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Iontronics in 1D and 2D nanomaterials

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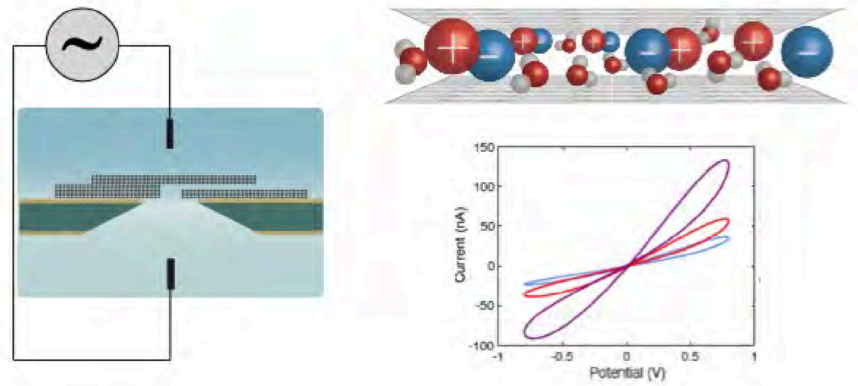
Nature does many exquisite things with ions and fluids at small scales, and in a very efficient way. Mimicking some of its functionalities in artificial devices would be tremendous, for example to design new energy-efficient computation architectures based on ions rather than electrons. In the emerging nanofluidic field, there has been considerable progress recently in the design and study of transport in channels at nanoscales. These artificial systems still remain far from the impressive complexity of the biological machinery. However, a wealth of interesting far from equilibrium and many-body behaviours have been revealed, which constitute building blocks to build such advanced functionalities.
In this talk, I will report on our recent progress in 1D and 2D iontronics, involving experiments and theory of water and ion transport across carbon nanotubes and 2D (sub) nanometer slits made of van der Waals heterostructures. I will report on the strongly non-linear transport properties across these 1D and 2D. This includes voltage gating and pressure-dependent conductance, which closely mimics the response of biological (Piezo) mechano-sensitive ion channels.
Beyond, we predict how the peculiar ion transport in 2D nanometric channels leads to a memristor behaviour with a history-dependent conductivity. Such a device allows us to reproduce the Hodgkin-Huxley neuron model in a 2D nanoslit and a simple circuitry highlights spontaneous emission of voltage spikes trains characteristic of neuromorphic activity. I will show that memristive behavior is indeed highlighted experimentally in the 2D systems, allowing to design the basic functions of a synapse with elementary 'learning' functionality using the nanofluidic circuitry.



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