Student Workshop on Integrability
Scientific Program

Online, 26 - 30 April 2021

Contents

1 General Information

It is already the second time we have the pleasure to organise the Student Workshop on Integrability. We are glad to (virtually) see a lot of familiar faces and warmly welcome all the new participants. Please do keep in touch with us after the event and look out for the future editions of SWI.

You can follow us on

Web:	https://integrability.pj4e.de/
Facebook:	https://www.facebook.com/swintegrability
LinkedIn:	https://www.linkedin.com/groups/12509309/

Or send us an email at: organizers@integrability.pj4e.de

Any questions can be sent also directly to the organisers.

- Philipp JAEGER (U Manitoba and BU Wuppertal), jaegerp@myumanitoba.ca

- Andrew URICHUK (U Manitoba), andrew.urichuk@gmail.com

- Aleksandra ZIOLKOWSKA (U Oxford), aleksandra.ziolkowska@physics.ox.ac.uk

1.1 Scientific Program

All talks will take place on BigBlueButton. The conference room is accessible under:
https://meet.gwdg.de/b/phi-owk-ntk-bvr.

We will be recording the talks and upload them here:
https://moodle.integrability.pj4e.de.
You will need to sign up and "register" for the SWI 2021 course in order to access the materials. The recordings will be available ONLY to the participants of the workshop.

1.2 Social Program

The social event are going to happen at wonder.me

https://www.wonder.me/r?id=ef703342-9273-4f70-b186-b402cbc5ad8f

This room will be open also outside of the official social events, so feel free to use it for socialising during the day!

"Online Social Night" and "Integrable Beers Online" are planned to be an opportunity for you to get to know the integrability community or just catch up with the old friends. Feel free to bring to your screen your favourite alcoholic or non-alcoholic beverage and prepare for a time of leisurely conversations. Though of course if you are still in a scientific zeal, feel free to have beer infused physics discussions!

1.3 Instructions

We're all getting more familiar with video-conferencing tools as the time goes by, but it's probably useful to share the following remarks:

- The video conferencing tool we use is BigBlueButton (BBB). It looks and feels a lot like many other solutions, but has some quite useful features we'd like to use, and is more privacy-friendly than for example zoom or MS Teams. Here is the access link: https://meet.gwdg.de/b/phi-owk-ntk-bvr

- BBB runs in the usual web browsers, installation of a client program is not necessary. For the discussions session after the talks each day, we will create break-out rooms and assign one to each speaker. Here the main benefit of BBB comes to play: while in the main room, users can select any breakout room they wish to join. So everyone can move around, and there is no need for an administrator assigning people to new breakout rooms. BBB supports a multi-user whiteboard mode. Users may want to have a blank pdf document available to upload and use as a drawing canvas.

- All participants join the conference room muted. Please only unmute yourself when instructed to do so by the session chair. During the day, the public chat and the shared notes in BBB will be used for housekeeping information. Please make sure to monitor the chat.

- All talks will be recorded and made available to the participants who aren't able to attend the session live through moodle at
https://moodle.integrability.pj4e.de/course/view.php?id=3.
You will need to create an account using your email address to access the course. This platform is private, and the recordings will be deleted after the workshop. However, some speakers may like to have their talks published. We have created a youtube channel to which we optionally upload the recordings.

- We use wonder.me as a networking platform. The platform will be available at all times during the conference. Users can move around freely, and if they come close to each other, they create a bubble in which they can video-chat. By default, other users can join an existing bubble, but bubbles can be made private using the lock toggle. The SWI 2021 room is here:
https://www.wonder.me/r?id=ef703342-9273-4f70-b186-b402cbc5ad8f

