

Doctoral School of Physics - Eötvös Loránd University (ELTE)

PhD Semester Progress Report: Semester I

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Program: Theoretical Physics

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1. Introduction

My doctoral research is conducted within the Particle Physics group, where we address the fundamental challenge of understanding Quantum Field Theories (QFTs) beyond the perturbative regime.

While standard field theory relies on series expansions that often fail at high coupling strengths, our group utilizes Integrability as a powerful non-perturbative alternative. In 1+1 dimensional systems, the existence of an infinite set of conserved charges allows us to bypass traditional approximations. By solving the Yang-Baxter equations and employing the Bootstrap program, we determine the exact S-matrix of a theory without relying on Feynman diagrams.

Our methodology focuses on the interplay between the Lagrangian description of a model and its exact solution via the Thermodynamic Bethe Ansatz (TBA) and Form Factor bootstrap. The goal of this approach is to provide exact analytical results for the spectrum and correlation functions of these theories, which serves as a vital benchmark for higher-dimensional gauge theories and the AdS/CFT correspondence.

2. Educational Activities

To develop the rigorous analytical framework required for this field, I have completed the following doctoral courses:

- **Conformal Field Theory EA FIZ/2/018E:** Advanced study of 2D invariance, representations of the Virasoro algebra, and the Operator Product Expansion.
- **Integrable Quantum Field Theory FIZ/2/084E:** Investigation of exact S-matrix bootstrap, the Yang-Baxter equation, and the properties of integrable models like the Sine/Sinh-Gordon systems.

Note: Final assessment for these courses is currently in progress

3. Research Progress & Literature Review

The first semester served as a transition into specialized research, characterized by a deep dive into the mathematical foundations of integrable models.

Specialized Literature Review: I have focused on the foundational framework of 1+1 dimensional integrable models, with particular emphasis on the Sine-Gordon and Sinh-Gordon systems. My review included a detailed study of the S-matrix bootstrap and the analytical properties of these models as discussed in key pedagogical texts and specialized reviews, such as those by Bajnok and Šamaj. This study was instrumental in understanding the mapping between Lagrangian parameters and the spectrum of physical excitations.

Next Semester Goal: Having solidified this theoretical foundation, I will initiate my active research journey in the second semester. My primary objective is to apply these exact methods to a specific open problem in integrable systems under the direct supervision of Prof. Bajnok

4. Scientific Activity

Seminars: I have been a regular participant in the Theoretical Physics Departmental Seminars and internal research group workshops.