The Mathematics of Conformal Field Theory II

Title & Abstracts

5 – 9 July 2021

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Scaling limit of the six-vertex model and two-dimensional black holes

Vladimir Bazhanov
Australian National University

In this talk I will report a detailed study of the scaling limit of a certain critical, integrable inhomogeneous six-vertex model subject to twisted boundary conditions. It is based on a numerical analysis of the Bethe ansatz equations as well as the powerful analytic technique of the ODE/IQFT correspondence. The results indicate that the critical behaviour of the lattice system is described by the gauged SL(2) WZW model with certain boundary and reality conditions imposed on the fields. Our proposal revises and extends the conjectured relation between the lattice system and the Euclidean black hole non-linear sigma model that was made Ikhlef, Jacobsen and Saleur in the 2011.

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Results on genus two supermoduli

Kowshik Bettadapura
University of Melbourne

It is a folklore result that the supermoduli space of curves in genus two is `split' as a superspace. Roughly this means the genus two, supermoduli space can be holomorphically fibered over its underlying space. In this talk I will explain why such fibrations are important to superstring theory and why it seems they rarely exist. In addition, I will describe an explicit splitting of the genus two, supermoduli space thereby confirming the folklore and suggest directions for further research.

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Jones Actions: From Conformal Field Theory to Richard Thompsons Group

Arnaud Brothier
UNSW Sydney

In his quest in constructing conformal field theories from subfactors Vaughan Jones found an efficient machine to produce actions of groups such as the celebrated Richard Thompson's group. I will tell this beautiful story and present a general overview of this novel technology. Examples and applications toward group theory will be discussed.
Some of the results presented come from joint works with Vaughan Jones and with Valeriano Aiello and Roberto Conti.

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Defects in Abelian gauged linear sigma models

Ilka Brunner
Ludwig-Maximilian University, Munich

I will consider supersymmetric Abelian gauge theories in two dimensions that exhibit geometric as well as Landau-Ginzburg phases. The category of D-branes is described in terms of the derived category of coherent sheaves in a geometric phase, and in terms of matrix factorizations in the Landau-Ginzburg phases. I will discuss functors between these categories that are constructed in terms of defects.

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Moduli spaces of principal 2-group bundles and a categorification of the Freed- Quinn line bundle

Emily Cliff
University of Sydney / Université de Sherbrooke

A 2-group is a higher-categorical analogue of a group, while a smooth 2-group is a higher- categorical analogue of a Lie group. An important example is the string 2-group, defined by Schommer-Pries. We study the notion of principal bundles for smooth 2-groups and investigate the moduli “space” of such objects.
In particular, the case of principal bundles for a finite 2-group over a Riemann surface, we prove that the moduli space gives a categorification of the Freed-Quinn line bundle. This line bundle has as its global sections the state space of Chern-Simons theory for the underlying finite group. We can also use our results to better understand the notion of geometric string structures (as previously studied by Waldorf and Stolz-Teichner).

This is joint work with Dan Berwick-Evans, Laura Murray, Apurva Nakade, and Emma Phillips.

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Subregular W-algebras

Zachary Fehily
The University of Melbourne

While regular W-algebras have enjoyed many years of study and attention, recent developments in physics have the less popular subregular W-algebras playing an important role. Moreover, these subregular W-algebras appear at levels where the corresponding conformal field theory is likely non-rational. This necessitates a deeper understanding of the representation theory of such vertex operator algebras at non-rational levels. In this talk, I will describe how an 'inverse quantum Hamil- tonian reduction' approach relates much of this representation theory to that of the corresponding regular W-algebra at rational levels.

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Codes, spinors and topological modular forms

Nora Ganter
The University of Melbourne

I will report on some recent work with Gerd Laures, exploring the role of codes, lattices and vertex operator algebras in the context of stable homoloty theory in a new light.
We will see how the Hamming code H(8,4) is responsible for some important classical phenomena at the number 8, such as Bott periodicity in KO-theory or the triality symmetry of Spin(8). Time permitting, I will touch on the next chromatic level, elliptic cohomology, and explain what is understood here.

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Small index subfactors, quadrilaterals and fusion categories

Pinhas Grossman
UNSW Sydney

This talk will describe a coincidence of 3 stories in subfactor theory. The first story is the classification of small index subfactors beyond index 4, initiated by Haagerup, which found exactly 3 examples below index 5 which appear unrelated to groups or quantum groups.
The second story is the Galois group classification of non-commuting, co-commuting quadrilaterals of subfactors with "minimal extra structure", which found 3 such classes.

The third story is the representation theory of fusion categories associated to small index subfactors, which allows for a complete description of related intermediate subfactors. It turns out that the three “exotic” subfactors of small index realize small or minimal examples of the three Galois classes of quadrilaterals.

This is based on joint work with Masaki Izumi, Scott Morrison, David Penneys, Emily Peters, and Noah Snyder.

