

Constructive Renormalization Group: A conference in memory of Pierluigi Falco

Tuesday 09 June 2015 - Thursday 11 June 2015

INFN - Laboratori Nazionali di Frascati

Book of abstracts

0 - Renormalization group, Kondo effect and hierarchical models

Tuesday 09 June 2015 14:30

Presenter: GALLAVOTTI, Giovanni (ROMA1)

A manifestation of the Kondo effect is the non divergence at zero temperature

of the susceptibility of an impurity magnetization to the action of a field. It is a quantum phenomenon not accessible to perturbation theory because it is essential that the interaction with the host lattice electrons is antiferromagnetic, no matter how small. Its theory in one dimension, due to Wilson, is based on the renormalization group and its interest is that it has been one the first and few cases in which a multiscale phenomenon controlled by a non trivial fixed point as been understood.

Wilson's approach has not been based on functional integration: here I shall discuss

a hierarchical model for a system exhibiting the Kondo effect: its nine running couplings (of which 2 are relevant 4 are marginal and 3 irrelevant) flow under a beta function which can be computed exactly and which generates a flow with several properties which give a picture of the phenomenon.

1 - Validity of Spin Wave Approximation for the Quantum Heisenberg Ferromagnet

Thursday 11 June 2015 14:30

Presenter: Dr. CORREGGI, Michele (Roma Tre University)

We consider the quantum ferromagnetic Heisenberg model in three dimensions, for all spins $S \geq \frac{1}{2}$. We report on a rigorous proof of the validity of the spin-wave approximation for the excitation spectrum, at the level of the first non-trivial contribution

to the free energy at low temperatures. Our proof comes with explicit, constructive upper and lower bounds on the error term. Such estimates are obtained combining the bosonic Holstein-Primakoff representation of the Heisenberg model with localization bounds and operator inequalities. Joint work with A. Giuliani (Roma 3) and R. Seiringer (IST Austria).

2 - Limit Theorems in Quantum Theory

Wednesday 10 June 2015 09:30

Presenter: Prof. FROELICH, Juerg (ETH Zurich)

I present an outline of the theory of information acquisition in quantum mechanics. I discuss some relevant mathematical techniques from functional analysis and probability theory needed to develop this theory. In order to keep the presentation down to earth, I focus on the discussion of concrete examples of indirect and non-demolition measurements.

4 - Height Fluctuations in Interacting Dimers

Wednesday 10 June 2015 12:00

Presenter: Prof. GIULIANI, Alessandro (Univ. Roma Tre)

Perfect matchings of Z^2 (also known as non-interacting dimers on the square lattice) are an exactly solvable 2D statistical mechanics model. It is known that the associated height function behaves at large distances like a massless gaussian field, with the variance of height gradients growing logarithmically with the distance. As soon as dimers mutually interact, via e.g. a local energy function favoring the alignment among neighboring dimers, the model is not solvable anymore and the dimer-dimer correlation functions decay polynomially at infinity with a non-universal (interaction-dependent) critical exponent. We prove that, nevertheless, the height fluctuations remain gaussian even in the presence of interactions, in the sense that all their moments converge to the gaussian ones at large distances. The proof is based on extension of the Interacting Fermions Picture method, proposed and employed by P. Falco in the study of the universality of critical exponents in the interacting dimer model. An important novelty of our approach is the combination of multiscale methods with the path-independence properties of the height function.

Joint work with V. Mastropietro and F. Toninelli.

7 - Universality of conductivity in interacting graphene

Wednesday 10 June 2015 11:00

Presenter: PORTA, Marcello (Zurich Univ.)

Graphene is a recently discovered material, which can be considered as the first realization of a two-dimensional crystal. Its unique physical properties elicited great interest in the condensed matter physics community, both from a theoretical and an experimental point of view.

Remarkably, some interesting features of graphene can be understood from a mathematically rigorous viewpoint. In this talk, I will consider the Hubbard model on the honeycomb lattice at half-filling, as a model for undoped graphene in the presence of short-range interactions. I will present a rigorous proof of the universality of the optical conductivity, which agrees with recent experiments: the conductivity has a universal value, which does not depend on the microscopic details of the model. In particular, there are no interaction corrections, provided that the interaction is weak enough. Also, I will report about recent progress in the understanding of the universality of the Hall conductivity in a related model, the interacting Haldane model. The results are based on a rigorous formulation of the Wilsonian renormalization group and on Ward identities. This is joint work with A. Giuliani and V. Mastropietro.