2 Schedule

	26/4 MONDAY	27/4 TUESDAY	28/4 WEDNESDAY	29/4 THURSDAY	30/4 FRIDAY
	All times are given in British Summer Time (UTC+1)				
11:00	Welcome Address	Jules Lamers (40) & Yuan Miao (40)	Cecilia de Fazio (40) & Levente Pristyak (40)	Kristof Hodsagi (40) & Ilya Vilkoviskiy(20)	Jonathan Belletete (40) & Alec Cooper (40) & Vadim Prokofev (20)
11:30	Joseph Durnin (40) & Cameron Booker (20)				
12:00				Break	
12:30	Break	Break	Break		
13:00				Nicolo Primi (20) & Per Moosavi (40)	Break
13:30	Aleksandra Ziolkowska (40) & Lucas Sa (40)	Invited Talk: Andreas Klumper	Invited Talk: Olalla Castro-Alvaredo		
14:00				Break	Lenart Zadnik (40) & Sandrine Brasseur (40)
14:30					
15:00	Break	Break	Gilles Parez (40) & Giuseppe (Del Vecchio)^2 (40)	Ziga Krajnik (40) & Brandon Morrison (40)	
15:30					Break
16:00	Etienne Garnet (40) & Giridhar Kulkarni (40) & Arthur Hutsalyuk (20)	Philipp Jaeger (20) & Andrew Urilyon (40) & Rodrigo Alves Pimenta (40)	Discussion Rooms	Discussion Rooms	Closing Address & Best Talk Award!
16:30					
17:00					
17:30		Discussion Rooms			
18:00	Discussion Rooms				
18:30					
19:00	Online Social Night			Integrable Beers Online	
19:30					
20:00					
20:30					
21:00					

List of Talks

Invited Talks

1. **Andreas Klümper**: *Thermodynamics and finite-size studies of integrable models: from TBA equations to reduced non-linear integral equations*
2. **Olalla Castro-Alvaredo**: *Entanglement Measures, Integrability and Out-of-Equilibrium Dynamics*

Contributed talks

Monday

1. **Joseph Durnin**: *Non-Equilibrium Dynamics for Weakly Broken Integrability*
2. **Cameron Booker**: *Bethe Ansatz Techniques for Dissipative Systems*
3. **Aleksandra Ziolkowska**: *Yang-Baxter Integrable Lindblad Equations*
4. **Lucas Sa**: *Integrable non-unitary open quantum circuits*
5. **Etienne Granet**: *Form factor expansions for correlations in and out-of-equilibrium*
6. **Giridhar Kulkarni**: *Asymptotic analysis of the form-factors of XXX chain*
7. **Artur Hutsaliuk**: *Leclair-Mussardo expansion of the correlation functions*

Tuesday

8. **Jules Lamers**: *Recent advances for integrable long-range spin chains*
9. **Yuan Miao**: *Q operator, spectrum and hidden Onsager algebra in XXZ model at root of unity*
10. **Philipp Jaeger**: *Relaxation dynamics after a quantum quench*
11. **Andrew Urichuk**: *Form factor expansions for correlations in and out-of-equilibrium*
12. **Rodrigo Alves Pimenta**: *Scalar product for the XXZ spin chain with general integrable boundaries*

Wednesday

13. **Cecilia De Fazio**: *Generalised Hydrodynamics of Unstable Excitations*
14. **Levente Pristyak**: *Current mean values in integrable spin chains*
15. **Gilles Parez**: *Quasiparticle dynamics of symmetry-resolved entanglement after a quench*
16. **Giuseppe Del Vecchio Del Vecchio**: *The hydrodynamic theory of dynamical correlation functions in the XX spin chain*

Thursday

17. **Kristof Hodsagi**: *Kibble-Zurek mechanism in an integrable field theory*
18. **Ilya Vilkoviskiy**: *Integrable theories consistent with affine Yangian symmetry*
19. **Nicolo Primi**: *Boundary integrability for cusped Wilson Loops in N=4 SYM*
20. **Per Moosavi**: *A geometric approach to Floquet systems described by inhomogeneous CFT*

