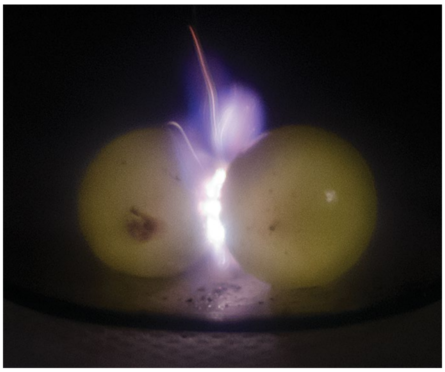
PLASMA PHYSICS

Grape balls of fire

Proc. Natl Acad. Sci. USA **116**, 4000–4005 (2019)



Credit: Slepkov Biophotonics Lab, Trent University

Take a grape. Cut it in half, but leave a thin strip of skin connecting the two halves. Put it in a household microwave and turn it on full blast. Observe the ignition of a plasma.

This simple experiment has inspired many science-fair projects and has even generated its own dedicated category of YouTube videos, but the precise mechanism through which it comes about has never been fully understood. One plausible explanation is that the skin acts as a short dipole antenna and that the conducting ion-rich skin 'bridge' plays an important role — but so far this had remained untested.

Using a combination of thermal imaging experiments and finite-element simulations, Hamza Khattak and colleagues have uncovered an altogether more surprising explanation: the grapes form resonant cavities at their centres that concentrate microwaves to much smaller wavelengths, which leads to the creation of the plasma. The effect was known in nanoscale metallic objects, but it now looks set to become relevant to a range of different macroscopic objects at microwave frequencies. *AT*

https://doi.org/10.1038/s41567-019-0496-6

STATISTICAL PHYSICS

Many-particle robots

Nature **567**, 361–365 (2019)

Emergent behaviours are arguably one of biology's better tricks, and robotics would be well served to follow suit. Now, Shuguang Li and colleagues have implemented a robot comprising particles that move as an amorphous collective — remaining robust in the event of partial malfunction.

The system comprises ring-shaped particles undergoing cycles of expansion and contraction with a phase that is modulated according to each particle's position. Li and colleagues induced autonomous locomotion by means of an algorithm familiar from collective cell migration: setting the phase offset proportional to the intensity of an external signal circumvents the need for interparticle coordination.

The team fabricated small robots to demonstrate their locomotive ability, as well as their capacity for moving and avoiding other objects. And unlike many robots, in which failure of a single part can result in malfunction, simulations of much larger systems showed these robots were robust to failure — moving at half their maximum speed even when 20% of the particles ceased to function. *AK*

https://doi.org/10.1038/s41567-019-0495-7

NONLINEAR DYNAMICS

Exotic yet easy

Science **363**, eaav7932 (2019)

Networks of coupled identical oscillators can settle into symmetric phase-locked synchronized states that are robust to underlying disorder. But what's even more interesting is that they can be probed for the emergence of exotic broken-symmetry states. Pattern formation in biological systems, for example, arises from oscillations whose symmetry has clearly been broken, resulting in inhomogeneous phase distributions.

As Matthew Matheny and colleagues have now shown, such exotic states do not require precisely designed couplings, but can appear in a system as simple as eight nonlinear nanoelectromechanical oscillators with linear nearest-neighbour couplings. In the team's experiments, when the oscillators' mutual coupling was strong enough to require a description that went beyond first order, a plethora of states with exotic phase relations was observed — including travelling waves, weak chimeras and more. This wealth of states was reproduced theoretically by taking into account higher-order interactions, but will doubtless offer a treasure trove for theorists to come. *FL*

https://doi.org/10.1038/s41567-019-0498-4

OPTICAL PHYSICS

Prime interference

Phys. Rev. Lett. **122**, 090201 (2019)

There are many methods for finding prime numbers, some of which date back to antiquity. Timothy Peterson and co-workers have suggested an analogous optical manifestation of the prime number sieve of Eratosthenes by superposing light in multiple diffraction patterns.

The bright spots of a diffraction pattern generated by a grid serve to label a set of discrete points that represent the integer numbers. By superposing Hermite–Gauss beams on this lattice, the amplitude at each point becomes variable and may be zero or finite, depending on the mode selected. Adding multiple grids corresponding to successive prime numbers mimics the iterative elimination of composite numbers suggested by Eratosthenes. Eventually, a finite value in the far-field diffraction pattern indicates a composite number, zero means a prime.

The authors showed simulations for primes up to 31, and suggested that simpler optical sieves could go even further. *DA*

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NUCLEAR PHYSICS

The size of the proton

Phys. Rev. C **99**, 035202 (2019)

Even though Ernest Rutherford discovered the proton more than a hundred years ago, some of its properties still remain a mystery. The radius of the proton, commonly defined via the proton's three-dimensional charge density, is one of them. The proton radius measured from hydrogen spectroscopy and electron–proton scattering experiments is about 0.88 fm, whereas spectroscopy of muonic hydrogen atoms reveals a radius of 0.84 fm. The origin of this small difference of 4% remains unclear.

Now, Gerald Miller has argued that the quarks and gluons inside the proton behave relativistically, and that any measurement of the proton will change the proton's interior wave function, making the definition of a three-dimensional charge density impossible. Based on a two-dimensional charge density, the proton radius is defined as a measure of the interaction between a photon and one of the charged constituents of the proton. This means that both experiments refer to the same quantity when they measure the proton radius. *SR*

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