Electron transfer pathway control in biomolecular and small molecule systems: the role of fluctuations

Prof. Paolo Zanardi

Dept. of Physics & Astronomy University of Southern California
Los Angeles, CA 90089-0484

In the last few years we have witnessed a strong revival of interest in foundational issues of quantum statistical mechanics . The central question of this field goes back to the time of Boltzmann: under which circumstancescan we justify the amazing effectiveness of statistical ensembles in predicting the equilibrium properties of macroscopic observables in physical systems? The resurrection of such a long-standing and difficult problem in theoretical physics has been experimentally motivated by a series of exciting and groundbreaking works on the thermalization dynamics of nanoscale systems, in particular ensembles of ultra-cold atoms. Furthermore, there have recently been some exquisite theoretical insights due to a new paradigm that goes under the name of typicality.

This approach states that we do not need statistical ensembles, because the overwhelming majority of individual quantum states for a given system lead to predictions that are practically indistinguishable from those one can obtain by postulating the validity of a statistical ensemble . The dynamical counterpart of this argument allows one to make progress on the related and equally hard problem of thermalization - or more generally equilibration: how can we understand the apparently universal and irreversible approach to equilibrium?

In this set of lectures we will discuss the key new insights provided by the quantum information approach to these fundamental topics. Emphasis will be on rigorous techniques and general results. We will first cover the static case of typical states in the Hilbert space and then move to consider equilibration dynamics after a so-called quantum quench.