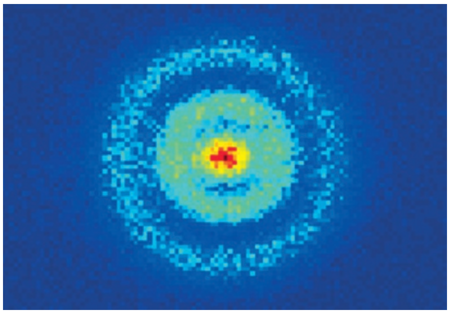
HYDROGEN ATOMS

A look at electron orbitals

Phys. Rev. Lett. **110,** 213001 (2013)



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The wavefunction of a particle represents the probability distribution of its position in space. Measuring the particle's position, however, involves the projection of its wavefunction onto one of the possible eigenstates. Only by performing statistics on the outcome of these measurements can the quantum state of the particle be reconstructed. Aneta Stodolna, Mark Vrakking and co-workers have now used photoionization microscopy measurements to observe the nodal structure of the wavefunction of the electron in an excited hydrogen atom, in the presence of an applied electric field.

The researchers — who are based at the FOM Institute AMOLF, Max-Born-Institut, Université Lyon, University of Ioannina and Auburn University — generate a beam of hydrogen atoms that they subsequently excite with two laser pulses. The hydrogen atoms are first excited to a mixture of 2*s* and 2*p* states, and then finally to a highly excited state in which the atoms are ionized. Tuning of the laser wavelength allows different atomic states to be selected. The emitted electrons travel towards a detector positioned orthogonally to the electric field, and generate an interference pattern that is captured on the detector screen. The observed interference pattern reflects the nodal structure of the electronic wavefunction, which in turn is related to the quantum number.

With the approach, the team are able to observe the nodal structure of four distinct excited atomic states with a principal quantum number $n = 30$. *ED*

CARBON NANOTUBES

Grown from a ring

Nature Chem. **5,** 572–576 (2013)

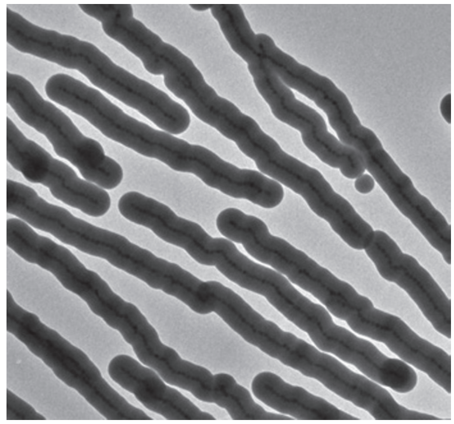
Carbon nanotubes are of interest in a variety of applications because of their electronic, optical and mechanical properties. These properties are, however, sensitive to the diameter and sidewall structure (or chirality) of the nanotubes, and current synthesis methods cannot produce materials with well-defined diameters and chiralities. The recent synthesis of carbon nanorings (cycloparaphenylenes), which are the basic structural units of a carbon nanotube, with precise diameters and chiralities has suggested that a bottom-up method for synthesizing carbon nanotubes could be developed.

Kenichiro Itami and colleagues at Nagoya University have now shown that cycloparaphenylene nanorings can be used as templates to grow carbon nanotubes with diameters similar to those of the templates. The nanotubes are created by heating the template molecules to around 500 °C in flowing ethanol gas that acts as a carbon source. Itami and co-workers suggest that the tube growth is probably due to a radical mechanism in which active carbon species from ethanol replace hydrogen atoms in the nanoring molecules. The distribution of nanotube diameters created with the approach is, however, far from monodisperse because radical reactions alter the structure of the tube and introduce 'errors' during growth. *AM*

MAGNETIC NANOSTRUCTURES

Mix it up

Angew. Chem. Int. Ed. http://doi.org/f2c9wk (2013)



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Spinning magnetic stir bars in glass beakers are a common sight in many chemical and biological research laboratories and are used to effectively mix chemical reactions. Micrometre-sized droplets can also function like miniature beakers, allowing numerous reactions to be carried out in parallel. However, mixing such small volumes can be difficult and is typically achieved with micrometre-sized stir bars, which, due to gravitational and magnetic forces, tend to stir only the bottom of the reaction vessel. To address this, Hongyu Chen and colleagues at Nanyang Technological University have now created nanoscale magnetic stir bars.

The stir bars are made from linear chains of Fe_3O_4 nanoparticles, which are formed by aligning the nanoparticles with a magnet and then coating them with a silica shell to preserve the structure. The nanoparticles have a diameter of around 40 nm, but the bars can have widths of between 75 nm and 1.4 μm by adjusting the thickness of the silica shell. Chen and co-workers show that the bars can be used to stir droplets with volumes as small as 4 pl and can be rotated with an ordinary magnetic stir plate.

The stir bars remain suspended in the droplets because of their size and can therefore stir all parts of the solution. *OV*

GRAPHENE

Hot spots on the map

Nano Lett. http://doi.org/mvz (2013)

A temperature gradient applied across a solid-state material generates an electric voltage. This is the basis of thermoelectric devices, which can transform wasted heat into electricity, or through the opposite principle, can act as solid-state refrigerators. The thermal generation of a voltage also occurs in a scanning tunnelling microscope when the tip and the sample are at different temperatures. Jewook Park and colleagues at Oak Ridge National Laboratory and Carnegie Mellon University have now used this effect to study samples containing mixed domains of monolayer and bilayer graphene grown on silicon carbide.

The researchers obtained thermovoltage maps that were distinct from standard topography images, and revealed a high sensitivity of the thermovoltage to the local charge density. The thermovoltage exhibits periodic oscillations on the bilayer domains and are essentially absent on the monolayer domains. This can be ascribed to intervalley electron scattering, which can occur in bilayer but not in monolayer graphene. Moreover, the samples exhibit domain patterns that are absent in the topography images. Park and colleagues suggest that these patterns are due to the formation and collapse of wrinkles created by thermal expansion during cooling after growth. If the wrinkles are collapsed, the chemical bonding to the substrate has been modified irreversibly, and this is reflected in the charge density and picked up by the thermovoltage. *FP*

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

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