2024

Integrable models and their applications — The aim of our research group is to develop new integrable techniques and apply them in simplified models relevant for particle and statistical physics.

AdS/CFT duality. One of the main applications of integrability is in the AdS/CFT duality. This duality relates the maximally supersymmetric four dimensional gauge theory to string theory on the five dimensional anti de Sitter space and can be described by a two dimensional integrable quantum field theory. The recent focus of studies is on the calculation of the gauge theory's correlation functions.

Our research group have managed to connect the 3-point functions to finite volume form factors in the previous years. In the last year we published a new technique to calculate these finite volume form factors in two dimensional integrable quantum field theories.

In parallel, we have initiated a new approach to investigate 3-point functions in generic conformal field theories based directly on their integrable description. We pushed forward this program in the sine-Gordon model and managed to go beyond the leading order calculation. The second order calculation was more demanding but it can be used to determine all 3-point functions in the simplest non-trivial minimal model, i.e. in the Potts model.

Eventually, the gauge theory's 3-point functions should be expressed in terms of the Q-functions of the quantum spectral curve formulation. We developed a mathematica package, which calculates the spectrum of anomalous dimension in the maximally symmetric gauge theory, allowing us to extract 3-point functions with high precision numerically [1].

Many observables in four dimensional supersymmetric quantum gauge theories can be written as determinants of semi-infinite matrices. These observables include the octagon 4-point function, 3-point functions of orbifold and deformed theories, fluxe tube correlators, finite N corrections to free energies, expectation values of cusped Wilson loops and hexagon gluon scattering amplitudes and form factors. Based on the relation of these determinant observables to the Tracy-Widom distribution we developed a new technique to expand them both at weak and strong coupling at any order [2]. These strong coupling expansions are quite unique in the literature and we used our experience with asymptotic series to reveal their resurgence structure. Our paper [2] was selected among the highlights by the editors of PRL.

Non-trivial 1-point functions appear in the supersymmetric gauge theory if we introduce some defects. Previously we determined the expectation values of local single trace operators asymptotically in the presence of codimension one defects. In the integrability description they are related to overlaps between integrable boundary states and finite volume Bethe states. This year we managed to dualize these overlap formulas and describe the asymptotic overlaps at all coupling in the presence of the recently discovered integrable 't Hooft loop.

We investigated the generalizations of the standard holographic duality from anti de Sitter to more complicated backgrounds. In particular, we studied how the bulk geometries could be reconstructed in the various cases.

Integrability in statistical physical models. In the application of our results for statistical physical models we investigated renormalization group flows between different conformal field theories. We classified all integrable ultraviolet safe irrelevant perturbations of the minimal conformal field theories and provided the Ginzburg-Landau description of multi-critical Lee-Yang models. We also investigated the various ways of breaking integrability in the free fermion quantum spin chain and their effects on the adiabatic gauge potentials.

Integrable boundary states appear in statistical physics in quench problems, when we suddenly change a parameter of a system in thermal equilibrium. The relaxation to the new equilibrium state can be calculated from overlaps with the boundary quench state. We managed to derive exact overlaps for all integrable two-site boundary states for gl(N) symmetric spin chains. We are currently extending these formulas for integrable matrix product states.

Integrability and resurgence. Perturbative expansions are typically asymptotic signaling the presence of non-perturbative corrections. They are related by resurgence relations, which are difficult to analyze. We published our comprehensive review about the complete Wiener-Hopf solution of the free energy problem in the O(N) symmetric nonlinear sigma models [3]. We payed particular attention to the exceptional O(3) case where we identified various instanton sectors. We computed the complete transseries for the expectation values of conserved charges, in the presence of a magnetic field and revealed their intrinsic resurgence relations.

References

[1] https://doi.org/10.1007/JHEP05(2024)185

[2] https://doi.org/10.1103/PhysRevLett.133.031601

[3] https://doi.org/10.1007/JHEP11(2024)093