Water flows freely through carbon nanotubes

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Citation: Physics Today **69**, 11, 25 (2016); doi: 10.1063/PT.3.3357
View online: http://dx.doi.org/10.1063/PT.3.3357
View Table of Contents: http://physicstoday.scitation.org/toc/pto/69/11
Published by the American Institute of Physics

Stokes equations establish that the force must be proportional to L, but the sum delivers a net force that scales as L^2.

Kamrin and Askari call their analysis the garden hoe test, after the square plate's resemblance to the familiar tool. They envision applying it to predict how well RFT will perform for other types of media. For instance, the test shows that for certain types of gels, pastes, and muds—media that produce drag forces proportional to L^2—RFT correctly predicts the forces.

In addition, the pair explains that the agreement between granular RFT and their continuum model means that the model can be used to generate inputs for RFT calculations. That could spare researchers the labor-intensive force measurements currently required. And RFT could be used for off-Earth or other environments that can't easily be reproduced in the lab.

Sung Chang

References

1. J. Gray, G. H. Hancock, *J. Exp. Biol.* **32**, 802 (1955).
2. R. D. Maladen et al., *Science* **325**, 314 (2009).
3. H. Askari, K. Kamrin, *Nat. Mater.* (in press).
4. Y. Ding, N. Gravish, D. I. Goldman, *Phys. Rev. Lett.* **106**, 028001 (2011).

HOW TYPHOONS CHANGE THE UNDERWATER SOUND FIELD

A typhoon or hurricane pushes surface water before it. When the wind-driven water hits the coast, it can no longer move forward. Forced downward and backward, the surface water displaces deeper, colder water and sends it far out to sea. Because the speed of sound in seawater rises with temperature, a typhoon's passage alters the coastal sound field. Now Guang-Bing Yang and his colleagues from the First Institute of Oceanography in Qingdao, China, have identified a second, related effect to do with seafloor sediment. On 1 August 2012, one day before Typhoon Damrey (shown here) made landfall in eastern China, the crew of the fishing boat *Lulaoyu* took the temperature profile of the water at a location 10 km off the coast of Qingdao. Four days later, after the typhoon had left, the *Lulaoyu* returned to take a second profile. When Yang and his collaborators analyzed the profiles, they found that water at the maximum depth of 32 m had risen in temperature by 5 °C. According to calculations by Yang and his collaborators, heat from the warmer water diffused through the sediment and raised the temperature there and, with it, the sound speed—by up to 15 m/s. To quantify that effect, the researchers modeled the case of a sound source positioned 1 m above the seafloor.

NASA/LANCE MODIS RAPID RESPONSE TEAM

For a distance up to 16 km from the coast and for four days after a typhoon, the warmer sediment changed the acoustic power by at least 10 dB. (G.-B. Yang et al., *J. Acoust. Soc. Am.* **140**, EL242, 2016.) —CD

In addition to having a mass near that of the Milky Way, Dragonfly 44 encompasses nearly 100 globular clusters, an anomalously large number for such a dim galaxy. The large mass and cluster population of Dragonfly 44, says van Dokkum's team, seem to rule out scenarios, plausible for lighter UDGs, in which the galaxy started as a conventional one that subsequently puffed up. Instead, the researchers argue, Dragonfly 44 is more likely a "failed" galaxy in which supernova explosions or some other process somehow squelched star formation at an early age. (P. van Dokkum et al., *Astrophys. J. Lett.* **828**, L6, 2016.) —SKB

WATER FLOWS FREELY THROUGH CARBON NANOTUBES

Despite the frenzy of research into carbon nanotubes (CNTs) over the past few decades (see, for example, the article by Thomas Ebbesen, Physics Today, June 1996, page 26), there isn't much experimental evidence for one of the tiny structures' most talked-about superpowers: the ability to funnel water with nearly zero friction. The problem has been achieving the sensitivity to measure water transport rates as feeble as a femtoliter a second. Now Lydéric Bocquet and his colleagues at École Normale Supérieure in Paris have confirmed the slipperiness of CNTs by directly measuring water flow through individual nanotubes whose bores ranged from 15 nm to 50 nm. The researchers stuck a multiwalled CNT inside a small pipette and essentially turned the nanotube into the needle of a syringe. Pressure applied inside the pipette caused water to flow through the CNT and into a tank of water. Rather than tracking the water as it flowed through the tube, Bocquet and his team analyzed the motion of suspended polystyrene nanobeads in the tank to deduce the strength of the jet emerging from the CNT (see the image, which shows the response at various pressures). The results verify that CNTs allow water to flow extremely efficiently. Bocquet's team also confirmed its 2010 prediction that the flow rate would increase as the tube's radius decreased, although the dependence turned out to be roughly quadratic rather than quartic. The biggest surprise came when the researchers replaced the CNTs with nanotubes of boron nitride. Although the BN tubes are nearly structurally identical to their carbon counterparts (see the article by Marvin Cohen and Alex Zettl, Physics Today, November 2010, page 34), they proved far more resistant to water flow. The finding seems to suggest that electronic properties—CNTs are conductors; boron nitride nanotubes are insulators—play a role in hydrodynamics at very small scales. Bocquet and his team plan to investigate that possibility as they explore the nanotubes' potential for applications such as water distillation and filtration. (E. Secchi et al., *Nature* **537**, 210, 2016.) —AG PT