21. **Ziga Krajnik**: *Anistropic Landau-Lifshitz model in discrete space-time*

22. **Brandon Morrison**: *Excited States of the Sinh-Gordon Model Via Analytic Continuation of the TBA Equations*

Friday

23. **Jonathan Belletete**: *Topological defects in integrable lattice models*

24. **Alexander Cooper**: *TQ-Relations for Open Spin Chains - An Algebraic Approach*

25. **Vadim Prokofev**: *Elliptic solutions to the KP hierarchy and elliptic Calogero-Moser model*

26. **Lenart Zadnik**: *Rigorous bounds on dynamical response functions and time-translation symmetry breaking*

27. **Sandrine Brasseur**: *Sum rules for the supersymmetric eight-vertex model*

3 Invited Talks

1. THERMODYNAMICS AND FINITE-SIZE STUDIES OF INTEGRABLE MODELS: FROM TBA EQUATIONS TO REDUCED NON-LINEAR INTEGRAL EQUATIONS

   Andreas Klümper
   University of Wuppertal

   In this talk I will present a unified treatment for the calculation of finite-size data to the energy eigenvalues of integrable Hamiltonians and of their thermodynamic potentials at arbitrary temperatures. The goal is achieved in two steps. First a Trotter-Suzuki like mapping of the Hamiltonian to an exactly solvable staggered vertex model and the formulation of a suitable transfer direction reduces the problem of thermodynamics to the calculation of just the leading eigenvalue of the quantum transfer matrix. This task is very much like that for calculating eigenvalues for finite row-to-row transfer matrices of integrable vertex models. The second step concerns the actual calculation of the eigenvalues either by use of a Bethe ansatz or by use of the fusion procedure and solving functional equations of T- and Y-system type. This will result in coupled non-linear integral equations (NLIE) of thermodynamical Bethe ansatz (TBA) type. I will show how in general, without restricting the treatment to special anisotropies corresponding to roots of unity and without approximation errors, the NLIEs can be truncated to a finite set. The seminal models for the presentation of these methods will be su(2) invariant systems. However, some generalizations to higher rank models will be given.

2. ENTANGLEMENT MEASURES, INTEGRABILITY AND OUT-OF-EQUILIBRIUM DYNAMICS

   Olalla Castro-Alvaredo
   City, University of London

   In this talk I will review a particular approach to the evaluation of measures of entanglement in 1+1-D Integrable Quantum Field Theory, known as the Branch Point Twist Field Approach. This is an area in which I have worked (with various collaborators) for the past 13 years. I will show with few examples how this powerful method can give us access to universal (e.g. largely theory-independent) features of entanglement beyond criticality. Drawing on more recent results, I will also discuss how the same approach can be generalized to deal with some out-of-equilibrium problems, that is, the investigation of the dynamics of entanglement after a quantum quench.

4 Contributed talks

4.1 Monday

1. NON-EQUILIBRIUM DYNAMICS FOR WEAKLY BROKEN INTEGRABILITY

Joseph Durnin
King's College London

I will describe how these defects can be constructed for certain classes of integrable models, and how the structure of the resulting system can be obtained from the representation theory of the underlying algebra. I will also present some of the more exotic models which we have built this way.

2. BETHE ANSATZ TECHNIQUES FOR DISSIPATIVE SYSTEMS

Cameron Booker
University of Oxford

I will discuss how to use the Bethe Ansatz technique to study dissipative systems experiencing loss by exactly calculating the Liouvillian spectrum and particular eigenstates. This opens the possibility of analytically calculating the dynamics of a wide range of experimentally relevant models including cold atoms subjected to one and two body losses, coupled cavity arrays with bosons escaping the cavity, and cavity quantum electrodynamics. As an example of our approach I will discuss the relaxation properties in a boundary driven XXZ spin chain. I will demonstrate how we may exactly calculate the Liouvillian gap and find different relaxation rates with a novel type of dynamical dissipative phase transition. This physically translates into the formation of a stable domain wall in the easy-axis regime despite the presence of loss. Such analytic results have previously been inaccessible for systems of this type. Based on: Buca, B., Booker, C., Medenjak, M., & Jaksch, D. (2020). Bethe ansatz approach for dissipation: exact solutions of quantum many-body dynamics under loss. New Journal of Physics.

