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Human brain operates near, but not at, the critical point

A recent study published in *Physical Review Letters* reveals that many widely used signatures of criticality in brain data may be statistical artifacts. They propose a more robust framework that, when applied to whole-brain fMRI data, confirms the brain operates near, but not exactly at, a critical point.

Neuroscientists have long found the idea fascinating—that the brain operates near a "critical point," a phase transition between stable and chaotic dynamics. Theory suggests this sweet spot enhances computational flexibility, dynamic range, and sensitivity to inputs. Evidence has mounted over the years from neural recordings showing approximate scale invariance and power-law behavior across spatiotemporal scales.

The concept has even influenced AI, particularly reservoir computing, where networks near the "edge of chaos" tend to perform best. However, the field faces a persistent concern: are these criticality signatures intrinsic to the brain's recurrent dynamics, or do external inputs and data limitations shape them?

Two common features of neural recordings—temporally autocorrelated signals and limited data sampling—can mimic the statistical fingerprints of criticality, even in systems with no genuine collective dynamics whatsoever.

Phys.org spoke to Rubén Calvo Ibáñez, a Ph.D. student at Universidad de Granada and one of the co-authors of the study. "I've always been drawn to fundamental questions—how complicated behavior emerges from simple rules. What excited me about complex systems and non-equilibrium physics is that you can bring those tools to messy, real biological data, like brain activity, and still ask principled questions."

https://phys.org/news/2026-03-human-brain-critical.html

Physicists create laser tornado in miniature structures using synthetic magnetic field

Can light behave like a whirlwind? It turns out it can—and such "optical tornadoes" have now been created in an extremely small structure by scientists from the Faculty of Physics at the University of Warsaw, the Military University of Technology, and the Institut Pascal CNRS at Université Clermont Auvergne. This discovery opens a new pathway for creating miniature light sources with complex structures, potentially enabling the development of simpler and more scalable photonic devices in the future, for applications such as optical communication and quantum technologies. The research is published in the journal *Science Advances*.

"Our solution combines several fields of physics, from quantum mechanics, through materials engineering, to optics and solid-state physics," explains Prof. Jacek Szczytko from the Faculty of Physics at the University of Warsaw, the leader of the research group. "The inspiration came from systems known from atomic physics, where electrons can occupy different energy states. In photonics, a similar role is played by optical traps, which confine light instead of electrons."

"You can think of it as an optical vortex," says Dr. Marcin Muszyński from the Faculty of Physics at the University of Warsaw and Department of Physics City College of New York, the first author of the study. "The light wave twists around its axis, and its phase changes in a spiral manner. Moreover, even the polarization—the direction of oscillation of the electric field—begins to rotate."

https://phys.org/news/2026-03-physicists-laser-tornado-miniature-synthetic.html

Experimental evidence shows how photons spread across multiple paths in an interferometer

The nature of quantum particles has long puzzled scientists. While single-particle interference suggests that a photon can behave like a spread-out wave, a whole photon is only ever detected in one specific place. Traditional interpretations of quantum mechanics often address this by suggesting the particle is in a superposition of being here and there at the same time. However, this tells us only where the particle is when it is measured, not where the particle physically is when no detector is present.

A research team led by Hiroshima University, led by Holger F. Hofmann, professor at the Graduate School of Advanced Science and Engineering, has now developed a method to measure this delocalization without disturbing the photon's wave-like path.

In a study published in the *New Journal of Physics*, the researchers applied a modification of the well-established method of "weak measurements" to a two-path interferometer. As the photon traveled, they applied a tiny rotation by a positive angle in one path and a negative angle in the other. If the two paths interfere in the output, the average rotation angle is always zero. However, this is only a statistical average.

To identify the variation of angles for individual photons, the researchers looked at the rate of quantum jumps to orthogonal polarizations. The rate of these jumps depends on the square of the rotation angle, and this squared value can reveal whether the photons were in only one path or not.

https://phys.org/news/2026-03-experimental-evidence-photons-multiple-paths.html

Now you see it, now you don't: Material can transition between quantum states

A team of scientists led by the U.S. Department of Energy's (DOE) Argonne National Laboratory has identified a rare, switchable quantum property in a new type of nickel sulfide material. The discovery could have applications in high-speed transistors, adaptive sensors and other devices that require a material's electronic structure to be controlled on the fly. The research is published in the journal *Matter*.

