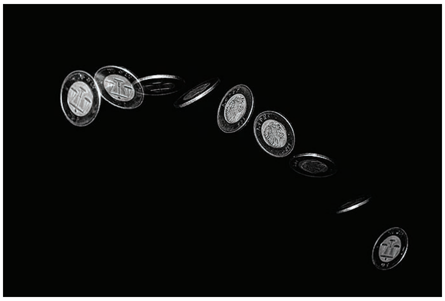
RANDOM NUMBERS

A quantum coin toss

Phys. Rev. X **7,** 041050 (2017)



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The ability to generate genuinely random numbers is crucial for digital security, and typically relies on hardware design to introduce randomness. The emergence of light-based circuits for data processing means that an all-optical method for generating random sequences would be very useful. Tobias Steinle and collaborators have accomplished this, using a technique with several practical advantages.

An optical parametric oscillator produces single photons by down-converting a pumped state into one of two possible states that are either in phase or out of phase with a reference signal. Which state emerges is determined by, among other effects, the randomness of the quantum vacuum fluctuations in the optical cavity. The generated state can be interpreted as a binary bit, or the head and tail of a coin toss.

Analysis of the output shows that the generated bit stream is random with perfect entropy for up to 10^5 samples. Importantly, the non-degeneracy of the two output states means that the generation scheme is robust against fluctuations in the pump power, and the state detection via phase difference introduces less noise than other detection schemes. *DA*

BIOMIMETICS

Fold-up skeleton

Proc. Natl Acad. Sci. USA
http://doi.org/cgwk (2017)

Fluids are popular design components for artificial muscles, but usually operate under high pressures that compromise safety and robustness. Now, Shuguang Li and co-workers have come up with an architecture driven by fluids at negative pressures — exploiting ideas from origami metamaterials to build biocompatible muscles capable of complex multiaxial motions.

The design proposed and tested by Li *et al.* involves a flexible skin filled with fluid and wrapped around a skeletal structure comprising structural voids — like those found in the complex folds of origami. A mechanical model explains the interaction of the three components: pressure differences between the internal and external fluids cause the skin to deform inward towards the voids, which in turn are driven to contract under tension.

The team investigated different skeletal structures, finding that linear zigzag actuators with nylon skins were able to generate actuation stresses of up to 600 kPa, six times larger than that of mammalian skeletal muscle. *AK*

BIODIVERSITY

Winning ways

Phys. Rev. Lett. (in the press); preprint at
https://arxiv.org/abs/1706.02666

Biodiversity is stunning yet puzzling. How can several species compete for the same nutrient sources and still coexist, rather than having one winner monopolizing the resources? One approach to resolving this sort of paradox is the 'kill the winner' hypothesis: the most successful species is selectively decimated (by, say, a predator) and different prey species take turns at winning. That model has proved insightful, but Chi Xue and Nigel Goldenfeld argue that in its original form it misses important aspects that actually prevent a stable coexistence state. Luckily, they also show how diversity can be restored.

The original model assumes continuous population densities, which is not warranted for finite populations. Xue and Goldenfeld took into account 'demographic stochasticity' — think shot noise for populations — and found that coexistence broke down as species became extinct. But when predators and prey were allowed to coevolve, continuously adapting to one another, then the appearance of fit mutants counteracted the elimination of species. And for sufficiently large mutation rates, winner-alternating and coexisting phases emerged from the interplay between ecological and evolutionary processes. *AHT*

GEOPHYSICS

Lightning-fast tremors

Science **358,** 1164–1168 (2017)

In this era of gravitational-wave detection, our imagination is routinely captured by astronomical events of colossal magnitude. But one need not travel far to encounter phenomena capable of shaking the gravitational field — it's enough to consider what happened in Japan seven years ago. Using data from the 2011 Tohoku earthquake, Martin Vallée and co-workers have demonstrated that perturbations to the gravitational field generated by elastogravity waves leave a detectable signal in distant seismometers.

Acting as additional sources of elastic deformation, these gravitational disturbances are difficult to isolate, as seismographs are attached to the ground, and thus detect both gravity's pull and the acceleration of the ground. A careful computation allowed the authors to derive the difference between these two quantities, obtaining the actual detected signal, and revealing that it contains information about both the earthquake and its magnitude. Travelling at the speed of light, the gravitational perturbation might allow a much earlier detection of the strength of larger seismic events, which is notoriously difficult to establish near the epicentre. *FL*

EVOLUTIONARY GAME THEORY

Metric of cooperation

Nat. Commun. **8,** 1888 (2017)

The theoretical machinery used to study complex networks has found extensive use in evolutionary game theory, particularly when it comes to understanding the dynamics of cooperation and the emergence of complex societies.

Most contact networks have a heterogeneous structure: they are made up of many connected clusters of varying size, as opposed to the homogeneous lattice structure commonly seen in models describing (say) magnetic systems. Provided the distribution of the connected clusters in a contact network is scale free — so that the degree of their connectivity follows a power law distribution — it has been shown theoretically that cooperation is favoured. Unfortunately, this prediction has not been confirmed in recent experiments, suggesting something deeper must be at play.

By mapping the nodes of real complex networks onto a metric space, Kaj-Kolja Kleineberg was able to make a more useful representation, in which the popularity of a node and its degree of similarity to other nodes was made explicit. Using this representation, he confirmed that heterogeneity does not always favour cooperation. It can, in fact, even hinder it. *AT*

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