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Representation theory of vertex operator algebras and conformal field theory

Yi-Zhi Huang
Rutgers University

A program to construct weakly and full conformal field theories in the sense of Segal using the representation theory of vertex operator algebras was started more than 30 years ago. After more than 30 years, major progresses have been made and many problems in this program have been solved.

In this talk, I will review the history of and the major progresses in this program and will also discuss the current status of this program.

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On TTbar deformations and supersymmetry

Gabriele Tartaglino-Mazzucchelli

University of Queensland

In the last few years there has been considerable interest in quantum field theories in two dimensions deformed by the irrelevant “TTbar” operator (the determinant of the stress-energy tensor).

In this talk I will give a brief overview of this research topic and describe results on TTbar deformation of supersymmetric theories.

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Jim McCarthy
Defence Science and Technology Group

Celebrating the work of Peter Bouwknegt

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Heterotic Moduli Spaces and Universal Geometry

Jock McOrist
University of New England

This talk is about derivatives.
In studying the moduli space of the compactifications of the heterotic string, a key principle is gauge invariance. Deformations of gauge dependent quantities, such as the connection 1-form, are required to transform appropriately under gauge transformations. This leads to a covariant derivative with respect to parameters. This in turns leads to studying the differential geometry of the total space of a fibration of heterotic vacua over its moduli space.
There are natural tensors defined on fibration that satisfy relations similar to F-terms of supersymmetry. That these tensor equations hold at all is surprising. Moreover, they lead to short-cuts to otherwise difficult algebraic calculations.

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Vertex algebras associated with centralizers

Alexander Molev
Sydney University

By a celebrated theorem of Feigin and Frenkel (1992), the center of the affine vertex algebra at the critical level, associated with a simple Lie algebra **g**, is an algebra of polynomials in infinitely many variables. This theorem was extended in a more recent work by Arakawa and Premet (2017) to the case where **g** is replaced by the centralizer of a nilpotent element in **g**.
We construct a family of generators of the center in the case of simple Lie algebras of type A and arbitrary nilpotent elements. Furthermore, we use a version of the BRST complex of the quantum Drinfeld–Sokolov reduction, to introduce a new family of W-algebras associated with such centralizers. A family of free generators of these W-algebras is produced in an explicit form.

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AdS Vacua of Maximal Supergravities

Krzysztof Pilch
University of Southern California

I will review recent progress in classifying critical points of scalar potentials in maximal gauged supergravities in four and five dimensions and their uplifts to AdS solutions of M-theory and type IIA/IIB supergravities.

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Symmetry protected topological phases and dualities

Robert Pryor
The University of Melbourne

Certain quantum spin chains exhibit symmetry protected topological (SPT) phases, the transitions between which cannot be detected by any local order parameter. They can however be detected by a certain class of objects known as the Pollmann-Turner invariants. Recently Thomas Quella has presented significant evidence that SPT phases can also exist in systems which lack conventional symmetries, instead possessing only dualities. However, there has so far been no general way to distinguish these phases. In this talk I will first introduce the Pollmann-Turner in- variants, and then develop a generalisation of this theory which allows one to distinguish SPT phases in spin chains with dualites.
This talk is based on joint work with Thomas Quella.

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Conformal Field Theory, Topological Phases of Matter and Long-Range Spin Models

Thomas Quella
The University of Melbourne

In this talk we review connections between Conformal Field Theory and Topological Quantum Field Theories as well as their realization in terms long-range spin models. The latter are constructed as parent Hamiltonians associated with infinite-dimensional matrix product states that arise from CFT correlation functions. Examples will focus on SU(N) level 1 and SU(2) level k WZW models.

References:
[1] https://doi.org/10.1016/j.nuclphysb.2014.07.002
[2] https://doi.org/10.1088/1742-5468/ab7c62

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On the representation theory of $A_1^{(1)}$ at fractional level

Jorgen Rasmussen
The University of Queensland

We will discuss the representation theory of the affine Lie algebra $A_1^{(1)}$ at fractional level and its links to the representation theory of the Virasoro algebra. We will introduce affine Kac modules and the corresponding affine Kac tables, discuss staggered modules, and classify and express irreducible (including non-admissible) characters in terms of so-called reduced theta functions. We will extend the applicability of the Goddard-Kent-Olive coset construction to include the affine Kac modules and staggered modules and introduce a map between the associated categories of $A_1^{(1)}$ and Virasoro modules. At the level of characters, its action generalises the Mukhi-Panda residue formula.

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Wightman CFT and vertex operator algebras

Christopher Raymond
Australian National University

This talk presents recent work on the relationship between vertex operator algebras (VOAs) and conformal Wightman quantum field theories. Motivated by bridging the descriptions of chiral CFT provided by VOAs and conformal nets, we make use of Wightman axiomatic QFT as a touchstone. In particular, we develop the dictionary between conformally covariant Wightman fields and smeared fields of a unitary VOA.

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Twisted D-modules on affine flag varieties and Whittaker modules

Anna Romanov
University of Sydney

We propose a construction of twisted equivariant D-modules on the affine flag variety whose global sections have the structure of negative level Whittaker modules for an affine Kac-Moody algebra. We prove non-existence of such modules in the case of non-degenerate nilpotent character.
In this talk I will describe results that we have established so far, focusing on the example of SL2. This is joint work with Emily Cliff (Sydney/Sherbrooke).

