proof of the sharp Fermi surface in the normal state, which is central to the perturbative Landau theory, is the observation of periodic oscillations in the magnetization as the magnetic field is varied, known as de Haas–van Alphen oscillations. Mackenzie *et al.*[7] succeeded in observing these oscillations and determined the shape of the Fermi surface, which agreed with band-structure calculations. The effective electron masses are unusually enhanced (factors of 3–5), indicating a strongly interacting Fermi liquid. The formal valence is Ru^{4+}, implying four electrons in bands of predominantly 4*d* character with {xy, yz, zx} symmetry, all of which contribute to give three Fermi surface sheets with cylindrical topology.

The Ru^{4+} ion can be viewed as two holes in the 4*d*-complex and by Hund's rule their spins align parallel to give a triplet, $S = 1$, ion. Furthermore, the related cubic compound $SrRuO_3$ is a ferromagnetic metal. Such considerations led myself and Sigrist[8] to speculate that the electrons in the Cooper pairs would have aligned spins leading to triplet superconductivity, and an odd orbital (for example, *p*-wave) wavefunction, analogous to ^3He and contrasting with the spin singlet *d*-wave pairing in the copper oxides.

Experiments determining the symmetry are now at hand. Luke *et al.*[1] performed spin-resonance experiments on muons implanted in Sr_2RuO_4, which are a sensitive test for induced magnetic fields in the superconducting state. The observation of such fields shows that the angular momentum of the Cooper pairs is not quenched by the crystal environment, and that the superconducting state has a broken time-reversal symmetry. Ishida *et al.*[3] show that the Knight shift of the NMR peaks (which measures spin susceptibility) of oxygen nuclei remains unaffected by the transition to superconductivity. This is a clear sign of triplet pairing, because singlet pairing necessarily has a vanishing spin susceptibility as $T \rightarrow 0$ K.

There is another twist to the story. Specific-heat measurements[9] showed that only about half of the Fermi surface had an energy gap in the superconducting state. A characteristic of Cooper pairs is that they can always scatter around a Fermi surface, conserving energy and momentum. As a result the whole Fermi surface should participate in electron pairing and possess an energy gap. Agterberg *et al.*[10] suggested that the highly planar character of Sr_2RuO_4 would prevent scattering between {xy} and {yz, zx} sheets of the Fermi surface owing to their differing parities under reflection (that is, $z \rightarrow -z$). The question then is, which sheets are involved in the superconductivity?

Neutron scattering experiments by Riseman *et al.*[2] provide the answer. Agterberg[11] calculated that, in a magnetic field, the vortex lattice of flux lines that penetrate the material should unusually have square symmetry, whose orientation depended on which Fermi surface sheets are involved in superconductivity. Riseman *et al.* confirm the square symmetry, and from its orientation it follows that the pairing is occurring on the {xy}-sheets. The results yield a complete description of the superconducting state — it is a two-dimensional analogue of the A-phase, one of the two distinct superfluid phases observed in ^3He.

So what have we learned? In a Landau–Fermi liquid, spin fluctuations can strengthen the pairing attraction, but it remains weak. Simultaneously, the mass enhancement lowers the characteristic energy scale of the attraction. As a result T_c is low. This combination of low T_c and unconventional superconductivity makes for extreme sensitivity to sample defects. Indeed, in the Sr_2RuO_4-system a residual resistivity under 1 μΩcm is required to observe superconductivity[12]. Presumably many more unconventional superconductors could be found among the transition metal oxides if only they could be made perfect enough.

Although it is pleasing to see the original theory of superconductivity driven by electron–electron interactions verified, this route doesn't lead to high T_c. The copper oxides have a much higher T_c than the ruthenates; so what sets them apart? It cannot be the nearly two-dimensional character or the presence of strong spin fluctuations. These features are common to both. One difference lies in the formation in ruthenates of a well-defined Landau–Fermi liquid in the normal state ($T > T_c$). As emphasized by Anderson and others, such Landau character breaks down in the copper oxides. But this is a symptom rather than the cause of the

Atmospheric chemistry

Smelly cats

Since January 1993, all new cars in the European Union have had to be fitted with a three-way catalytic converter. Although three-way converters will lower emissions of certain harmful chemicals, such as oxides of nitrogen, S.F. Watts and C.N. Roberts raise the question of whether they may result in a shift in the balance of sulphur species, especially in cities (*Atmospheric Environment* 33, 169–170; 1999). Before the introduction of three-way converters, sulphur in petrol was emitted mostly as sulphur dioxide (SO_2), but the authors estimate that in the future, emissions of hydrogen sulphide (H_2S) will increase. Both H_2S and SO_2 are respiratory toxins, but only levels of SO_2 are regularly monitored.

The data are both few and preliminary. Nonetheless, roadside measurements of H_2S in Britain and the United States seem to indicate that it reaches higher levels in Britain. Watts and Roberts speculate that this is due to different driving conditions, and point to previous studies that identified situations that favour higher emissions of H_2S instead of SO_2. These include driving in built-up city areas, notably in urban 'stop-and-go' traffic, and the first 10–20 km of a journey after cold starting, when the engine is rich in fuel. In Britain, as many as 40% of all car journeys are under 5 km and with increasing traffic congestion, the situation is likely to get worse.

Not only are emission data scarce, but it is hard to evaluate the levels of exposure that are harmful to humans. Concentration levels have been set for occupational hazards that are many times lower than have been recorded from traffic. But these limits appear to have been set simply on the basis of odour (that rotten egg smell) and are comparable with levels found around natural sulphur springs. **Sarah Tomlin**