin cluster…

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Non-positive bootstrap

Participant: Miguel Fernandes Paulos[1]

[1] *Ecole Normale Superieure*

I work on understanding the crossing equations arising in the study of CFTs and how to extract their physical implications in an optimal way. In recent years I've been developing a set of tools called analytic functionals which in a sense provide a dual basis for these equations. For this meeting, I am particularly interested in understanding how to extend traditional bootstrap methods for problems

without positivity, such as non-unitary CFTs, defect bootstrap, thermal bootstrap, etc. My hope is that these analytic functional methods, which to a large extent are independent of unitarity, or relatedly the technique of extremal flows/Gliozzi's method can be put to use for this, e.g. by continuously deforming a unitary solution to crossing, which we can bootstrap efficiently, to a non-unitary one.

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Bootstrap for phase transitions

Participant: Slava Rychkov[1]

[1] *IHES & ENS*

For the purposes of this program, my main interest is to applying the conformal bootstrap to study interesting stat-phys and cond-mat phase transitions.

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Semi-definite programming for non-unitary CFTs?

Participant: Sylvain Ribault[1]

[1] *IPhT Saclay*

Semi-definite programming is a technique for solving unitary CFTs, which relies on the positivity of squared structure constants. Positivity is violated in non-unitary CFTs, so the technique may not apply. However, looking at exactly solved 2d CFTs such as minimal models, we see that positivity is violated in a very secific way: minus signs can be traced back to some two-point functions. This raises the hope of using semi-definite programming for a large class of non-unitary CFTs.

For more details, see this Wikiversity page.

I am interested in using Wikis (Wikipedia, Wikiversity) for research in general and for Bootstat 2021 in particular. There is no Wikipedia page on structural phase transitions…