3. YANG-BAXTER INTEGRABLE LINDBLAD EQUATIONS

Aleksandra Ziolkowska
University of Oxford

Open quantum systems are ubiquitous in the contexts of atomic and molecular physics, circuit QED and optomechanics. Despite their relevance, the theoretical methods used to approach them are far less developed than for closed systems. This talk aims to show that for a large group of Markovian open quantum systems, it is possible to obtain exact analytic solutions through a connection with integrable models. I will describe how such a correspondence can be established and what information about the open systems it provides. In particular, I will discuss the equivalence in structure of generalised Hubbard models and vectorised Lindblad equations. If time permits, I will also mention the newest extension to this formalism based on the operator space fragmentation. The talk

is mainly based on the work with F. Essler presented in SciPost Phys. 8, 044 (2020).

4. Integrable non-unitary open quantum circuits

Lucas Sa

CeFEMA & IST, University of Lisbon

Local quantum circuits have become an important paradigm of many-body physics as, in particular, they allow for the simulation of complex quantum systems in emerging quantum computing facilities. While much is already known about unitary and projective-measurement circuits, it is also of interest to extend their study to open and nonequilibrium quantum setups. With this goal, we consider quantum circuits in the Kraus map representation of completely positive quantum dynamics and discuss the first exactly-solvable, yet strongly-interacting, non-unitary open quantum circuit. We prove integrability by constructing an inhomogeneous transfer matrix generating conserved super-operator charges, show that the circuit is completely positive and trace-preserving, and identify regimes of integrability-breaking. We confirm all our analytical results by using the recently introduced complex spacing ratios to examine the spectral statistics of the dissipative circuits.

5. Form factor expansions for correlations in and out-of-equilibrium

Etienne Granet

University of Oxford

I will consider the problems of calculating the dynamical order parameter two-point function at finite temperatures and the one-point function after a quantum quench in the transverse field Ising chain. Both of these can be expressed in terms of form factor sums in the basis of physical excitations of the model. I will present a general framework for carrying out these sums based on a decomposition of form factors into partial fractions, which leads to a factorization of the multiple sums and permits them to be evaluated asymptotically. This naturally leads to systematic low density expansions. At late times these expansions can be summed to all orders by means of a determinant representation.

6. Asymptotic analysis of the form-factors of XXX chain

Giridhar Kulkarni

University of Burgundy, Dijon

One of the important and interesting aspect of studying quantum integrable models is to access the exact results for correlation functions using non-perturbative method. Form-factor approach, with regards to two-point correlation function in particular, has been proved to be a very effective tool. In this talk I will present a new technique that was developed to obtain thermodynamic limit of form-factors of quantum spin chains starting from their determinants representations in algebraic Bethe ansatz. In a joint work with N. Kitanine, we first proposed this approach for two-spinon form-factor of XXX model where previous results obtained from q-vertex operator algebras were retrieved exactly in the algebraic Bethe ansatz framework for the first time. We further applied this approach to the form-factors of a generic low-lying excitation of the XXX

model described by 2n spinons and containing complex roots that are determined from higher-level Bethe equations originally found by Destri & Lowenstein. Using our approach we find that generic form-factors can be written in terms of determinants of finite size involving an emergent higher-level structure due to the presence of complex roots.

7. LECLAIR-MUSSARDO EXPANSION OF THE CORRELATION FUNCTIONS

Artur Hutsaliuk
Eotvos Lorand University Budapest

I will talk about the Leclair-Mussardo expansion of the correlation functions. This expansion allows one to express correlators in terms of a series of so-called symmetric form factors, which are the special limit of the matrix elements of operators. In a strong coupling regime, such corelators have a good convergence, that allows significantly simplify computation correlation functions.