8 - Anomaly cancellation to all orders in chiral abelian gauge theories - A perturbative analysis based on (Bi)flow equations -

Thursday 11 June 2015 09:30

Presenter: KOPPER, Christoph (Ecole Polytechnique Palaiseau)

We prove that the cancellation of the chiral anomaly in four-dimensional axial QED, as a consequence of a sum rule on the fermion charges, is valid to all orders in perturbation theory. The proof is based on analysing separately the fermionic and bosonic renormalization group flows.

9 - Quantum Phase Transition in an Interacting Fermionic Chain

Thursday 11 June 2015 15:30

Presenter: BONETTO, Federico (Georgia Tech - Atlanta)

We rigorously analyze the quantum phase transition between a metallic and an insulating phase in (non solvable) interacting spin chains or one dimensional fermionic systems. In particular, we prove the persistence of Luttinger liquid behavior in the presence of an interaction even arbitrarily close to the critical point, where the Fermi velocity vanishes and the two Fermi points coalesce. The analysis is based on two different multiscale analysis; the analysis of the first regime provides gain factors which compensate exactly the small divisors due to the vanishing Fermi velocity. This is a joint work with Vieri Mastropietro.

10 - Renormalization Group Approach for the Optimally Doped Cuprates

Thursday 11 June 2015 12:00

Presenter: FERRAZ, Alvaro (Rio Grande do Norte Univ. (Brazil))

We present an overview of the field-theoretical renormalization group approach for interacting electrons in the normal phase of the optimally doped cuprates. Earlier calculations predicted the existence of d-wave charge density instabilities (d-CDW) which were later verified in several experiments in non-Lanthanum materials. However the onset of the so-called pseudogap state remains an open problem to this date. We will discuss some alternatives for this riddle

11 - The rigorous construction of the 1D Extended Hubbard model by RG techniques

Tuesday 09 June 2015 15:30

Presenter: BENFATTO, Giuseppe (Tor Vergata Univ.)

In the last twenty years, many people in Rome have studied various types of Fermion models, by applying rigorous RG techniques. One of these people was Pierluigi Falco and the paper I will speak about, written in collaboration with Vieri Mastropietro and myself, was his last one.

The line of research on rigorous RG was open at the end of the 80's by Giovanni Gallavotti, who published on JSP in 1990, in collaboration with myself, a paper on the weakly interacting Fermi gas in one and three dimensions.

In this talk I will give, without too many technical details, a review of the results that have been obtained in the case of the one dimensional extended Hubbard model (a gas of fermions of spin 1/2 on the one dimensional lattice) at weak coupling and generic repulsive short range interaction.

These results concern the existence of the zero temperature limit of the Grand Canonical Ensemble, the Borel summability of perturbation theory and some universal relations satisfied by some critical indices and certain thermodynamical quantities (all depending on the coupling and all other details of the model). These universal relations were conjectured many years ago in the physical literature, but were checked only in some special solvable spinless fermion models.

12 - The Coulomb system at the KT transition, part I

Tuesday 09 June 2015 11:00

Presenter: BAUERSCHMIDT, Roland (Harvard Univ. (USA))

In a recent paper <http://arxiv.org/abs/1311.2237>, Pierluigi Falco derived the detailed asymptotics of the correlation function of the critical Coulomb system in two dimensions at low density, as predicted by Berezinskii, Kosterlitz and Thouless. In this first of a two part lecture

we will review this result and explain some key ideas in this remarkable achievement.

13 - The Coulomb system at the KT transition, part II

Tuesday 09 June 2015 12:00

Presenter: BRYDGES, David (British Columbia Univ. (Canada))

In a recent paper <http://arxiv.org/abs/1311.2237>, Pierluigi Falco derived the detailed asymptotics of the correlation function of the critical Coulomb system in two dimensions at low density, as predicted by Berezinskii, Kosterlitz and Thouless. In this second of a two part lecture

we will review this result and explain some of key ideas in this remarkable achievement.

