Final report, ESF exchange grant: P. Calabrese

EXCHANGE GRANT

Awarded to Pasquale Calabrese, Dipartimento di Fisica, Università di Pisa, Italy.

9 weeks stay in Amsterdam at the Institute of Theoretical Physics
Travel started April 9, 2007, ended July 8, 2007.
Grant reference number: 1311
Note: The part of the staying exceeding the 9 weeks has been covered by other funding.

PURPOSE OF THE VISIT AND RESULTS

The goal of the visit was to strength the ongoing collaboration with the group of J.-S. Caux on the problem of the calculation of exact correlation functions in integrable models with the method of Algebraic Bethe Ansatz.

During this period we worked on several projects that can be summarized as follows:

- **Correlation functions of the BCS model in the canonical ensemble**

  Ordinary superconductivity is well described by the well-known BCS theory. This theory is usually formulated in the gran canonical ensemble (i.e. the number of electrons is allowed to fluctuate). However experiments with ultrasmall grains of superconductor showed unambiguously that superconductivity persists when the pairing happens between few (like 20,40) electrons where the gran canonical assumption is not justified. Long ago Richardson (in the context of nuclear physics) realized that the resulting model is exactly solvable and recently a full description in terms of Algebraic Bethe Ansatz has been achieved. We (myself, J.-S. Caux and A. Faribault) exploited such integrability to give exact expressions for the correlation functions. In the static limit we showed that correlation functions have almost a closed analytical form, instead the dynamical one still require hard computational effort (but still we can obtain exact or extremely precise results). We were also able to describe the non-equilibrium dynamics.

  On this subject the following publications are planned:

  1. "Thermodynamic and static correlation functions for the BCS model in the canonical ensemble" with A. Faribault and J.-S. Caux

  2. "Dynamical correlation function in the Richardson model" with A. Faribault and J.-S. Caux

  3. "Quantum quenches for the BCS model in the canonical ensemble" with A. Faribault and J.-S. Caux

- **1D Bose Gases**

  With J.-S. Caux we continued our project on the calculation of dynamical correlation functions in one dimensional Bose gas. We almost finished the calculations for the density-density correlation functions in the repulsive case (some results on this topic already appeared in March 2006). Also the ongoing calculation for the attractive case are almost finished. In fact the two following papers will appears soon

  1. "Dynamics of the attractive 1D Bose gas: analytical treatment from integrability" with J.-S. Caux, to appear really soon

  2. "Density-density correlations in the one-dimensional Bose gas" with J.-S. Caux

We also start developing some methods for the calculation at finite temperature in the attractive and repulsive case. However these work are still at the very first stage. Furthermore we attacked the problem of calculation of higher moments of the density that are extremely important experimentally because they are connected to the stability of the gas. Unfortunately the scheme that we developed didn't work, but thanks to this we have now a better understanding of the model that can help in future investigation on the same subject. We are also currently trying to understand whether non-equilibrium properties can be studied exploiting integrability.

- **Quantum quenches**

  The fate of a quantum system after a sudden change of a quantum parameter (quench) is the subject of intensive recent research. During this visit I concluded some calculations or the global quenches and we developed a new method to calculate correlation function and entanglement with conformal field theory after a local perturbation of the Hamiltonian. This work resulted in the following publications:

  1. "Quantum Quenches in Extended Systems" with J. Cardy, appeared as J.Stat.Mech. 0706 (2007) P008.

  2. "Correlation functions and entanglement following a local quench" with J. Cardy, to appear really soon.

- **Other**

  The vivacity of the theoretical institute in Amsterdam also led to some collaborations not planned at the beginning of the visit. In particular some discussions with Prof. B. Nienhuis allowed to discover connections between the entanglement entropy of spin chains and the thermodynamics of dense loop models. Also interesting properties of the Lieb-Liniger anyonic gas has been observed with R. Santachiara (that was visiting the institute during part of my visit). Thes interactions will probably result in the following publications

  1. "Correlation functions in the Lieb-Lineger anyonic gas" with R. Santachiara and M. Mintchev

  2. "The anyonic Luttinger Liquid" with M. Mintchev

  3. "The entanglement entropy and dense loop models" with B. Nienhuis and M. Campostrini

  4. "Particle entanglement entropy in 1D Bose gases" with J.-S. Caux

Some of these publications are almost finished and will appear soon, others are still at an embryonal level and can get substantial changes before submission.

OTHER COMMENTS