4.2   Tuesday

1. RECENT ADVANCES FOR INTEGRABLE LONG-RANGE SPIN CHAINS

Jules Lamers
University of Melbourne

I will introduce the landscape of quantum-integrable long-range spin chains, give an overview of the associated (quantum-)algebraic structures, and describe some of the recent advances and open problems in the field.

Unlike for the traditionally studied nearest-neighbour Heisenberg spin chains, the exact solvability / quantum integrability of long-range spin chains exploits connections to quantum-many body systems of Calogero–Sutherland (or Ruijsenaars–Macdonald) type. For the so-called Haldane–Shastry spin chains this can be understood in terms of affine Hecke algebras, which yield Yangian (or quantum-loop) symmetries as well as eigenvectors featuring Jack (or Macdonald) polynomials. The Inozemtsev spin chain interpolates between Heisenberg and Haldane–Shastry. Its spectrum admits an exact characterisation in terms of eigenfunctions of the elliptic quantum Calogero–Sutherland model; here the underlying quantum-algebraic structure is not understood yet.

My talk is based on joint work with R. Klabbers (Nordita), with V. Pasquier and D. Serban (IPhT CEA/Saclay), and work in progress.

2. Q OPERATOR, SPECTRUM AND HIDDEN ONSAGER ALGEBRA IN XXZ MODEL AT ROOT OF UNITY

Yuan Miao
University of Amsterdam

I will discuss the recent progress on the construction of Q operator and complete spectrum of XXZ model at root of unity. I will also mention conjecture on the hidden

Onsager algebra symmetry as a generalisation of the XX case.

3. Relaxation dynamics after a quantum quench

Philipp Jaeger

University of Manitoba, Bergische Universität Wuppertal

Dynamics of many-body quantum systems is a notoriously complicated problem. Naively, the dimension of the Hilbert space grows exponentially. If the particles interact, solutions are only available for very small systems ($\sim$ dozens of particles) in general. Integrable models represent special cases where the presence of conserved quantities can be exploited to find explicit solutions. However, calculations based on the Bethe ansatz are often tedious, and the full time evolution remains unknown to date. We approach this problem numerically using DMRG, and investigate the decay of correlation functions after a quantum quench towards their equilibrium value. For some cases in integrable models, the equilibrium value is known from TBA or Quench Action calculations. If integrability is broken, we find the thermal state through the DMRG algorithm in imaginary time evolution mode.

4. Form factor expansions for correlations in and out-of-equilibrium

Andrew Urichuk

University of Manitoba, Bergische Universitat Wuppertal

In the XXZ model at zero external magnetic field conservation laws protect part of the spin current, resulting in a non-zero spin Drude weight $D(T)$. Numerical computations imply that the Drude weight exhibits a nowhere continuous (or fractal) dependence on the anisotropy of the model when $T > 0$, this is consistent with exact infinite temperature results. Here I present analytic results for $D(T)$ at low temperatures for anisotropies $\cos(n\pi/m)$ with n, m coprime integers as treated by thermodynamic Bethe ansatz as appears in the preprint arXiv:2104.0326.

5. Scalar product for the XXZ spin chain with general integrable boundaries

Rodrigo Alves Pimenta

Federal University of Lavras

We calculate the scalar product of Bethe states of the XXZ spin-1/2 chain with general integrable boundary conditions. The off-shell equations satisfied by the transfer matrix and the off-shell Bethe vectors allow one to derive a linear system for the scalar product of off-shell and on-shell Bethe states. We show that this linear system can be solved in terms of a compact determinant formula that involves the Jacobian of the transfer matrix eigenvalue and certain q-Pochhammer polynomials of the boundary couplings.

