Cours de Physique Théorique de l'IPhT, année 2011-2012

Organisé en collaboration avec

Ecole Doctorale de Physique de la Région Parisienne - ED 107

Supersymmetry in Condensed Matter and Statistical Physics

Konstantin B. **Efetov**

Université de la Ruhr, Bochum

Les vendredis 9/3, 16/3, 23/3, 6/4, et 13/4 à 10h00.

The goal of these lectures is to present an introduction to the use of modern, Supersymmetry-inspired tools in Condensed Matter and in Statistical Physics.

I will motivate why Grassmann variables are useful in the study of disordered metals. I will show how one develops the conventional diagrammatic technique, and why one encounters problems in applying it for most interesting systems. Then, I will show how anti-commuting variables help averaging over the disorder, and I will derive the super-matrix non-linear σ-model. After that I will present how non-trivial problems of disordered systems have been attacked by using the σ-model. Proceeding in this way I will discuss Anderson localization in one dimensional thick wires and in two dimensional films, and I will find the solution in high dimensionality or on the Bethe lattice. Then, I will present how the zero dimensional σ-model can be useful for mesoscopic systems, and I will show that Random Matrix Theory is equivalent to the zero dimensional σ-model. This equivalence establishes the connection between disordered mesoscopic systems and quantum chaos. I will show an extension of the conventional σ-model to the ballistic one and an exact mapping onto a generalized σ-model (super-bosonization formula). The tentative plan of the lectures follows.

1 – Disorder in normal metals

2 - Grassmann variables and non-linear supermatrix σ-model.

3 - Renormalization group for the σ-model in 2 and 2 + ε dimensions.

4 - Solving one dimensional and high dimensional models.

5 - Zero dimensional σ-model for small metal particles. Random Matrix Theory and the supersymmetry. Ballistic σ-model and Superbosonization.