

Sciencewatch

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Modelling the mechanics of curly hair

Nothing in nature is exempt from investigation by physicists, and the shape of suspended hairs has now come under scrutiny. James Miller and colleagues at Massachusetts Institute of Technology and the Université Pierre et Marie Curie in Paris combined precision desktop experiments with theoretical analyses to study the shapes taken by thin elastic rods suspended by their own weight – essentially a hanging hair. Being thin, such rods can acquire large twists while remaining in the small-strain regime.

The researchers constructed a phase diagram in terms of a dimensionless curvature and weight, and found three distinct regions: planar curls, localized



helices and global helices. Given curvature, length, weight and stiffness, their model will predict the shape of a hair, steel pipe or

Flexible segments of tubing that James Miller made with varying degrees of curliness and used for the lab experiments. (Image credit: James Miller and Pedro Reis.)

cable suspended under its own weight. The work is relevant for computer animations – where flowing curly hair has been difficult to simulate – and covers a surprising range of systems including DNA and plant tendrils, as well as hanging pipes and cables.

● Further reading

JT Miller *et al.* 2014 *Phys. Rev. Lett.* **112** 068103.

Cracks toughen glass

Many brittle materials, such as glass or ceramic tiles, can be broken readily if the surface is cracked first. It might come as a surprise then to find that such materials can be toughened by etching a pattern of tiny cracks into them.

Taking a hint from strong natural materials such as teeth and mollusc shells, M Mirkhalaf and colleagues at McGill University in Montreal laser-etched a 3D pattern of micro cracks (up to about 25 μm across and spaced by 130 μm) into glass and filled them with shock-absorbent polyurethane. This impedes the ability of cracks to propagate into the bulk and gives a bio-inspired glass that is more deformable and 200 times tougher. The technique should be extendable to other brittle materials.

● Further reading

M Mirkhalaf *et al.* 2014 *Nature Comm.* **5** 3166.

Subdiffraction-limited imaging inside a cell

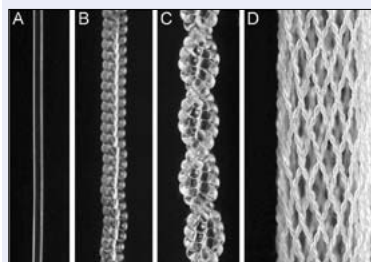
Non-classical light can be used to circumvent traditional diffraction limits on imaging, and has now been demonstrated to look inside a living cell. To do this, Michael A Taylor of the University of Queensland and colleagues tracked lipid nanoparticles as they diffused through a live yeast cell using squeezed light in a photonic force microscope (PFM).

Artificial muscles

A new type of artificial muscle made from fishing line and sewing thread dramatically outperforms predecessors. Carter S Haines of the University of Texas at Dallas and colleagues have shown how inexpensive, high-strength polymer fibres used for fishing line and sewing thread can be made into artificial muscles, with their force provided by temperature-dependent twisting. With high degrees of twisting, these can contract by 49%, lift more than 100 times the load that the same length and weight of human muscle can, and generate 5.3 kW of work per kilogram of muscle – comparable to a jet engine.

● Further reading

CS Haines *et al.* 2014 *Science* **343** 868.



(A) A non-twisted 300- μm -diameter fibre; (B) fibre A after coiling by twist insertion; (C) a two-ply muscle formed from coil B; (D) a braid made from 32 two-ply, coiled, 102- μm fibres produced as in (C).

A PFM is similar to an atomic force microscope, but uses a nanoscale particle trapped in optical tweezers instead of the usual probe tip. Using squeezed light reduced the measurement signal-to-noise, allowing the construction of 1D spatial profiles within a cell down to 10 nm. Seeing below 1 nm *in vivo* looks possible. This is the first time that squeezed light has been used in biological imaging.

● Further reading

MA Taylor *et al.* 2014 *Phys. Rev. X* **4** 011017.

One-way sound

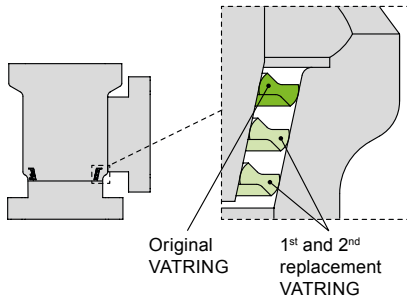
Sound transmission is usually reciprocal – if you want to listen to someone you have to let them be able to hear you. Now, Romain Fleury of the University of Texas at Austin and colleagues have found how to obtain sound transmission that favours one direction over the opposite one. They found the required time-reversal invariance violation – sound propagation normally knows no direction of time – in an acoustic analogue of the Zeeman effect, where a magnetic field makes a material birefringent.

In place of a magnetic field, they used airflow around a circular cell so that sound propagates differently with or against the flow. Their device, built from simple off-the-shelf components, gives 40 dB of non-reciprocal sound isolation.

● Further reading

R Fleury *et al.* 2014 *Science* **343** 516.

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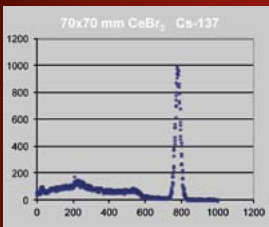


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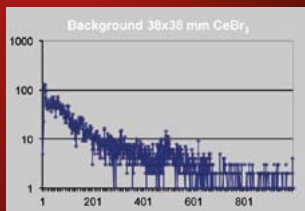


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