4.3 Wednesday

1. ### GENERALISED HYDRODYNAMICS OF UNSTABLE EXCITATIONS

Cecilia De Fazio
City, University of London

In quantum field theory, unstable particles are associated to a special analytic structure of the S-matrix. Because of their finite lifetime, they are generally hard to study. In this talk we investigate further the physics of unstable particles by implementing the generalised hydrodynamic (GHD) approach. Based on two recent works (*arXiv:2005.11266* and *arXiv:2103.03735*), we consider a model possessing both unstable excitations and quantum integrability, and analyse the effects of instability on the out-of-equilibrium states arising from two different set-ups: the partitioning protocol and an inhomogeneous quench. We will see that in these two cases, the GHD approach unveils new evidence of unstable excitations, going much beyond their definition in terms of the analytic structure of the S-matrix.

2. ### CURRENT MEAN VALUES IN INTEGRABLE SPIN CHAINS

Levente Pristyak
Budapest University of Technology and Economics

Integrable models are unique among physical systems because of the high number of conserved charges present in them. The current operators corresponding to these charges attract attention for several reasons: they play an important role in Generalized Hydrodynamics, which describes the Euler-scale transport processes of these systems, and also they are connected to the theory of factorized correlation functions. In my talk, I present two approaches for the calculation of the expectation values of the current operators in the finite size XXZ spin chain: one based on a form factor expansion and one using algebraic Bethe Ansatz. Some preliminary results on the current operators of the XYZ model are also presented. This talk is based on joint work with Márton Borsi and Balázs Pozsgay.

3. ### QUASIPARTICLE DYNAMICS OF SYMMETRY-RESOLVED ENTANGLEMENT AFTER A QUENCH

Gilles Parez
Catholic University of Louvain

For quantum many-body systems with a global conserved charge, it is a non-trivial task to understand the contribution of each charge sector to the total entanglement. The interest for this « symmetry resolution of entanglement » gained a considerable attention during the last years. This interest is due to pioneering cold-atom experiments where it was argued that a refined understanding of the entanglement contribution from each symmetry sector is needed to better understand the many-body dynamics. In this talk, I will discuss the dynamics of the symmetry-resolved entanglement after a global quench in free fermionic systems and conformal field theories. In particular I will highlight two physical phenomena: (i) the symmetry-resolved entropies start evolving after a delay time that depends on the charge sector, and (ii) there is an effective equipartition of

entanglement when the charge sector is close to the mean value of the charge. I will also briefly discuss the case of entanglement measures for disjoint systems, namely the mutual information and the negativity. This talk is based on the paper Parez, Bonsignori, Calabrese, PRB 103, 2021.

4. THE HYDRODYNAMIC THEORY OF DYNAMICAL CORRELATION FUNCTIONS IN THE XX SPIN CHAIN

Giuseppe Del Vecchio Del Vecchio
King's College London

Correlation functions in theoretical models is what connects calculations to physical observables and it is well known that they are extremely difficult to compute in generic systems. Leaving apart numerical methods which, suffer their own problems, in cases where some analytic treatment is possible one can opt for two main approaches: one possibility is to exploit special underlying structures, like integrability, but one has to be able to carry out most of the times highly non-trivial computations; the second one is to perform some approximation based on physical considerations. In my talk I will talk about taking ideas from hydrodynamic theories, integrable models and large deviation theory to compute the leading exponential decay of certain kind of correlation functions. Using the example of the XX spin chain, I will show how this theory of large deviations for Euler scale observables reproduces the results of A.G. Izergin, V.E. Korepin et al. and how it gives a physical interpretation to the semiclassical theory developed by S. Sachdev. If time remains, will briefly discuss how to apply the same theory to interacting models.