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From N=2 SCFT to supersymmetric lattice models

Kareljan Schoutens
University of Amsterdam

One of the many intricate connections between lattice models and CFT's is finitisation, starting from a 'particle' basis of the CFT, and capping the 1-particle momenta leads to a finite dimensional Hilbert space which sometimes admits an interpretation as a quantum lattice model. Applying this procedure to the k-th minimal model of N=2 superconformal field theory (SCFT) leads to (integrable & critical) lattice models, known as Mk models, with manifest N=2 supersymmetry on the lattice. There are many interesting ramifications. Off-critical extensions in 1D have characteristic kink excitations and connect to integrable massive N=2 QFT, while the M1 model on 2D grids displays a phenomenon called superfrustration – a massive degeneracy of zero-energy supersymmetric ground states.

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More about CFT correlators

Christoph Schweigert
University of Hamburg

We give a complete description of the field content of a rigid finite local conformal field theory. This does not require semi simplicity of the underlying modular tensor category. We show that, if the modular category is semi simple, the Lewin-Wen string net construction provides a direct description of CFT correlators.

Based on work with Jürgen Fuchs and Yang Yang.

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Tensor network bootstrap of 2d Topological Quantum Field Theories

Sukhbinder Singh
University of Melbourne

I will show how the algebraic data (a commutative Frobenius algebra) underlying 2d TQFTs arises when combining scale and translation invariance in quantum lattice systems. Scale invariance is defined with respect to a particular lattice renormalization group transformation known as entanglement renormalization [1]. A scale-invariant quantum state under this transformation is described by a tensor network called the (scale-invariant) multi-scale entanglement renormalization ansatz (MERA) [2] — a successful numerical ansatz for ground states of 1d quantum critical models [3]. However, a generic quantum state within this ansatz

breaks translation symmetry. I will propose (sufficient but perhaps not necessary) polynomial tensor constraints that when fulfilled by a MERA imply translation invariance, and show that some solutions of these constraints correspond to the algebraic data of 2d TQFTs. Time permitting, I will speculate why there might also be solutions that analogously correspond to 2d rational CFTs.
Based on ongoing work.

REFERENCES

1. Entanglement renormalization was proposed in G. Vidal, PRL 99, 220405 (2007); arXiv:cond-mat/0512165
2. MERA was proposed in G. Vidal, PRL 101, 110501 (2008); arXiv: quant-ph/0610099
3. Remarkably, from the MERA representation of a 1d critical ground state, one can easily and accurately extract the scaling dimensions and OPE coefficients of the underlying conformal field theory. See e.g. R. N. C. Pfeifer, G. Evenbly, and G. Vidal, PRA Rapid Communications 79(4), 040301 (2009); arXiv:0810.0580

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Examples of monoidal equivalences

Daniel Tan
The University of Melbourne

The representation theory of vertex operator algebras gives rise to monoidal categories. I will discuss two examples of when said monoidal categories are equivalent to monoidal categories obtained through other structures, specifically quantum group representations and matrix bifactorisations.

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The ring structure of twisted equivariant *KK*-theory for noncompact Lie groups and the relation to CFT

Mathai Varghese
The University of Adelaide

Let G be a connected semi-simple Lie group with torsion-free fundamental group. We show that the twisted equivariant KK-theory $KK_\bullet^G(G/K, \tau_G^G)$ of G has a ring structure induced from the renowned ring structure of the twisted equivariant K-theory $K^\bullet_K(K, \tau_K^K)$ of a maximal compact subgroup K. We give a geometric description of representatives in $KK_\bullet^G(G/K, \tau_G^G)$ in terms of equivalence classes of certain equivariant correspondences and {obtain an optimal set of generators of this ring}. We also establish various properties of this ring under some additional hypotheses on G and give an application to the quantization of q-Hamiltonian G-spaces in an appendix. We also suggest conjectures regarding the relation to positive

energy representations of *LG* that are induced from certain unitary representations of *G* in the noncompact case. This is joint work with Alex Fok.

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Discrete fluxes, higher-form symmetries and ward identities

Siye Wu
Department of Mathematics, National Tsing Hua University, Hsinchu 30013, Taiwan

We study discrete electric and magnetic fluxes in gauge theories from algebraic and topological viewpoints. We explain that for a general choice of spacial slice and gauge group, the electric and magnetic fluxes can not be simultaneously specified in a sector of quantum Hilbert space and we relate this phenomena to the uncertainty of fluxes discovered previously in Abelian gauge theories. We further interpret the discrete fluxes as charges of higher-form symmetries, which leads to an enhanced understanding of higher-form symmetries in terms of cohomology groups of spacetime with coefficients in a group. More generally, higher-form symmetries exist whenever there are constant gauge transformations. Finally, we explore the relations to Noether's second theorem and higher Ward identities.

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