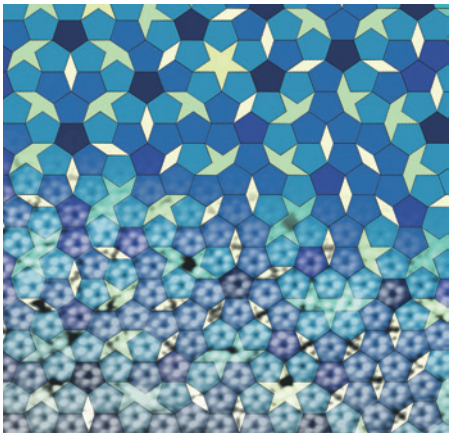
QUASICRYSTALS

Now in molecular layers

Nature **507,** 86–89 (2014)
Nano Lett. **14,** 1184–1189 (2014)



© S. ALEX KANDEL

Quasicrystals have long-range order but no periodicity, and were first observed by Dan Shechtman in 1982, a discovery that he was awarded the Nobel Prize in Chemistry for in 2011. The structures are typically found in metal alloys such as AlCuMn, but they have also been reported in more unusual systems such as liquid crystals, nanoparticle assemblies and perovskite thin films. Two independent research teams have now discovered different ways to create quasicrystals from a layer of molecules on a surface.

Alex Kandel and colleagues at the University of Notre Dame formed self-assembled two-dimensional quasicrystals using ferrocenecarboxylic acid molecules adsorbed on a gold surface. The carboxyl groups of the molecules can form hydrogen bonds and these bonds drive the molecules into cyclic pentamers. This leads to the formation of molecular monolayers — which the researchers imaged with a scanning tunnelling microscope (STM) — that have local five-fold symmetry, but no periodicity.

Alternatively, Joe Smerdon and colleagues at the University of Central Lancashire, the University of Liverpool and Tohoku University used the surface of a ternary metal alloy quasicrystal as a template to grow a quasicrystalline layer of C_{60} or pentacene molecules. The molecules preferentially adsorb on specific sites on the surface, creating molecular layers that reflect the structure of the substrate below. The resulting quasicrystalline molecular layers were also imaged with an STM. *OV*

SINGLE-MOLECULE THERMOMETRY

A controlled jump

Angew. Chem. Int. Ed. **53,** 3470–3474 (2014)

Probing the physicochemical properties of single molecules while varying their temperature is usually carried out with indirect methods, because the laser irradiation that is typically used to induce a temperature jump can destroy the sample. These methods cannot provide *in situ* temperature information, which leads to uncertainties in the measurements. Hanbin Mao and colleagues at Kent State University have now developed a technique that allows mechanochemical experiments with single DNA molecules to be carried out with precise temperature control.

The researchers use a carbon microparticle that is placed at the tip of a capillary. The microparticle can efficiently absorb light and through a photothermal effect can increase the temperature of its immediate environment by about 30 °C within milliseconds. The microparticle is placed in close proximity to a DNA hairpin, which is tethered between two optically trapped beads that can register the force exerted by the DNA as it unfolds; this mechanical unfolding is temperature dependent and can be used to determine the *in situ* temperature of the experiment.

With the set-up, Mao and colleagues are able to extract the enthalpy and the entropy of the unfolding of the DNA hairpin, and reconstruct the energy landscape of the transformation. *AM*

SILICON NANOPARTICLES

Made to measure

Nature Commun. **5,** 3402 (2014)

Dielectric nanoparticles with controlled shapes and sizes could be used in nanophotonic components such as metamaterials and nanoantennas owing to their resonant optical responses. However, although methods exist to controllably fabricate metal nanostructures, fabricating dielectric nanoparticles with similar levels of control remains a challenge. Boris Chichkov and colleagues at the Laser Zentrum Hannover have now used laser printing to fabricate silicon nanoparticles with a specific size and a defined position on a glass support.

A single 50-fs laser pulse, with energy of 5 nJ, is shot at a silicon-on-insulator wafer, locally melting the top silicon layer. The liquid silicon forms a droplet that is ejected from the wafer and hits a glass support placed 5 μm above it. The process forms a single amorphous silicon nanoparticle on the [illegible] are [illegible] energy used, can have diameters of between 160 and 240 nm. The silicon nanoparticles also show strong dipole responses in the visible range.

A second, stronger (58 nJ) laser pulse can subsequently be used to crystallize the amorphous nanoparticles, with the extent of crystallization depending on the pulse energy. The crystalline nanoparticles exhibit an optical response that is stronger, and has different colours, than the amorphous nanoparticles. By tailoring the size and crystallinity of the silicon nanoparticles, the researchers can control the magnetic and electric dipole scattering spectra of single nanoparticles. *ED*

HETEROSTRUCTURES

Skyrmions at the interface

Phys. Rev. Lett. **112,** 067202 (2014)

by Xiaopeng Li, W. Vincent Liu, Leon Balents

Magnetism has been observed at the conductive interface of insulating oxide heterostructures such as $LaAlO_3/SrTiO_3$. However, its microscopic origin remains controversial. Several explanations have been proposed, ranging from the formation of local magnetic moments to itinerant magnetism. Regardless of the specific mechanism that gives rise to magnetic order, Xiaopeng Li and colleagues have now shown that it is possible to describe the magnetism in oxide heterostructures with a phenomenological model based on symmetry arguments, under the assumption that the spin–orbit coupling is weak.

The researchers — who are based at the University of Pittsburgh, University of California, Santa Barbara, and the Chinese Academy of Sciences — first derive the free energy of the system, and then minimize it to find a phase diagram that features a variety of magnetic phases below a spin-ordering transition temperature. The phase diagram is rather complex and includes in-plane ferromagnetic, spiral, cone and skyrmion lattice phases, the appearance of which depend on the strength of a phenomenological coupling parameter *g*. Of particular interest, the skyrmion state differs from that found in non-centrosymmetric materials such as helimagnetic MnSi, in that it has nodal points that are protected by geometrical and time-reversal symmetries. Magnetic and transport experiments will be able to confirm the presence of these magnetic phases in $LaAlO_3/SrTiO_3$ heterostructures. *ED*

Written by Elisa De Ranieri, Alberto Moscatelli and Owain Vaughan.