Through the phases

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When infected with *Plasmodium falciparum*, red blood cells undergo substantial changes. The malaria-inducing parasite causes modifications in the structure and mechanical properties of the cells, as well as biochemical alterations. YongKeun Park and colleagues show how such changes are reflected in the optical properties of red blood cells, and how advanced microscopy techniques should provide a fresh approach to studying parasite attacks.

Park *et al.* used diffraction phase microscopy to look at membrane fluctuations with nanometre and millisecond resolution in space and time, respectively. They found that the cell membrane becomes less flexible as the infection progresses. Such a loss in deformability is one of the factors that cause parasitized red blood cells to clump in small blood vessels.

By recording three-dimensional refractive-index maps of the cells, using so-called tomographic phase microscopy, Park *et al.* could trace the progressive destruction of haemoglobin — which has a central role in oxygen transport — throughout the stages of parasite maturation inside the cell.

Back in time

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Physicists have known about negative refraction — the ability of certain materials to bend light the 'wrong way' — since the 1960s. But it remained largely a theoretical curiosity until recently, when the engineering of such materials became possible. Now John Pendry has proposed that negative refraction is intimately linked to the phenomenon of time reversal. He suggests a scheme in which time-reversal effects could be used to mimic negative refraction, potentially offering a simpler route towards superlenses with subwavelength resolution.

Pendry has clarified the link between the mathematics of time reversal, in which a wave's phase is wound backwards in time to refocus on the source, and negative refraction, in which waves focus back on themselves inside a medium. He explains how time-reversing a beam in a suitable medium (a chiral one, for example) and then reflecting it from a conventional mirror can lead to focusing akin to that produced by a negatively refracting material. In practice, building such a system will be tricky, but the promise of subwavelength resolution is a spur to progress.

Magnetic oddity

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Physical properties at the nanoscale can be starkly different from those in the bulk. Magnetic nanostructures, such as antiferromagnetic wire-like atomic chains on magnetic surfaces, can be particularly complex, but Samir Lounis and colleagues have a prediction for the magnetic ordering in such wires — that it is determined in a non-local way by the number of atoms in the wire.

Antiferromagnetic nanostructures typically exhibit the effects of magnetic frustration, which arises through the inability to satisfy exchange interactions between neighbouring atoms. The frustration becomes yet more complicated when the nanostructure is coupled to a ferromagnetic substrate. To accommodate the spin frustration, the nanostructure typically forms a non-collinear magnetic structure, in which the quantization axes, along which the magnetic moments point, change between atoms.

Ab initio calculations by Lounis *et al.* show that even-number manganese atomic chains on nickel substrates form a non-collinear structure; odd-number chains, however, form a collinear ferrimagnetic structure. Thus, a single atom can non-locally change the magnetic structure of the whole wire.

A charmed life

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When the J/Ψ meson was found in 1974, it signalled the discovery of the charm quark and sparked a revolution in high-energy physics. Since then, the J/Ψ has revealed a rich array of physics, and now members of the CLEO Collaboration, sifting through electron–positron collision data from the Cornell Electron Storage Ring, have observed the decay of a J/Ψ into three photons for the first time.

The J/Ψ is made up of a charm quark bound to its antiquark. Its much lighter cousin, ortho-positronium, a bound electron–positron state, decays almost exclusively to three photons and has been used to probe quantum electrodynamics with high precision. Similarly, the decay of the J/Ψ to three photons is important for precise tests of quantum chromodynamics (QCD).

The J/Ψ only disintegrates into three photons every one in 100,000 decays. These events are selected by identifying pairs of pions recoiling from the J/Ψ and verifying that charged-particle tracks from the J/Ψ decay are missing, which is consistent with photon production. The measurement should provide crucial experimental input to QCD predictions.

Vector dominance

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The Universe is expanding, and the rate of expansion is accelerating. Dark energy is a favoured explanation — some kind of strange phenomenon, exerting a negative pressure — and one that can be encapsulated in the notion of a cosmological constant.

But setting up this kind of cosmology raises as many questions as it answers. In particular, there is the problem of 'fine-tuning' — the improbability of getting everything set just right for the Universe as we know it to exist. More dynamic models of dark energy have been considered, usually invoking some type of cosmological scalar field rather than the constant. But how about a vector field instead?

Jose Beltrán Jiménez and Antonio L. Maroto show that a vector theory built on the action of two fields, without potential terms or free parameters, can describe periods of accelerating expansion in the Universe. It's a neat way around the fine-tuning problem and an effective description of dark energy — although, as the authors admit, there are still some issues to address before the viability of the model is confirmed.