The compound, $K_xNi_4S_2$ ($0 \leq x \leq 1$), contains nickel and sulfur sandwiched between layers of potassium. The "($0 \leq x \leq 1$)" in the name means that the amount of potassium in the material can vary from no potassium at all to a full potassium atom, depending on the sample.

First detailed in a 2021 paper, it was created as part of an ongoing quest to develop more superconductors. As researchers examined the layered material's characteristics, they happened upon a remarkable feature: applying an electrical current could drive the potassium layers out, collapsing the sandwich and changing the material's structure.

This action, which is reversible, allows one material to host two different types of quantum features: Dirac cones and flat band systems.

"You can tune how much potassium comes out of the material, from full to empty and everything in between. This means you can switch from one quantum state to another, all within the same material," said Mercouri Kanatzidis, a professor at Northwestern University with a joint appointment as a materials scientist at Argonne, who led the research.

https://phys.org/news/2026-03-dont-material-transition-quantum-states.html

DNA origami precisely positions single-photon emitters for quantum technologies

An international research team led by scientists from Skoltech has developed a method to position molecules on the surface of ultrathin materials with unprecedented precision using molecular DNA self-assembly, enabling the creation of quantum light sources. The results, published in the journal *Light: Science & Applications*, pave the way for the production of compact and efficient components for future quantum computers and secure communication networks.

Two-dimensional materials such as molybdenum disulfide are promising candidates for quantum light sources due to their ability to emit photons under laser excitation. However, until now, scientists have been unable to precisely control the location of emission centers—they emerged randomly upon ion beam irradiation or mechanical deformation of the material.

The authors of the study proposed a different approach. The research is based on the DNA origami method, which allows the construction of nanoscale objects of a specified shape from DNA molecules. Triangular structures measuring 127 nanometers were assembled, each carrying 18 thiol molecules. These structures were placed onto a silicon chip with a lithographic pattern. The positioning yield of each DNA origami structure at its designated location exceeded 90%, significantly surpassing the statistical limit of traditional single molecule deposition methods.

https://phys.org/news/2026-03-dna-origami-precisely-positions-photon.html

Challenging a 300-year-old law of friction

Researchers at the University of Konstanz have uncovered a new mechanism of sliding friction: resistance to motion that arises without any mechanical contact, driven purely by collective magnetic dynamics. The study, published in *Nature Materials*, shows that friction does not necessarily increase steadily with load, as postulated by Amontons' law—one of the oldest and most fundamental empirical laws of physics—but can instead exhibit a pronounced maximum when internal magnetic ordering becomes frustrated.

Rethinking a centuries-old friction law

For more than three centuries, Amontons' law has linked friction directly to load, reflecting the everyday experience that heavier objects are harder to move; for example, pushing a heavy piece of furniture requires far more effort than sliding a light chair. This behavior is commonly attributed to tiny deformations of the surfaces in contact under load, which increase the number of microscopic contact points and thereby enhance friction.

In most classical situations, these deformations remain small and do not qualitatively change the internal structure of the materials during sliding. It is therefore not clear whether Amontons' law will also hold when sliding induces much stronger internal reconfigurations, as can occur in magnetic materials where motion can modify the magnetic order.

https://phys.org/news/2026-03-year-law-friction.html

Is glass a solid or a super slow liquid? Physicists create equilibrium glassy phase from rod-shaped particles

Glass appears to be a solid, but in theory it sometimes behaves more like an extremely slow liquid. Physicists in Utrecht now show that glass-like structures can also exist in equilibrium, which is something many theories say should be impossible.

The bottom parts of medieval window panes, such as those in old cathedrals, are often thicker than the top. Has the material slowly flowed downward over the centuries, and does this mean that glass actually flows? This is a persistent myth, and the explanation lies in the way glass was produced in the Middle Ages. Because window panes were made by hand, their structure was often irregular and contained thinner and thicker parts. The panes were usually installed in the frame with the thicker side at the bottom, which made them more stable.

Still, the story touches on a real physics question. What glass actually is, a solid or a very slow liquid, turns out to be more difficult to answer than it seems.

Researchers at Utrecht University have now created a glass-like state that is in thermodynamic equilibrium. According to common theories, such a state should not really be able to exist. "A glass and an equilibrium state exclude each other in many people's minds," says Thijs Besseling, first author of the study.

The paper is published in the journal *Nature Communications*.

https://phys.org/news/2026-03-glass-solid-super-liquid-physicists.html

Thank you

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