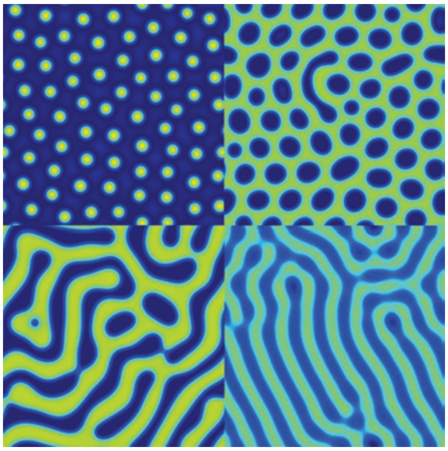
Segmentation diagnosis

New J. Phys. **13,** 115013 (2011)



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The proliferation of microstructures throughout a tumour is a tell-tale sign of malignancy. However, the physical origin of these structures remains unknown, despite their prevalence in current techniques for skin-cancer diagnosis. By analysing the dynamics of binary mixtures, Clément Chatelain and colleagues have shown that model tumours are capable of undergoing a spinodal decomposition, which heralds the emergence of microstructure patterns.

The model cells begin to segregate as soon as a particular type of adhesion between tumour cells reaches a critical value. But it's their access to nutrients that holds the key to stable phase separation. It imposes two key length scales on the system: one encoding the extent to which nutrients can penetrate the cell mass, and the other resulting from the dynamics of cell proliferation, which are controlled by the local nutrient concentration. The existence of the second length scale has the effect of stabilizing the microstructures, for which the model predicts a typical size, commensurate with that observed clinically. *AK*

Guided matter

Phys. Rev. Lett. **107,** 230401 (2011)

Interfering laser beams can reflect particles — a phenomenon now demonstrated by Charlotte Fabre and colleagues, who have created a matter mirror by crossing two infrared beams.

Optical interference creates a periodic energy potential where the two laser beams meet. By launching a cloud of rubidium atoms towards this mirror and then imaging the atoms after they had interacted with the laser light, Fabre *et al.* were able to measure what fraction of the incident cloud was reflected, and how many atoms were transmitted. The reflectivity of the mirror could be controlled by increasing the laser power.

Periodic mirrors are already well known in optics, where they are called distributed Bragg reflectors. Alternating layers of high- and low-refractive-index materials can trap photons in cavities, to construct lasers, for example, or guide light propagation, as in optical fibres. The development of distributed Bragg reflectors for matter waves will aid the translation of these concepts from light to matter. *DG*

Cooling by numbers

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Like electrons trapped in the potential of a nucleus, bosonic atoms residing at the individual sites of an optical lattice — a periodic structure defined by interfering laser beams — can occupy discrete motional orbitals. Waseem Bakr and colleagues have now implemented a technique for deterministically controlling the distribution of atoms across these different energy states, and establish it as a new means of cooling quantum gases.

The key is a mechanism Bakr *et al.* call 'orbital excitation blockade'. They transfer ground-state atoms to a higher orbital by modulating the lattice depth at a suitable frequency; but once one atom is transferred, it shifts the energy levels to a degree that other atoms at the same site are pushed off-resonance — the first excitation blocks further ones.

Bakr and colleagues use this mechanism to reshuffle and selectively remove atoms from a lattice with random occupation numbers. As atom-number fluctuations across the lattice are the main source of entropy, levelling the number of atoms at each site amounts to cooling the gas. The authors expect that in the future their method can also serve in quantum computations on optical-lattice systems. *AT*

Luminous repulsion enhanced

Opt. Lett. **36,** 4638–4640 (2011)

When a dielectric particle is exposed to a strong optical gradient it becomes electrically polarized and subject to an attractive force in the direction of increasing field strength. This is the principle by which optical tweezers are able to trap and manipulate living cells and other microscopic objects.

A similar force can be generated between two light-carrying microscopic (and nanoscopic) waveguide structures. Moreover, the sign of the force can be tuned from attractive to repulsive by shifting the phase of the light travelling in one waveguide relative to the other — which is potentially useful for optomechanical sensing and switching applications. Unfortunately, the magnitude of such forces is much less than the force exerted by optical tweezers. And at small separations the sign is invariably attractive.

Ardavan Oskooi and colleagues propose a way to increase the repulsion between waveguides. Their calculations suggest that the key is to cut each waveguide in half, as semicircular waveguides perform much better than circular. This works even better in the case of photonic crystal waveguides, which show a 30-fold increase in repulsive force that remains repulsive even at small separations. *EG*

Spot the difference

Phys. Rev. Lett. **107,** 241801 (2011)

Neutrinos oscillate — that is, each of the three types of neutrino (electron, muon and tau) can evolve into one of the others, a behaviour that is captured in a matrix of mixing angles. This also brings the possibility of 'CP violation' in the neutrino sector, complementing that seen in the mixing of quarks, which could be spotted through a detectable difference in the oscillation probabilities for neutrinos and antineutrinos.

Discrepancies between neutrino and antineutrino data have been noticed by some experiments, notably MINOS and MiniBooNE, which both use neutrino beams generated at Fermilab, in the United States. K. Abe and colleagues have now searched data collected for atmospheric neutrinos over an 11-year period by the Super-Kamiokande apparatus, located in the Mozumi mine under Mount Kamioka in Japan.

In Super-Kamiokande's huge underground tank, lined with photomultiplier tubes and filled with 50,000 tons of water, Abe *et al.* sought evidence of the disappearance of muon neutrinos and muon antineutrinos as they oscillated into the other particle types. Through a challenging analysis that allows for 120 sources of systematic uncertainty, the authors conclude that, as yet, the mixing parameters for neutrinos and antineutrinos from atmospheric sources are entirely consistent with each other. *AW*

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