BIOPHYSICS

How to go viral

eLife **8**, e43764 (2019)

Credit: Phanie / Alamy Stock Photo

Anyone prone to viral infection would assume that getting inside a host is a cakewalk. But it's actually more like an obstacle course: a race to engage receptors at the cell's surface without getting wiped out by the organism's natural defences. The most common type of the flu, influenza A virus, accomplishes this feat by using separate binding and cleaving proteins to avoid immobilization by the host's mucus. Now, Michael Vahey and Daniel Fletcher have determined that its success may be attributed to the spatial organization of these proteins within the viral envelope.

In hosts, the virus has a filamentous form that differs from the spherical morphology of laboratory strains. Vahey and Fletcher showed that in the filamentous particles, the binding and cleaving proteins are asymmetrically distributed. Invoking a Brownian ratchet mechanism, they found that this distribution could result in persistent motion — allowing the virus to penetrate the host's mucus without compromising its ability to engage receptors on the cell surface. *AK*

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NON-EQUILIBRIUM PHYSICS

Far from perfect

J. R. Soc. Interface **16**, 20190098 (2019)

Periodically oscillating biochemical systems are like internal clocks for organisms. The stochastic nature of their underlying dynamics — from proteins cycling through different states, for example — inevitably generates random fluctuations in the oscillation periods. As these oscillations can hamper biological function, it has been conjectured that real oscillators are optimized to suppress them. But Robert Marsland III and co-workers have now shown that real biochemical clocks operate in a regime that is far from optimal.

Thermodynamic uncertainty relations impose a trade-off between the fluctuations and dissipation of a non-equilibrium current or, in this case, in the first-passage time required to accumulate a fixed current. Through these relations, the authors determined an upper bound to the accuracy of a clock in relation to its entropy production per cycle. Computational models of real biochemical clocks, such as the KaiC protein, were found to perform well below this optimum. The shortfall may be due to the additional complexity required by optimality and existing biological constraints. *FL*

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NUCLEAR PHYSICS

It's magic

Nature **569**, 53–58 (2019)

When atomic nuclei have particularly stable configurations with fully occupied energy shells, their nucleon numbers are said to be magic. However, experiments suggest that the shell-closure criterion need not apply for magic nuclei with vastly different proton and neutron numbers. The ^{78}Ni isotope has 28 protons and 50 neutrons — both magic numbers — making it a unique testbed to investigate this question.

Ryo Taniuchi and colleagues studied ^{78}Ni spectroscopically at the Radioactive Isotope Beam Factory, confirming predictions of its doubly magic nature and spherical shape despite asymmetric nucleon numbers. What came as a surprise was that the spherical shape competes with a prolate deformation. As a result, heavier nickel isotopes with 28 protons or lighter isotones with 50 neutrons should not have spherical shapes despite their magicity. The onset of shape deformations in these neutron-rich nuclei may influence the synthesis of elements heavier than iron via rapid neutron capture in the Universe. *SR*

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OPTICS

Stay in shape

Optica **6**, 598–607 (2019)

Unlike most light, propagation-invariant beams neither diffract nor disperse when they pass through a medium, allowing them to sustain their focal width for more than the Rayleigh length and to self-heal after they encounter an obstacle. All non-diffracting beams are characterized by tight correlations between the spatial and temporal frequencies underlying their beam profiles, which is why they are often realized using pulsed lasers, as a loss of spatiotemporal coherence is expected to destroy the beams' non-diffracting nature. But now, Murat Yessenov and co-workers have succeeded in creating non-diffracting beams with fully incoherent light, operating instead in quasi-continuous-wave mode.

Taking inspiration from ultrafast optics, Yessenov and colleagues used a fully linear approach to shape the wave from an incoherent broadband LED, imparting it with the necessary correlations to create non-diffracting beams with a 300-fold enhanced Rayleigh length. The advance could relax the source requirements for imaging thick samples with, for example, light-sheet microscopy. *NM*

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TOPOLOGICAL SEMIMETALS

Sound of Weyl

Phys. Rev. X (in the press); preprint at https://arxiv.org/abs/1901.09926

Sound propagation relies on interactions — meaning sound travels faster in hot air than in cold air because atomic collisions occur more frequently at high temperatures. However, when Coulomb interactions dominate, its long-range nature induces an energy gap for charge density waves, preventing it from propagating in an electron liquid. Now, Zhida Song and Xi Dai have shown that in Weyl semimetals, this difficulty can be overcome. A new acoustic collective mode carried by Weyl electrons emerges under a magnetic field, giving rise to so-called chiral zero sound.

The sound relies on a chiral magnetic effect, which produces a net charge current at each Weyl valley parallel to the external magnetic field, and causes the valley occupation number to oscillate, forming a breathing mode for the Fermi surface at different valleys. Under certain conditions, the charge currents between different pairs of Weyl points cancel, leaving the oscillation neutral — an acoustic mode reminiscent of Landau's zero sound for a Fermi liquid. *YL*

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