Chemistry revealed

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Watching chemistry happen at the atomic level is a chemist's dream — and one that is now coming true. Using non-contact atomic force microscopy, Dimas de Oteyza and colleagues have obtained spectacular images of individual hydrocarbon molecules — with single-bond resolution — before and after a chemical reaction.

To study rearrangement reactions known as cyclization processes, de Oteyza *et al.* synthesized multicyclic hydrocarbon molecules on a silver surface and probed them using a single CO molecule tip. The high-resolution images reveal the mechanisms of thermally induced breaking and formation of molecular bonds, resulting in a variety of unexpected products. These observations, together with *ab initio* calculations, provide a clearer picture of the complex surface chemistry.

Cyclization processes are the key to the bottom-up molecular assembly of polyaromatic hydrocarbons and eventually of more complex graphene-like nanostructures. *IG*

Correspondence course

Phys. Rev. Lett. **110,** 231601 (2013)

Although still light on testable predictions, string theory has led many physicists into a rich realm of mathematics. But a tool identified in the 1990s by Juan Maldacena is proving a useful link between the abstract world of string theory and more familiar problems in, for example, condensed-matter systems or the high-energy-density environment of heavy-ion collisions. That tool is 'AdS/CFT correspondence', and Yolanda Lozano and colleagues are now exploiting it to access a set of seemingly intractable 5D theories. Gauge theories in five dimensions are basically non-renormalizable, and hence of little use for physics, but a more useful subset of 'fixed point' 5D theories has been recognised. The principle of AdS/CFT correspondence links string theory (which includes gravity) defined on a space to quantum field theory (without gravity) defined on the conformal boundary of that space, and hence in a lower dimension. Using a transformation of an existing solution, Lozano *et al.* have found a new AdS_6 solution that, through the correspondence, should reveal new possibilities for fixed-point theories in five dimensions — moreover, with supersymmetry preserved. *AW*

Dust muster

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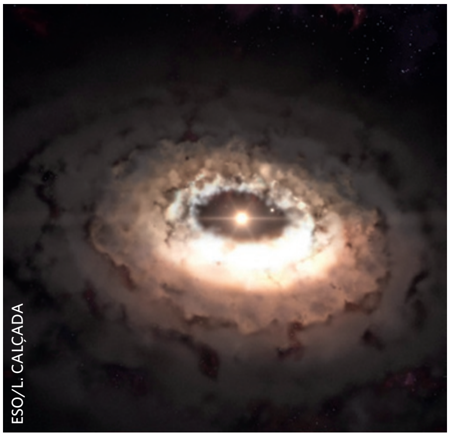

Many stars have orbiting planets. Such satellites form within a young star's circumstellar disk of dust and gas — the left-over debris from star formation — which lingers for about ten million years. But the details of how planets grow from submillimetre particles are not clear. Assuming that collisions lead to the formation of ever larger clumps of material, what stops planetesimals from fragmenting or crashing into the central star? Observations presented by Nienke van der Marel and co-workers now support a model that proposes a dust trap as a nursery for planets.

Using the Atacama Large Millimeter/submillimeter Array (ALMA) in Chile, the authors studied the local star Oph-IRS 48 (pictured in this artistic impression), which has an inner and outer disk separated by a gap (inner cavity). They resolved an asymmetric arc containing a high density of millimetre-scale particles, up to 4 mm, in the outer cavity. Smaller dust grains are uniformly distributed. Their numerical simulations support the idea that a gas-pressure 'bump' created by an anticyclone can concentrate dust grains and stop them spiralling into the star. *MC*

Odd property

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Physical properties and symmetry are intricately linked. For example, crystals that lack inversion symmetry can 'convert' incoming laser light into radiation with twice the original frequency — a nonlinear optical effect known as second-harmonic generation. The phenomenon is absent for centrosymmetric structures.

Yilei Li and colleagues have now explored second-harmonic generation in two types of layered materials: hexagonal boron nitride (hBN) and molybdenum disulphide (MoS_2). For each compound, stacks built of an odd number of layers — including the case of just a single layer — are non-centrosymmetric; those having an even number of sheets are centrosymmetric. Accordingly, Li *et al.* saw strong second-harmonic signals for stacks of an odd number of layers. For hBN, the intensity is nearly constant, whereas for MoS_2, the second-harmonic response decreases with increasing (odd) number of layers. This latter effect is attributed to increasing light absorption, which in turn is a consequence of the electronic band structure's dependence on the number of layers.

Hence second-harmonic generation provides a simple optical tool for characterizing the (parity of the) number of layers in hBN or MoS_2 stacks. Moreover, the measured intensity of the emitted radiation depends on the mutual orientation of the sample and the detector, enabling precise determination of the crystal's orientation. *BV*

A molecular signature

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An optical technique for identifying lone molecules is now demonstrated, which could significantly improve molecular analysis and the search for dangerous materials.

Photons scattered inelastically (also called Raman-scattered) from a crystal lattice provide detailed information about the vibrational structure of the solid. Applying this same idea to just a single molecule is difficult because of the tiny amount of light and the subnanometre lengthscales involved. The first problem can be tackled by taking advantage of plasmonics: using metallic nanostructures to enhance the local optical field. However, for a tip used in scanning tunnelling microscopy (STM), for example, the spatial resolution remains limited to just a few nanometres.

Rui Zhang and colleagues have now combined low-temperature STM with tip-enhanced Raman spectroscopy to enhance the field surrounding a molecule near the end of the tip. Varying the potential difference between the point and the silver substrate enabled the researchers to tune the resonance of the plasmonic cavity to match the signature vibration modes of an organic molecule with submolecular spatial resolution. *DG*

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