BIOMATERIALS

A good egg

Sci. Adv. **4**, eaar3219 (2018)

Credit: RubberBall / Alamy Stock Photo

The characteristic shape of eggs makes them surprisingly resistant to mechanical pressure. However, to understand other remarkable properties of eggshells — whose basic structure has changed relatively little since the days of baby dinosaurs — requires taking a look at the nanoscale. Dimitra Athanasiadou and colleagues have done just that.

Using atomic-force electron and optical microscopy, they found a hierarchical nanogranular structure that varied distinctly across the three major layers of chicken eggshells. Moreover, the nanostructure changed during egg incubation. For eggs incubated for 15 days (chicks hatch typically after some 21 days) the nanostructure of the outermost layer was the same as that of fully developed eggs, but in the innermost layer features were significantly smaller.

The resulting larger area of the inner surface might mean that minerals there dissolve more easily. This helps to deliver calcium for building up the embryo's skeleton, but should also conveniently weaken the shell structure such that chicks can break through more easily when they hatch. Call that an evolutionary advantage. *AHT*

https://doi.org/10.1038/s41567-018-0142-8

NON-EQUILIBRIUM DYNAMICS

Towards thermalization

Phys. Rev. X (in the press); preprint at https://arxiv.org/abs/1707.07031

Newton's cradle is a device that famously demonstrates the conservation of momentum and energy in classical mechanics. A row of metal balls swing back and forth, striking their neighbours without ever coming to rest. A similar non-equilibrium motion occurs in the quantum world if a large number of conserved quantities associated with the system's integrability are available. The quantum version of Newton's cradle has been observed previously in contact-interacting Bose gas confined in one dimension.

Now Yijun Tang and co-workers have taken a further step forward, studying the crossover from integrable to thermalizing behaviour in a quantum Newton's cradle. The magnetic dysprosium atoms used in their experiment provide long-range and anisotropic dipole–dipole interactions, which can serve as an integrability-breaking perturbation in the system. By tuning the orientation of the dipoles — corresponding to different perturbation strength — a two-step thermalization process was identified: a rapid dephasing leading to the prethermal state followed by a nearly exponential approach to the final thermal distribution. *YL*

https://doi.org/10.1038/s41567-018-0146-4

NETWORK SCIENCE

Just wait

Phys. Rev. E **97**, 042306 (2018)

Every winter we hear forecasts on how bad the upcoming flu season is going to be. Seasonal peaks are but one example of cyclic epidemics, a phenomenon that is shared by several diseases — some of which have periods of months or even years. Seasonality can't explain these oscillations — but perhaps our reaction can.

From avoiding public transport to quarantines, people respond to outbreaks by changing habits. Mathematically, these changes can be captured by adaptive networks, where nodes redirect their links from infected neighbours towards healthy ones at a certain rate. However, epidemic models on these networks haven't displayed the expected periodicity so far.

Now, Neil Sherborne and colleagues demonstrate that an adaptive model with a delay between cutting and reconnecting links does the trick, leading to oscillations between states with high and low disease prevalence. Besides making sense behaviourally, this model provides a starting point for studying infections and adaptive behaviour. *FL*

https://doi.org/10.1038/s41567-018-0144-6

ADVANCED X-RAY DIFFRACTION

Sum it up

Phys. Rev. Lett. (in the press); preprint at https://arxiv.org/abs/1802.04421

Ultrafast X-ray diffraction promises dynamic information about molecular structure at an unprecedented spatio-temporal resolution. But when contributions from optically excited valence electrons are considered, only a limited share of the total electron density generates useful signals. Being able to visualize electron density changes would help us to obtain structural and electronic information from molecular photophysics. Now, Jérémy Rouxel and co-workers have proposed a variant of X-ray spectroscopy that is especially sensitive to optically active electrons.

Leaning on nonlinear signal generation from interfaces, Rouxel and colleagues propose the combination of an X-ray field with a visible field to create signals through a so-called sum-frequency generation. As electronic coherences contribute to the process, the emitted light is directly sensitive to the transition charge density, which can be viewed as an interference between charge densities from the contributing electronic states. With additional delays and frequency extensions, the method might serve as a flexible tool for experiments at next-generation free-electron lasers. *JPK*

https://doi.org/10.1038/s41567-018-0145-5

David Abergel, Jan Philip Kraack, Federico Levi, Yun Li and Andreas H. Trabesinger

NUCLEAR NON-PROLIFERATION

What's in the box?

Nat. Commun. **9**, 1259 (2018)

Nuclear non-proliferation treaties are vitally important for global security, but they are difficult to enforce because nations want to be secretive about the details of their weapons technology, even during inspections. To combat this, Jake Hecla and Areg Danagoulian propose a zero-knowledge method for examining the fissile plutonium 'pit' in a warhead, to verify its geometry and isotopic composition.

The isotopes of plutonium have quite different interaction cross-sections with neutrons in the 1-eV to 10-eV energy range, but doing a simple measurement of the absorption spectrum of the pit would reveal crucial information about it. The authors' proposal is to introduce a specially designed reciprocal mask so that the neutrons traverse both the pit and the mask. The mask is templated in such a way that the absorption spectrum verifies the construction of the pit but does reveal detailed information about its design. Crucially, detailed calculations show that this method is resistant to various types of hoaxes. *DA*

https://doi.org/10.1038/s41567-018-0143-7