vations show that the gas/dust ratio in such galaxies is a thousand times higher than that in the solar neighbourhood (P. Gondhalekar, Rutherford Appleton Laboratory); the most probable implication is that there is a pronounced paucity of dust. If dust is formed in stellar atmospheres, the low dust content implies either a slow rate or late start of star formation. It is still controversial as to whether we are witnessing the initial starburst or whether these galaxies have experienced a series of previous bursts.

Naturally the more exotic examples of active galaxies also received some attention. I reported new infrared results for an X-ray selected sample of Seyfert galaxies. Although there are exceptions, in most cases the dominant mechanism responsible for the strong infrared emission is not a massive burst of star formation such as observed in M82. It seems rather that the near infrared emission at a few microns is related, but not necessarily via the same physical process, to emission from the very compact regions. Good correlations are found with the strengths of the very broad emission lines and the X-ray emission, whilst at 20 microns the best correlation is with the narrow emission lines which originate in a volume of typically a thousand light years. This 20-micron luminosity could come from warm dust (200 K) mixed in with the line-emitting gas and heated by the very compact source at the centre of the active nucleus.

Because of the large apertures of the IRAS observations, their relation to the compact active nuclei in Seyfert galaxies is not clear. It seems probable that we are seeing a 'mixture' of several spatially-distinct components. Michael Rowan-Robinson (Queen Mary College, London) showed how, for Seyfert galaxies, the IRAS data can be separated into three components: a cooler disc component (seen in more normal galaxies), a warmer starburst component and a Seyfert component peaking at 25 microns. The latter could be radiation from a mini-quasar at the centre of the Seyfert absorbed by dust and re-radiated in the infrared.

The cosmological implications of the IRAS observations were also considered by Rowan-Robinson. Concentrating on the galactic polar caps, where confusing effects of the infrared 'cirrus' (see *Nature News and Views* **308**, 224; 1984) are smallest, he showed that there is a significant anisotropy in the number density of IRAS 60-micron sources between the north and south polar caps.

This seems not to be a local phenomenon since an identification programme carried out for the northern cap reveals that, after elimination of obvious stars, virtually every source is a galaxy and that the typical distance of IRAS galaxies is about 200 megaparsecs. Assuming that the infrared radiation traces the matter, it is possible to map the gravitational field and determine its dipole component. The direction of this component is in good agreement with the observed anisotropy in the intensity of the cosmic microwave background radiation. Thus this anisotropy could be explained as the result of the net gravitational pull on our local group of galaxies by the distribution of galaxies within about 200 megaparsecs.

Rowan-Robinson also showed that the 100-micron background radiation detected by IRAS can be separated into components due to interplanetary dust, interstellar dust and a roughly isotropic component which may be of cosmological origin. □

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Solid-state chemistry

Topotaxy in metal-oxide reduction

from Robert W. Cahn

A THIN metal film deposited by evaporation or sputtering on, say, a cleavage surface of sodium chloride is apt to be oriented in a reproducible way with respect to the substrate — this is the commonly found physical process of epitaxy, where the substrate is inert and unaffected. The chemical analogue is a topotactic reaction[1]: here a parent phase undergoes a reaction and the product phase has one or more defined orientations relative to the parent. Such reactions have been analysed by metallurgists (although they never use the term topotaxy) ever since the discovery of X-ray diffraction: the key investigations on so-called Widmanstätten reactions in metallic solid solutions were carried out in the early 1930s. Metallurgists usually analyse such reactions in terms of the fit of parent and product phases at their mutual interface.

The reverse reaction, reduction of an oxide to metal, has occasionally been examined from a kinetic point of view, especially in connection with the industrially important reduction of wuestite (FeO) to iron[2], but the first study of topochemical aspects has only just been performed. The results, reported by A. Revcolevschi and G. Dhalenne on page 335 of this issue[3], open up a new field of research.

In chemistry proper, topotaxy is usually demonstrated in dehydration reactions — for example, the conversion of $Mg(OH)_2$ into Mg(O) — or the conversion of one oxide of iron into another; other instances include breakdown of complex silicates into simpler ones, with release of water[4]. In all these reactions, the observed orientations imply that the network of oxygen ions remains more or less intact throughout the course of the chemical reaction.

The most studied category of topotactic reaction has been the oxidation of metals. The nature of both the topotaxy of a thin oxide layer and the oxidation kinetics depends not only on the oxidation conditions but also on the orientation of the metal surface (see refs 5 and 6 for review).

Revcolevschi and his collaborators at the University of Paris-Sud have for some time studied the orientation relationships between the phases of lamellar eutectic structures consisting of two metallic oxides (complementing the substantial body of information on such relationships as regards metallic eutectics[7]). For their new experiments, Revcolevschi and Dhalenne[3] have directionally solidified a eutectic of NiO and calcia-stabilized cubic ZrO_2 producing what is essentially an interpenetrating pair of epitaxially related single crystals which they then treat with a CO/CO_2 mixture that reduces the NiO to nickel without affecting the ZrO_2. The nickel proved to be in parallel orientation to the NiO which preceded it; the ZrO_2 phase acted as crystallographic reference. Just as earlier topotaxic experiments indicated that the oxygen skeleton was maintained and unchanged, so the new experiment[3] indicates that the nickel-ion skeleton remains fixed.

This pioneering experiment opens the way to various topotaxic studies. One might try to mimic Gwathmey's celebrated experiment on the oxidation of a spherical copper monocrystal (showing the sharp anisotropy of oxidation rates and topotaxy) by reducing an oxide sphere, or to study the orientation dependence of reduction kinetics. It is known that the reduction rate of wuestite is sensitive to the population of point defects — it would be interesting to see whether orientation relationships are affected by defects.

Revcolevschi and Dhalenne's observations have a potential practical interest: by reducing NiO without altering ZrO_2, it is possible to make a lamellar product where adjacent lamellae are electronically and ionically conducting. Such a structure can perhaps be applied in photoelectrolysis and novel solid-state batteries. □

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