TUT 5: Tutorial: Correlations in Integrable Quantum Many-Body Systems (TT)

The tutorial is planned to present recent developments and ongoing activities in the theory of exact correlation functions of Heisenberg spin chains and their relatives, such as integrable bosonic and fermionic gases. Recent theoretical developments go beyond the calculation of just universal properties of many body systems as captured in Tomonaga-Luttinger liquid theory. By taking account of the full interactions of integrable Hamiltonians the complete correlations at large and short distances respectively small and large frequencies can be calculated. Due to substantial experimental advances integrable models of condensed matter physics can be realized for instance by ultra-cold quantum gases in traps.

Organizers: Hermann Boos and Andreas Klümper (Universität Wuppertal)

Time: Sunday 16:00–18:30 Location: H20

Tutorial TUT 5.1 Sun 16:00 H20

Correlation functions of integrable models — •Frank Göhmann — Bergische Universität Wuppertal

This introductory tutorial reviews some of the progress in the theory of integrable quantum systems that led to the exact calculation of correlation functions of Heisenberg spin chains and related integrable quantum field theories. I shall mostly focus on two subjects: the factorization property of correlation functions of integrable models, discovered about 15 years ago, and the exact calculation and summation of matrix elements appearing in Lehmann representations of their correlation functions. Special emphasis will be put on methods which allow us to take into account the temperature dependence and on methods for calculating the long-time large-distance asymptotic behaviour of correlation functions.

Tutorial TUT 5.2 Sun 16:45 H20

Non-Abelian anyons — •Holger Frahm — Institut für Theoretische Physik, Leibniz Universität Hannover

In this tutorial we shall discuss the construction and analysis of integrable many-body quantum systems built from non-Abelian anyons – objects with most exotic statistics under permutation whose states are protected against local perturbations by the existence of topological charges. They can appear as quasi-particle excitations in certain topological quantum liquids and are possibly realized in quantum Hall states at certain fractional filling factors or frustrated two-dimensional quantum magnets. Integrable models can provide unbiased insights into the nature of the collective states of many anyons formed in the presence of interactions.

We begin the tutorial with a brief review of the theoretical description of interacting many-anyon lattice models starting from the underlying fusion category. Within this framework a basis of operators for local interactions of anyons as well as the topological charges characterizing the many-anyon state are built. Finally, we show how by fine-tuning of the coupling constants the resulting models can be embedded into families of commuting operators and discuss strategies for the calculation of their spectral properties.

15 min. break

Tutorial TUT 5.3 Sun 17:45 H20

Quantum quenches and equilibration of lattice and continuum systems — •Michael Brockmann — Max Planck Institute for the Physics of Complex Systems, Dresden, Germany

In this tutorial we will discuss the problem of relaxation and equilibration in closed quantum systems which are prepared in an off-equilibrium initial state. Quantum quenches are examples of such out of equilibrium situations. The focus will be on one-dimensional integrable theories where additional conservation laws heavily restrict the dynamics of the system.

I will briefly present two examples for which the steady state can be investigated by means of exact methods. The first example is a quench protocol where the ground state of a free many-particle bosonic theory unitarily evolves in time under the Lieb-Liniger Hamiltonian of δ-interacting repulsive bosons. In the second example the antiferromagnetic Néel state, the ground state of the spin-1/2 Ising chain, is released into the anisotropic Heisenberg spin chain. Using a variational method, the so-called quench action approach (QAA), one obtains the exact non-thermal steady state of the system in the thermodynamic limit, which correctly reproduces expectation values of local observables. Besides being rare cases of exact solutions of quench situations in truly interacting theories, those two quench protocols represent examples where a naive implementation of the generalized Gibbs ensemble (GGE) fails.