Cours de physique théorique

agréé par l'École doctorale "Physique en Ile de France"

An introduction to the non-perturbative renormalization group

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Les vendredis 10/1/2014, 17/1, 24/1, 31/1, 7/2, 14/2 à 10h00.

We provide an introduction to Wilson's renormalization group and its modern nonperturbative implementations (NPRG). The scalar O(N) models will be our favourite playground.

We start by introducing the conceptual and technical framework used throughout these lectures: Wetterich's version of Wilson's RG. The exact RG equation is derived showing how and why Kadanoff's block-spin idea is conveniently implemented on the Gibbs free energy (the generating functional of one-particle-irreducible correlation functions).

We then derive the two main nonperturbative approximation schemes: the derivative expansion (DE) on one hand and the Blaizot-Mendez-Wschebor (BMW) scheme on the other hand. We show how the DE truncated at its lowest order(s) yields both an intuitive and powerful method to compute in a unified scheme both universal and nonuniversal quantities, either at or away from criticality. We show in particular how a single set of equations allows us to retrieve all known results of the O(N) models in all dimensions (including the Kosterlitz-Thouless transition, the large N limit and accurate results in three dimensions). Then we will show how the BMW method allows us to compute the momentum dependence of the two-point functions which is out of reach of the DE. A comparison between the results thus obtained and the best experimental and numerical measurements will be presented on the example of the critical structure factor of the Ising model in three dimensions.

If time allows, we will review some important results obtained by means of the NPRG in different areas of physics. Among others, the Kardar-Parisi-Zhang equation describing in particular the growth of interfaces will be taken as an example where genuinely nonperturbative phenomena show up that can nevertheless be captured with the NPRG.