4.4 Thursday

1. KIBBLE-ZUREK MECHANISM IN AN INTEGRABLE FIELD THEORY

Kristof Hodsagi
Budapest University of Technology and Economics

How can we describe the formation of order in critical systems? If we tune the control parameters such that the system crosses the critical point, the answer is given by the Kibble-Zurek mechanism (KZM) [1] that predicts universal dependence of observables on the rate of change of the control parameter. In recent years, the focus on quantum critical points [2] demonstrated the validity of the KZM in an extended set of systems. Our recent work [3] explores the KZM in the Ising Field Theory, where the quantum critical point can be crossed in different directions in the two-dimensional coupling space leading to different scaling laws. Using the Truncated Conformal Space Approach, we investigate the microscopic details of the KZM in terms of instantaneous eigenstates in a genuinely interacting field theory. For different protocols in two integrable field theories, we demonstrate dynamical scaling in the non-adiabatic time window and provide analytic and numerical evidence for specific scaling properties of various quantities.

[1] T. W. B. Kibble, Topology of cosmic domains and strings, J. Phys. A: Math. Gen. 9, 1387 (1976); W. H. Zurek, Cosmological experiments in superfluid helium?, Nature 317, 505 (1985). [2] J. Dziarmaga, Dynamics of a quantum phase transition and re-

laxation to a steady state, Adv. Phys. 59, 1063 (2010). [3] K. Hódsági, M. Kormos, Kibble–Zurek mechanism in the Ising Field Theory, SciPost Phys. 9, 055 (2020).

2. INTEGRABLE THEORIES CONSISTENT WITH AFFINE YANGIAN SYMMETRY

Ilya Vilkoviskiy
Higher School of Economics and SkolTech, Moscow

In this talk I will review our progress in understanding of infinite dimensional Integrable theories arising from affine Yangian. Most naturally such theories appear as a UV limit of integrable Toda field theories, the well known example provided by ILW hierarchy, also known as q-KDV. Here we develop a different view on the same systems, namely we introduce an infinite dimensional R-matrix, and study the corresponding RLL algebra. I will review the Bethe vectors/ Bethe equations in this case, and provide examples of different integrable systems arising from different representations of RLL algebra. Finally I will speculate that each Integrable theory of Affine Yangian can be continued to IR, providing a massive integrable field theory, in analogy to q-KDV/ Sine Gordon relation, which allows conjecture of new integrable field theories. Based on: arXiv:2007.00535 and arXiv:2003.04234

3. BOUNDARY INTEGRABILITY FOR CUSPED WILSON LOOPS IN N=4 SYM

Nicolo Primi
King's College London

A cusped Wilson line with J insertions of scalar fields at the cusp in N= 4 SYM forms an integrable system. I will show how it is possible to map such system to a quantum spin chain with open boundary conditions, and by applying integrability techniques such as the Baxter TQ-relation I will present the full, non-perturbative quantum spectrum for such observable.

4. A GEOMETRIC APPROACH TO FLOQUET SYSTEMS DESCRIBED BY INHOMOGENEOUS CFT

Per Moosavi
ETH Zurich

Conformal field theory (CFT) in 1+1 dimensions is routinely used to effectively describe quantum many-body systems in equilibrium. Recently, CFT has been used to study such systems out of equilibrium, even inhomogeneous ones with deformations such as a smooth position-dependent velocity. In this talk, I will present a new geometric approach to Floquet systems described by inhomogeneous CFT based on establishing an exact correspondence with dynamical systems on the circle. Our approach allows one to, for instance, analytically (and numerically) construct phase diagrams with nonheating/heating phases characterized by absence/presence of periodic points of diffeomorphisms encoding the time evolution and study phase transitions between them. This generalizes previous results for a small subfamily of similar systems that used only a finite-dimensional subalgebra to general smooth deformations that require the full Vi-

rasoro algebra.

5. Anistropic Landau-Lifshitz model in discrete space-time

Ziga Krajnik
University of Ljubljana

We introduce an integrable model in discrete space-time whose continuum-time limit is the anisotropic lattice Landau-Lifhsitz model. There is an easy axis and an easy plane regime, depending on the anisotropy parameter. We study transport of magnetization in both regimes and obtain the transport coefficients as functions of anisotropy and chemical potential. Upon approaching the isotropic point a transition to superdiffusive (KPZ) dynamics is observed.

