desert ants[11], crickets[12] and flies[13] have recently been shown to have similar arrays of polarization-sensitive photoreceptors in dorsal eye regions, and the desert ant, which also navigates by celestial polarization patterns, makes analogous navigational errors to the bee[14].

Second, progress may soon be made in unravelling the mechanisms of information processing. The work of Rossel and Wehner provides an indication of what sort of interneurones we might expect to find, and some elegant anatomical studies in the fly, which use the powerful technique of trans-synaptic cobalt migration, identify many of the interneurones in the polarization-sensitive pathways of this insect[15]. □

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Surface science

Helium atoms reveal phases

from J.A. Venables

HELIUM atom scattering is the ultimate surface tool, in that penetration into the bulk can be entirely neglected. The latest of several powerful tools for studies of surface structure and vibrations to reach maturity, the technique has in the hands of a group at Jülich, West Germany[1-4] revealed surface phonons on a platinum crystal and, in physisorbed xenon on platinum, two-dimensional phase changes and a series of discrete transitions towards bulk behaviour as the number of atomic layers is increased.

Such work clearly demonstrates that helium atom scattering is going to be important in unravelling the nature of 'two-dimensional physics' at surfaces and in adsorbed layers. But the technique has only recently become practicable through the development of high-pressure nozzle beam sources, effective differential pumping, high-energy resolution time-of-flight spectrometers and efficient single atom counting detectors. These non-trivial pieces of hardware, when attached to a large, but essentially standard, ultrahigh vacuum chamber, form the basis of the technique. The high-pressure nozzle gives a suitably monoenergetic incident beam with thermal energies of 0 to 30 meV, and the spectrometer can measure its energy width within 0.3 meV. The beams come into and leave the differentially pumped scattering chamber through small apertures with overall angular resolution of around 0.3°; thus very detailed angular scans are possible to analyse the diffraction patterns, either by rotating the sample or the detector.

Because the beam has such a low energy, it is an easy matter to distinguish elastic from inelastic scattering. Elastic scattering consists of diffraction and diffuse scattering from defects, whereas inelastic scattering results from atomic vibrations (phonons), which cause energy changes in the range 0–20 meV. In this respect, the technique is similar to neutron scattering from bulk solids, which is the main technique for determining the energies and momenta of phonons. However, in sharp contrast to thermal neutrons which travel several centimetres through solids, thermal helium beams interact so strongly that they only probe the tail of the electron distribution of the outermost atoms. Consequently the helium beam does not penetrate into the bulk. Thus with improved intensities and energy and momentum resolution, helium scattering has become increasingly competitive with low-energy electron scattering for studies of surface vibrations, and with higher energy electron and X-ray scattering for studies of surface crystallography. Of course, these latter techniques still retain advantages; in particular X-ray scattering has the highest angular resolution, whereas now electron techniques have the highest signal strengths.

These developments in helium atom techniques are well illustrated by the Jülich work on the surface phonons on a Pt(111) crystal[1], including the changes in phonon structure induced by oxygen chemisorption[2] and the structural and vibrational changes attendant on physisorbing xenon onto this same surface[3,4]. The time-of-flight spectrum on the bare (111) surface is now sufficient to show up crystallographic anisotropies in the surface acoustic (Rayleigh) wave[1]. The effect of chemisorbing oxygen in the p(2×2) structure is to halve the extent of the surface Brillouin zone, and to open up a gap at the zone boundary; this gap has now been observed very clearly for the first time[2]. Theoretical calculations invoke particular force constants which, by adjustment to agree with experiment, give information on the strength of both central and non-central forces between Pt and O atoms at the surface.

The elastic diffraction peaks studied in the case of physisorbed xenon[3] have been sufficiently sharp to study three separate phases: the commensurate (C) phase in which the Xe has the so-called $(\sqrt{3}\times\sqrt{3})R30°$ structure, in which the Xe surface mesh is $\sqrt{3}$ times the Pt mesh and is rotated by 30°; the incommensurate (I) phase compressed by around 6 per cent, and a further phase (R) compressed by around 10 per cent and rotated some 3°.

The corresponding C–I–R transitions have been seen previously for Xe adsorbed on graphite by both electron and X-ray diffraction; but this is the first time that helium atom diffraction has had sufficient angular resolution to see such transitions. Moreover strong scattering from the high atomic number bulk material would make Xe/Pt(111) difficult for either electron or X-ray diffraction. Because the helium beam sees only the outermost layer, the nature of the substrate is essentially irrelevant. In the latest work, the Jülich group have also shown that the time-of-flight spectra from these monolayer and multilayer structures are also very characteristic. Whereas the monolayer has an Einstein-like mode with essentially no dispersion, increasing layer thickness introduces dispersion, neatly revealing a discrete series of transitions towards the bulk phonon behaviour as the number of layers is increased[4]. □

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Meteoritic nitrogen

A slice through the Bencubbin meteorite found in Australia shows the shock-welded matrix surrounding metal with silicate and chondritic clasts. On page 138 of this issue, I.A. Franchi, I.P. Wright & C.T. Pillinger of The Planetary Science Unit at the Open University, UK show that virtually all the nitrogen in the meteorite is enriched with ^{15}N. The authors discuss the implications of these results for the origin of the components of the meteorite. The meteorite is about 65 cm wide.