Nonequilibrium phenomena: response to perturbations

and metastable behaviour

Part I

Lamberto Rondoni

Politecnico di Torino

The microscopic theory of equilibrium phenomena is highly developed and rather exhaustive, while that of non-equilibrium phenomena still faces fundamental challenges and lacks a unitary formulation, although both the equilibrium and the non-equilibrium theories are born together. One may argue that this is due to the fact that every equilibrium state can be perturbed in many possible ways, making it a non-equilibrium state, hence non-equilibrium states constitute a much wider class than that of equilibrium phenomena. The available mathematical techniques, concern dynamical systems and stochastic processes, and include ergodic theory, linear response theory and fluctuation theorems, which have been successfully and widely applied in science and technology. Recently, a non-perturbative, exact response theory has emerged within the framework of molecular dynamics and fluctuations theorems. In the first part of this course, we will introduce the theory of response, following its historical development which, at the same time, provides a logical sequence of mathematical concepts and notions. The course will continue with one crucial aspect of non-equilibrium states, known as metastability.