6. Excited States of the Sinh-Gordon Model Via Analytic Continuation of the TBA Equations

Brandon Morrison
Durham University

We present the further development of a general method, first introduced by Dorey and Tateo in *arXiv:hep-th/9607167v2*, by which one may solve for the exact energy spectrum of an interacting quantum field theory. We begin from the model's ground state derived from the Thermodynamic Bethe Ansatz (TBA) equations. Using complex values for the coupling constant, we then use the technique of analytic continuation to entend the domain of analycity of the TBA equations. From here we can obtain the excited states of the given integrable model by analyzing the monodromies the TBA equations and their solutions undergo. This allows us to solve for the spectrum of an integrable model via an analysis of its Riemann surface. We choose to analyze the sinh-Gordon model and introduce our results. We also discuss some limitations of the technique.

4.5 Friday

1. Topological defects in integrable lattice models

Jonathan Belletete
CY Cergy Paris University

A defect is a boundary separating a system into multiple subsystems; it is topological if it can be deformed without changing the properties of the system as a whole, like its partition function or the eigenvalues of its Hamiltonian. While these defects can be interesting in their own right, one particular way to use them is to generate new integrable lattice models from old ones by stitching them together, using these defects as seams.

2. TQ-Relations for Open Spin Chains - An Algebraic Approach

Alexander Cooper
Heriot-Watt University

The existence of the Baxter TQ-Relation for some integrable model leads to an approach for diagonalising the Transfer Matrix of the system, through Bethe Ansatz-like equations. In this talk I will review the algebraic approach to constructing the Transfer Matrix and Q-Operator for the closed XXZ spin chain, and give a brief discussion of the extension of this method to the open XXZ and XXX chains.

3. Elliptic solutions to the KP hierarchy and elliptic Calogero-Moser model

Vadim Prokofev
MIPT, Skoltech

We consider solutions of the KP hierarchy which are elliptic functions of x=t1. It is known that their poles as functions of t2 move as particles of the elliptic Calogero-Moser model. We extend this correspondence to the level of hierarchies and find the Hamiltonian Hk of the elliptic Calogero-Moser model which governs the dynamics of poles with respect to the k-th hierarchical time. The Hamiltonians Hk are obtained as coefficients of the expansion of the spectral curve near the marked point in which the Baker-Akhiezer function has essential singularity.

4. Rigorous bounds on dynamical response functions and time-translation symmetry breaking

Lenart Zadnik
LPTMS, Université Paris-Saclay

Dynamical response functions are standard tools for probing local physics near the equilibrium. They provide information about relaxation properties after the equilibrium state is weakly perturbed. In this talk I will focus on systems which break the assumption of thermalization by exhibiting persistent temporal oscillations. We will discuss rigorous bounds on the Fourier components of dynamical response functions in terms of extensive or local dynamical symmetries, i.e. extensive or local operators with periodic time dependence. The paradigmatic example will be an interacting Floquet system, specifically the integrable Trotterization of the Heisenberg XXZ model.

5. Sum rules for the supersymmetric eight-vertex model

Sandrine Brasseur
Catholic University of Louvain

We are interested in the eight-vertex (8V) model on the square lattice with an odd number of columns and periodic boundary conditions. We consider a particular sub-family of parameters of the system, the ""supersymmetric"" or "combinatorial line", dubbed so due to its surprising links to combinatorics. More precisely, we are investigating a certain eigenvector of the transfer matrix of the model whose associated eigenvalue has been shown to have a remarkably simple expression. Incidentally, this vector also corresponds to the ground state of the XYZ spin chain Hamiltonian. Our goal is to evaluate specific scalar products (sum rules) involving this vector. These ultimately allow us to obtain exact expressions for conjectured XYZ ground-state components, as well as for 8V partition functions associated to different boundary conditions. This talk is based on joint work with Christian Hagendorf (arXiv:2009.14077 [math-ph]).

5   Acknowledgements

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