research highlights

EXTREME WAVES

Tamed by topology

Nat. Commun. **10**, 5090 (2019)

Credit: Oliver Hoffmann / Alamy Stock Vector

Tsunamis may be the best-known form of extreme wave, but nonlinear interactions between waves lead to numerous other types. To bring some order into this extreme-wave zoo, one can associate different types with different topologies. For example, dispersive shock waves can have the same topology as a sphere, whereas rogue waves have a double-ring topology. Yet, conversion between different kinds of extreme waves has remained elusive. Now, Giulia Marcucci and colleagues have exploited the topological properties to control such transitions, using optical waves as a testbed.

For nonlinear waves, the topological genus corresponds to the number of oscillating phases. This number changes while the wave propagates, and for light it is also linked to the initial beam waist. In numerical simulations and experiments, adjusting the beam waist then allowed the controlled transition from shock waves to Akhmediev breathers to Peregrine solitons at specific detection times. *NM*

https://doi.org/10.1038/s41567-019-0754-7

METROLOGY

Hold my gravimeter

Science **366**, 745–749 (2019)

Atom interferometers take advantage of the wave nature of atoms to measure fundamental constants and forces and may find use for sensing applications. The past two decades have seen a small but dedicated effort to improve their performance as gravity probes. So far, this has been limited by the time it takes for the atoms being probed by the interferometric measurement to drop down the measurement tower — typically a couple of seconds.

Victoria Xu and colleagues have now presented an order of magnitude improvement in this interrogation time, by using an optical trapping technique that allows them to measure gravitational potentials while holding, rather than dropping, atoms for up to 20 seconds. They thus reduced the dominant noise source of such measurements — the phase variance due to laboratory vibrations — by nearly four orders of magnitude, thereby drastically improving the precision of atom interferometers and opening up opportunities for fundamental tests of general relativity and measurements of other fundamental potentials. *AT*

https://doi.org/10.1038/s41567-019-0751-x

FLUID DYNAMICS

Slippery ice

Phys. Rev. X **9**, 041025 (2019)

As anyone who has ever attempted a pirouette on ice skates will know, ice is very slippery. This may appear obvious, but the reasons for the slipperiness of ice are not clear. Luca Canale and co-workers have now investigated the microscopic mechanisms behind the low friction of ice and have found that it is caused by the high viscosity of the meltwater layer between the sliding object and the ice surface.

The team simultaneously probed the friction and the mechanical properties of the meltwater film as it formed when a bead slid over the ice. The viscosity of this film can be up to two orders of magnitude higher than that of water that has been cooled to 0 °C. They also found that the film has a viscoelastic response that — coupled with the high viscosity — causes the slipperiness of ice. This result points to the need to consider complex rheology for ice friction models, rather than relying on the Newtonian descriptions that are currently used. *ED*

https://doi.org/10.1038/s41567-019-0752-9

QUANTUM PHYSICS

A machine to help machines

Phys. Rev. Lett. (in the press); preprint at https://arxiv.org/abs/1904.08441 (2019)

The dream of future quantum machines that can calculate or simulate what has so far been beyond our reach runs into several rather practical obstacles. The experimental challenges in controlling large quantum states are well known, but the equally relevant problem of state reconstruction — finding a way to efficiently determine the state of a device — often goes unmentioned.

In an experiment with a nine-atom programmable Rydberg quantum simulator, Giacomo Torlai, Brian Timar and co-authors have now shown that neural networks can be a great asset for state reconstruction. The team parametrized the almost-pure state of a one-dimensional array of strongly interacting neutral atoms with a restricted Boltzmann machine — a two-layer stochastic neural network. After adding a third layer to account for noise, they were able to reconstruct the state of the system by training the network with real experimental data. The trained network was then able to reach beyond experimental limitations and predict complex observables whose measurement requires specialized equipment. *FL*

https://doi.org/10.1038/s41567-019-0753-8

DARK MATTER

The Universe before our time

Eur. Phys. J. C **79**, 954 (2019)

Shortly after the Big Bang, primordial black holes might have formed, which later collapsed into black holes and might explain the observation of supermassive and intermediate-mass black holes. After the first discovery of gravitational waves, interest in primordial black holes was rekindled, not only to account for the intermediate masses inferred for the black holes involved in the merger but also as potential dark matter candidates.

Florian Kühnel and Katherine Freese studied the impact of quantum fluctuations of the scalar field driving inflation on primordial black hole formation. They calculated the power and mass spectra for a field with inflection points, and found that primordial black hole formation is significantly enhanced. Hence, the effects of quantum fluctuations need to be taken into account when studying the formation of primordial black holes and their suitability as dark matter candidates. *SR*

https://doi.org/10.1038/s41567-019-0755-6

Elizaveta Dubrovina, Federico Levi, Nina Meinzer, Stefanie Reichert and Andrea Taroni