14 - Large deviations for singular stochastic partial differential equations

Wednesday 10 June 2015 15:30

Presenter: JONA LASINIO, Giovanni (ROMA1)

We consider SPDE's whose solutions are distribution-valued fields. An example is provided by the stochastic quantization of a scalar field in $d=2,3$ where infinite counter-terms are necessary. We review large deviation estimates for probabilistic weak solutions in $d=2$, derived long ago with P. K. Mitter, which show that the rate functional does not depend on the renormalization counter terms. We shall compare this result with a similar conclusion reached recently by Hairer and Weber in the context of Hairer regularity structures, which cover also the $d=3$ case.

15 - Anomalies and universality in statistical mechanics

Tuesday 09 June 2015 16:30

Presenter: Prof. MASTROPIETRO, Vieri (Universita' di Roma Tor Vergata)

Around 2007 Pierluigi Falco sent me a two line mail writing something like "then we can prove the kadanoff relation $\chi_- - \chi_+ = 1$ ". This was the end of a two year discussion between we two (which I will be recall in my seminar)

on the renormalization/non renormalization of the anomalies in quantum field theory and its implications for universality in statistical mechanics; the complete proof of universality relations in non solvable spin models was later on published (Benfatto, Falco, Mastropietro CMP 292, 509 (2009)), and this opened a very exciting research line, crowned to

the proof of universality in the conductivity in Graphene or in the Hubbard model. While the combination

of the properties of anomalies with constructive Renormalization Group seems the right tool to understand universality in equilibrium statistical physics, I will describe some universality results in non equilibrium one dimensional interacting fermions which apparently do not fit in this scheme.

16 - Singular Stochastic PDEs and Dynamical Field Theory Models

Wednesday 10 June 2015 14:30

Presenter: MITTER, Pronob K. (Montpellier Univ. (France))

There is considerable interest at present in Singular Stochastic PDEs especially in connection with Rough Path Theory in different guises. The mathematical work started with results by Gianni Jona-Lasinio and myself a long time ago. I will review what was accomplished at the time and the progress that has been made since then. One reason for presenting this to this audience is that there is, in my opinion, considerable scope for rigorous renormalisation group work in this subject. I will also attempt to prepare the ground for Gianni's talk to follow on large deviations for singular SPDEs.

17 - Results and conjectures about the XY model

Tuesday 09 June 2015 09:30

Presenter: SPENCER, Thomas (IAS (USA))

In this review talk I will explain how Falco's work on the Coulomb gas is related to the 2D XY model at T_c . In 3D I will present some open problems at low temperature

19 - Probabilistic method in combinatorics using cluster expansion

Wednesday 10 June 2015 16:30

Presenter: SCOPPOLA, Benedetto (Univ. Tor Vergata Roma)

We will discuss the connection between the cluster expansion and the probabilistic method, used in order to give a-priori bounds for discrete combinatorics problems. Accurate estimates of the radius of convergence of the cluster expansion, as the Fernandez-Procacci construction, allow better estimates in the related combinatorics problems. We provide concrete examples of applications of this technique.

20 - Proof of a 43-year-old prediction by Wilson on anomalous scaling for a hierarchical composite field

Thursday 11 June 2015 11:00

Presenter: ABDESSELAM, Abdelmalek (Virginia Univ. (USA))

Hierarchical models a.k.a. the approximate recursion played a fundamental role in the discovery of the epsilon-expansion for critical exponents by Wilson and Fisher. In a not so well known 1972 article, Wilson showed, at the heuristic level, that at a nontrivial hierarchical model fixed point, the elementary field has no anomalous scaling whereas the composite square field does have one. I will report on a joint work with Ajay Chandra and Gianluca Guadagni on a particular hierarchical model, the p-adic model, which rigorously proves Wilson's prediction. The two main ideas are a constructive renormalization group for space dependent couplings and a holomorphic partial linearization theorem in infinite dimension, in the spirit of Wegner's theory of nonlinear scaling fields. I will also report on recent progress I am making in the analysis of short distance behavior such as the pointwise representability of correlation functions. The goal is to prove the operator product expansion and generalize the pathwise construction of squares of random distributions given by Wick powers to the setting of a nontrivial fixed point with anomalous dimensions.