SCIENCE FLASH NEWS

No. 10

October 2024

Scientists demonstrate precise control over artificial microswimmers using electric fields

In a new study in *Physical Review Letters*, scientists have demonstrated a method to control artificial microswimmers using electric fields and fluid flow. These microscopic droplets could pave the way for targeted drug delivery and microrobotics.

In the natural world, biological swimmers, like algae and bacteria, can change their direction of movement (or swimming) in response to an external stimulus, like light or electricity. The ability of biological swimmers to change directions in response to electrical fields is known as electrotaxis.

Artificial swimmers that can respond to external stimuli can be extremely helpful for targeted drug delivery applications. In this study, researchers chose to model artificial swimmers that respond to electric fields.

https://phys.org/news/2024-10-scientists-precise-artificial-microswimmers-electric.html

How a classical computer beat a quantum computer at its own game

Earlier this year, researchers at the Flatiron Institute's Center for Computational Quantum Physics (CCQ) announced that they had successfully used a classical computer and sophisticated mathematical models to thoroughly outperform a quantum computer on a task that some thought only quantum computers could solve.

Now, those researchers have determined why they were able to trounce the quantum computer at its own game. Their answer, presented in *Physical Review Letters*, reveals that the quantum problem they tackled—involving a particular two-dimensional quantum system of flipping magnets—displays a behavior known as confinement. This behavior had previously been seen in quantum condensed matter physics only in one-dimensional systems.

This unexpected finding is helping scientists better understand the line dividing the abilities of quantum and classical computers and provides a framework for testing new quantum simulations, says lead author Joseph Tindall, a research fellow at the CCQ.

https://phys.org/news/2024-10-classical-quantum-game.html

Investigating the flow of fluids with non-monotonic, 'S-shaped' rheology

Water and oil, and some other simple fluids, respond in the same way to all levels of shear stress. These are termed Newtonian fluids, and their viscosity is constant for all stresses although it will vary with temperature. Under different stresses and pressure gradients, other non-Newtonian fluids exhibit patterns of behavior that are much more complex.

Researchers Laurent Talon and Dominique Salin from Université Paris-Sacly, Paris, France have now shown that under certain circumstances, cornstarch suspensions can display a banding pattern with alternating regions of high and low viscosity. This work has been published in *The European Physical Journal E*.

Non-Newtonian fluids may exhibit shear thinning, where the viscosity decreases with stress; common examples include ketchups and sauces that can appear almost solid-like at rest. The reverse is shear thickening, in which viscosity increases with stress. Some suspensions exhibit a property called discontinuous shear thickening (DST).

"At low shear stress (these fluids) behave like Newtonian fluids, but at a certain stress value the viscosity increases very steeply," explains Talon.

https://phys.org/news/2024-10-fluids-monotonic-rheology.html

Optical technique that uses orbital angular momentum could transform medical diagnostics

An Aston University researcher has developed a new technique using light that could revolutionize non-invasive medical diagnostics and optical communication. The research showcases how a type of light called the orbital angular momentum (OAM) can be harnessed to improve imaging and data transmission through skin and other biological tissues. Professor Meglinski, in collaboration with researchers from the University of Oulu, Finland, conducted the research, which is detailed in the paper "Phase preservation of orbital angular momentum of light in multiple scattering environment" published in *Light: Science & Applications*. The paper has since been named as one of the year's most exciting pieces of research by the international optics and photonics membership organization, Optica.

The study reveals that OAM retains its phase characteristics even when passing through highly scattering media, unlike regular light signals. This means it can detect extremely small changes with an accuracy of up to 0.000001 on the refractive index, far surpassing the capabilities of many current diagnostic technologies.

Professor Meglinski, who is based at Aston Institute of Photonic Technologies, said, "By showing that OAM light can travel through turbid or cloudy and scattering media, the study opens up new possibilities for advanced biomedical applications.

https://phys.org/news/2024-10-optical-technique-orbital-angular-momentum.html

Room-temperature nonreciprocal Hall effect could heat up future technology development

An old physical phenomenon known as the Hall effect has revealed some new tricks, according to a team co-led by researchers at Penn State and the Massachusetts Institute of Technology (MIT). They have reported their findings, which they said have potential implications for understanding the fundamental physics of quantum materials and developing applied technologies such as quantum communication and harvesting energy via radio frequencies in *Nature Materials.*

The conventional Hall effect occurs only in electrical conductors or semiconductors in the presence of a magnetic field. It is characterized by a newly formed voltage, called the Hall voltage, that can be measured perpendicularly to the current and is directly proportional to the applied current.

However, the newly discovered nonreciprocal Hall effect does not require a magnetic field. Discovered by teams led by Zhiqiang Mao, professor of physics, of materials science and engineering and of chemistry at Penn State, and Liang Fu, professor of physics at MIT, this effect is instead denoted by a relationship between the Hall voltage and the applied current that can be described mathematically: The Hall voltage is always proportional to the square of the current.

https://phys.org/news/2024-10-room-temperature-nonreciprocal-hall-effect.html

The neutron lifetime problem—and its possible solution

Neutrons are among the basic building blocks of matter. As long as they are part of a stable atomic nucleus, they can stay there for arbitrary periods of time. However, the situation is different for free neutrons: They decay—after about 15 minutes, on average.

Strangely enough, however, different contradictory results have been obtained for this average lifetime of free neutrons—depending on whether neutrons are measured in a neutron beam or in some kind of "bottle."

A research team at TU Wien has now proposed a possible explanation: There could be previously undiscovered excited states of the neutron. That would mean that some neutrons could be in a state in which they have slightly more energy and a slightly different lifetime. This could explain the measured discrepancies.

The proposal is published in the journal *Physical Review D*. And the team already has ideas on how to detect this neutron state.

https://phys.org/news/2024-10-neutron-lifetime-problem-solution.html

First coherent picture of an atomic nucleus made of quarks and gluons

The atomic nucleus is made up of protons and neutrons, particles that exist through the interaction of quarks bonded by gluons. It would seem, therefore, that it should not be difficult to reproduce all the properties of atomic nuclei hitherto observed in nuclear experiments using only quarks and gluons. However, it is only now that an international team of physicists has succeeded in doing this.

It's been almost a century since the discovery of the main components of atomic nuclei: protons and neutrons. Initially, the new particles were considered indivisible. In the 1960s, however, there was a suggestion that, at sufficiently high energies, protons and neutrons would reveal their internal structure—the presence of quarks constantly held together by gluons.

Soon afterwards, the existence of quarks was confirmed experimentally. It may therefore seem surprising that, despite the passage of many decades, no one has been able to reproduce with quark-gluon models the results of nuclear experiments at low energies when only protons and neutrons are visible in atomic nuclei.

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This long-standing deadlock has only now been broken, in a paper published in *Physical Review Letters*. Its main authors are scientists from the international nCTEQ collaboration on quark-gluon distributions.

https://phys.org/news/2024-10-coherent-picture-atomic-nucleus-quarks.html

Thank you!

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