Wigner 121
Scientific Symposium

Wigner Research Centre for Physics
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Holographic Quantum Field Theory Group

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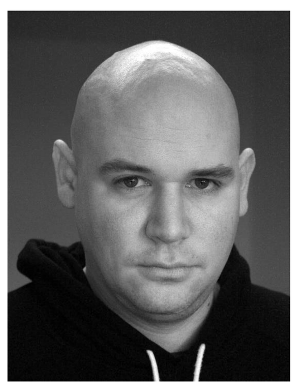
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Introduction

Two dimensional integrable quantum field theories play significant roles in various areas of theoretical physics. Besides describing strongly anisotropic condensed matter systems, they provide toy models for particle physics in which non-perturbative phenomena can be analysed exactly. The aim of our group is to develop new tools for integrable models and apply them to solve relevant non-perturbative problems appearing in particle and statistical physics.
Recently we planned the following applications:
I. to describe exactly the finite size effects of form factors and apply the results to determine the three-point functions of the maximally symmetric strongly interacting four dimensional gauge theory, the "hydrogen atom" of all gauge theories
II. to investigate integrability in the presence of boundaries and defects and apply the results to the one-point functions of the maximally symmetric four dimensional defect gauge theory and to quench problems in statistical physics
III. to understand the non-perturbative phenomena, which emerge from a sophisticated analysis of the perturbative series in asymptotically free quantum field theories and their consequences for the strong interaction

I. Finite size effects

We developed a new method to calculate finite size corrections for form factors, the matrix elements of local operators, in two-dimensional integrable quantum field theories. We extracted these corrections from the excited state expectation values of bilocal operators in the limit when the operators are far apart. We elaborated the finite size effects explicitly up to the 3rd Lüscher order and conjectured the structure of the general form. We also fully recovered the explicitly known massive fermion finite volume form factors.

[1] *Finite volume form factors in integrable field theories*, Z. Bajnok, G. Linardopoulos, I.M. Szécsényi, I. Vona, arxiv: 2304.09135
[2] *Lüscher-corrections for 1-particle form-factors in non-diagonally scattering integrable quantum field theories*, Á. Hegedűs, JHEP 07 (2021)

II.Integrable boundaries

Integrable boundary states can be built up from pair annihilation amplitudes, which are related to mirror reflections and they both satisfy Yang Baxter equations (YBEs). We related these two notions and showed how they are fixed by the unbroken symmetries, which, together with the full symmetry, must form symmetric pairs. We developed new methods for the calculation of the simplest asymptotic all-loop 1-point functions in the holographic defect duality. In doing so we classified the solutions of the boundary YBEs with centrally extended su(2|2) symmetry and calculated the generic overlaps in terms of Bethe roots and ratio of Gaudin determinants.

[1] *Boundary state bootstrap and asymptotic overlaps in AdS/dCFT*, T. Gombor, Z. Bajnok, JHEP 03 (2021) 222
[2] *Boundary states, overlaps, nesting and bootstrapping AdS/dCFT*, T. Gombor, Z. Bajnok, JHEP 10 (2020) 123

III. Non-perturbative effects

Perturbation theory in quantum field theories is typically asymptotic with factorially growing coefficients. This factorial growth can be attributed to the proliferation of Feynman diagrams related to instantons, or to integrals in specific so called renormalon diagrams, when the loop momenta lie in various IR and UV domains. Instantons correspond to non-trivial saddle points in the path integral, while renormalons do not have such a direct semiclassical interpretation. They both lead to non-perturbative contributions, exponentially suppressed in perturbation theory, which can typically be extracted from the large-order behaviour of the perturbative coefficients. The theory which describes this connection is known as resurgence theory.
The two-dimensional integrable models are ideal testing grounds for non-perturbative physics as they can exhibit interesting physical phenomena including dynamical mass generation and asymptotic freedom, while their integrability enables the exact determination of their mass gap, scattering matrices, and the ground state energy in a magnetic field in the form a liner integral equation.
Using the Wiener-Hopf technique we could manage to solve explicitly the integral equation in terms of a trans-series, which contains all the perturbative and non-perturbative corrections. We revealed the intrinsic relation between the perturbative and non-perturbative corrections.

[1] The full analytic trans-series in integrable field theories, Z. Bajnok, J. Balog, I. Vona, Physics Letters B844 (2023) 138075.
[2] Running coupling and non-perturbative corrections for O(N) free energy and for disk capacitor, Z. Bajnok, J. Balog, Á. Hegedűs, I. Vona, JHEP 09 (2022) 001.

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