

## Cuprate superconductors

## Old behaviour in new materials

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SINGLE crystals of the copper-oxide (cuprate) superconductors, including those of the lanthanum- and yttrium-barium-based materials reported last year and the newer bismuth- and thallium-based materials (see the recent discussion by Forgan and Greaves in News and Views<sup>1</sup>), all have remarkably similar behaviour. Solid-state theorists are capitalizing on this similarity as they try to identify an alternative to the traditional 'BCS' theory to explain the novel superconductivity<sup>2,3</sup>. These similarities in charge-transport, magnetic and optical properties undoubtedly arise from the close structural resemblance between the cuprates at the molecular level. Takagi *et al.* report, on page 236 of this issue<sup>4</sup>, measurements of the transport, magnetic and optical properties of single crystals of  $\text{Bi}_2(\text{Sr,Ca})_3\text{Cu}_2\text{O}_x$  that match those of  $(\text{La}_{1-x}\text{Sr}_x)_2\text{CuO}_4$  and  $\text{YBa}_2\text{Cu}_3\text{O}_{7-x}$  very closely.

Single crystals of the cuprate superconductors all show a strong anisotropy in the response of their transport properties to applied magnetic fields. The most obvious anisotropy is in the temperature dependence of the upper critical field (the applied magnetic field that quenches superconductivity in the crystal). A magnetic field has a much more pronounced and deleterious effect on charge transport if applied perpendicularly to the Cu-O conduction layers than if applied in the plane.

The two-dimensional structure is also evident in the temperature dependence of the resistivity above the transition temperature. Although Takagi *et al.* report<sup>4</sup> only the in-plane resistivity of  $\text{Bi}_2(\text{Sr,Ca})_3\text{Cu}_2\text{O}_x$ , this value agrees in both magnitude and slope (decreasing linearly with decreasing temperature) with that of  $(\text{La}_{1-x}\text{Sr}_x)_2\text{CuO}_4$  and  $\text{YBa}_2\text{Cu}_3\text{O}_{7-x}$ .

The *c*-axis (out-of-plane) resistivity of the latter compounds, in contrast, is substantially higher at room temperature and varies inversely with temperature. A comparison of the *c*-axis resistivity of  $\text{Bi}_2(\text{Sr,Ca})_3\text{Cu}_2\text{O}_x$  with that of  $\text{YBa}_2\text{Cu}_3\text{O}_{7-x}$  would be interesting, as the Cu-O planes are known to be more isolated in the new superconductor.

This anisotropy of superconductivity in the cuprates presents formidable problems. Materials scientists are faced with the task of favourably aligning these layered materials to optimize the effect of their directionally varying properties. For instance, a superconducting solenoidal magnet will require highly textured cuprates to ensure that the maximum field produced along the axis of the magnet does not destroy the superconductivity in unfavourably oriented crystals. Such

textured materials have been produced as thin films of  $\text{YBa}_2\text{Cu}_3\text{O}_{7-x}$ , which have superior current-carrying capacities<sup>5</sup>, but the use of these materials in practical designs will be difficult.

The similarities identified between these cuprates should help to elucidate the fundamental mechanism responsible for their superconductivity. It is also hoped that they will lead to materials with even higher, more practical superconducting transition temperatures. To this end, Takagi *et al.* note<sup>4</sup> that the increasing superconducting transition temperature of these three materials correlates well with increasing charge-carrier concentration. It is expected that other fundamental trends in behaviour will develop as better data are obtained. □

1. Forgan, E. M. & Greaves, C. *Nature* **332**, 14–15 (1988).
2. Anderson, P. W. & Zou, Z. *Phys. Rev. Lett.* **60**, 132–135 (1988).
3. Kivelson, S. *Phys. Rev.* **B36**, 7237–7240 (1987).
4. Takagi, H. *et al.* *Nature* **332**, 236–238 (1988).
5. Chaudhari, P., Koch, R. H., Laibowitz, R. B., McGuire, T. R. & Gambino, R. J. *Phys. Rev. Lett.* **58**, 2687–2690 (1987).

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## Atmospheric chemistry

## Increased tropospheric ozone

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In a careful re-examination of a data set on ambient ozone concentrations measured around the turn of the century, Volz and Kley conclude, on page 240 of this issue, that ozone levels in the lower atmosphere (troposphere) in Europe may have doubled over the past 100 years. This finding is as remarkable as the observation of a hole in the stratospheric ozone layer over Antarctica (see page 202) and potentially is just as consequential.

Global weakening of the stratospheric ozone shield is obviously detrimental to life on Earth, but we should not congratulate ourselves that it may be partially

compensated in the Northern Hemisphere by the presence of additional ozone in the troposphere. Such a redistribution is totally undesirable, because ozone in the troposphere is an efficient greenhouse gas, second only to carbon dioxide in importance, and it is highly toxic to plants at concentrations only slightly elevated above ambient levels. Perhaps of more significance in the long term, photolysis of ozone yields hydroxyl radicals which chemically control the trace-gas composition of the atmosphere. Unfortunately, high concentrations of ozone are not the desirable seaside tonic they were once supposed to be.

Interest in atmospheric ozone is not new. It was shown to be a common trace gas in the last century by Andrews (Queen's University, Belfast). Many professional people were then aware of its presence, believing it could act as a disinfectant against disease, and conducted measurements with test papers developed by the German chemist, Schönbein, to determine its behaviour. The database is extensive but, unfortunately, unreliable. In 1876, however, Albert-Levy started a series of measurements at the Montsouris Observatory on the south-west outskirts of Paris using a much more quantitative method, namely iodine-catalysed oxidation of arsenite in neutral aqueous solution. Ozone first oxidizes  $\text{I}^-$  to  $\text{I}_2$ , which in turn

## 100 years ago

A difficulty often experienced in laboratories is how to raise a body to a high temperature while surrounded by a gaseous atmosphere under considerable pressure. The apparatus makes it possible to bring bodies to a temperature approaching that of the fusion of platinum. A, mass of steel with cylindrical bore, with its stopcock B; G, mirror permitting the reaction to be seen; M, manometer; L, amperemeter.

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