Molecular electronics: challenges and perspectives

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The field of molecular electronics has grown considerably in recent years, following the demonstration that electronic functionalities can be achieved via molecular structures, either in the form of single molecules or of molecular films.

In the former case, phenyl-based chains or carbon nanotubes provide the building element of diodes, transistors or memory cells. In such elements, carrier transport is supposed to occur balistically, which might open the way for high frequency applications. Due to their intrinsically nanometer dimensions, contacting molecular structures pose considerable technological challenges. From the modeling point of view, novel quantum mechanical approaches have to be developed, in order to capture the atomistic nature of such nanostructures.

Organic films on the other side are considerably less challenging from a synthetic point of view, but they are expected to provide reduce performance with respect to the single-molecule systems. Recently, carbon nanotube networks and graphene sheets have partially modify such prediction and open new interesting possibilities for the realization of RF organic thin film transistors. The modeling and simulation of devices based on molecular films is of reduced complexity with respect to the single molecule counterpart and conventional tools can be used.

This tutorial will provide an overview of the field of molecular electronics, both from an experimental as well from a theoretical point of view. Challenges, open problems and potentials of the different approaches are going to be examined in detail