SFT-2014
Lectures on Statistical Field Theories
Galileo Galilei Institute
Florence, 3-14 February 2014

Program

Denis Bernard
SLE and CFT: An Introduction for (and by) Amateurs

The lectures will be devoted to a somewhat detailed presentation of Stochastic Schramm-Loewner Evolutions (SLE), which are Markov processes describing fractal curves or interfaces in two-dimensional critical systems. A substantial part of the lectures will cover the connection between statistical mechanics and processes which, in the present context, leads to a connection between SLE and conformal field theory (CFT). These lectures aim at filling part of the gap between the mathematical and physics approaches. They are intended to be at an introductory level.

Lecture 1-2: Statistical interfaces and SLE
Lecture 3-4: SLE/CFT correspondence
Lecture 5-6: SLE/CFT delicatessen.

Michele Burrello
Models of topological quantum computation:
Surface codes, Majorana modes and non-Abelian anyons

Condensed matter systems presenting topological order are not only interesting for their unusual and exotic properties but they provide also a possible playground to engineer new platforms for a fault-tolerant quantum computation protected against local noise and decoherence. These systems are described in terms of non-local order parameters and are characterized by both a protected manifold of degenerate ground states and localized quasi-particle excitations, named anyons, whose statistics is neither fermionic nor bosonic. In this lectures I will introduce the main facets of topological order and topological quantum computation through the analysis of several key-models which constitute paradigmatic examples for this branch of condensed matter physics. The main topics will be: toric and surface codes, non-Abelian Anyon models and Majorana modes in topological superconductors.

Jean-Sébastien Caux
Introduction to the Lieb-Liniger model

1. Interacting bosons in one dimension. The Lieb-Liniger model. Coordinate Bethe Ansatz.
2. Building the eigenstates basis. Bethe equations and their solutions. Properties of Bethe wavefunctions.
3. Going towards the thermodynamic limit. The ground state of the repulsive gas and the Lieb equation. Zero temperature physical properties.
4. Excitations. Lieb Type 1 and 2 modes. Link with bosonization. Calculation of effective Luttinger theory parameters.

5. Finite temperature equilibrium. The Yang-Yang formalism.
6. Advanced topics. The attractive gas. Algebraic Bethe Ansatz. Matrix elements. Correlation functions. Out-of-equilibrium effects and Quantum quenches.

Fabian Essler
Bosonization and Quantum Spin Chains: an Introduction

- some background on models of magnetism
- spin-1/2 Heisenberg XXZ chain and its relation to interacting fermions and free bosons.
- the transverse field Ising chain and Majorana fermions.
- refermionization approach to the 2-leg Heisenberg ladder.

Marton Kormos
Bethe Ansatz techniques

Lectures 1-2:
- Bethe Ansatz basics
- XXZ model introduction (symmetries, mapping to hopping particles, preview of the phase diagram)
- BA equations, rapidity variables in the various regimes
- ground state properties in the thermodynamic limit: integral equations and solutions

Lectures 3-4:
- excitations of the ground state, spinons etc.
- magnetisation and magnetic susceptibility

Lectures 5-6:
- basic facts about the string solutions
- TBA for the XXX model in some detail
- some features of the TBA for XXZ

Giuseppe Mussardo
Conformal Field Theory and Minimal Models

Conformal Field Theory:
- Conformal Invariance
- Ward identity and primary fields
- Virasoro algebra and central charge
- Representation theory of Virasoro algebra
- Casimir effect and other finite size phenomena
- Bosonic and fermionic fields

Minimal models:
- Differential equations of the correlation functions
- Coulomb Gas formalism
- Modular invariance

German Sierra
Conformal Field Theory, infinite Matrix Product States and applications to spin chains and quantum Hall effect

Lecture 1: Tensor Networks
- MPS
- PEPS and MERA
- Area Law
- Entanglement Entropy

Lecture 2: Infinite MPS
- Vertex operators
- XXZ model
- Haldane-Shastry model

Lecture 3: Fractional Quantum Hall Effect
- Laughlin and More-Read wave functions and CFT
- Kalmeyer-Laughlin model
- Lattice realizations