Nanofluidic transport in individual carbon and boron nitride nanotubes

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Liquid transport in nanopores challenges the fundamental frontiers of fluid dynamics and nanoscience. Recently a number of reports highlighted exceptional water transport properties when confined in carbon-based nanopores, and carbon nanofluidics raised a lot of hopes for new avenues for desalination, nano-filtration and energy harvesting. However many of these results still remain debated and the fundamental reasons why carbon materials is so specific to fluidic transport still remains debated. A major challenge to address the fundamental properties at the nanoscales lies in building distinct and well-controlled nanosystems, amenable to the systematic exploration of their properties. To this end, we have developed new methods based on the manipulation of nano-objects, displacing, cutting, and glueing these elementary building blocks. This allows us to fabricate original fluidic and mechanical systems involving single nanotubes.

I will first discuss our experiments on ionic transport through single nanotubes, made of both carbon (CNT) and boron-nitride (BNNT) materials. These results show a contrasting interfacial behavior between the rather hydrophobic CNT and its crystallographic analogue, BNNT. In particular these experiments highlights strong adsorption of hydroxyl ions at the pristine carbon-water interface.

I will then discuss experiments of nanoscale water jets emerging from single nanotubes. The peculiar jet geometry allows for a passive and dye free probe of the mass flow across a nanotube with an unprecedented sensitivity. Our experiments reveal considerable and diameter-dependent surface slippage in carbon nanotubes. In strong contrast, their boron- nitride analogues exhibit no slippage. This shows that interfacial slip originates in subtle and even sub-atomic details of the solid-liquid interface. Our work opens an unexpected avenue at the crossroad between nanoscale hydrodynamics and the quantum nature of confining matter.

References :

1. ≪ Nanofluidics, from bulk to interfaces ≫, L. Bocquet , E. Charlaix Chemical Society Reviews 39, 1073 - 1095 (2010)

2. ≪ Giant osmotic energy conversion measured in a single transmembrane boron-nitride nanotube ≫, A. Siria, P. Poncharal, A.-L. Biance, R. Fulcrand, X. Blase, S. Purcell, and L. Bocquet, Nature 494 455-458 (2013)

3. ≪ Ultra-high interlayer friction inside Boron-Nitride nanotubes ≫, A. Niguès, A. Siria, P. Vincent, P. Poncharal and L. Bocquet, Nature Materials 13 688-693 (2014)

4. ≪ Scaling behavior for fluidic transport and its fluctuations in single carbon nanotubes ≫, E. Secchi, A. Niguès, L. Jubin, A. Siria and L. Bocquet, Phys. Rev. Lett. 116 154501 (2016)