A Superconductivity Happening

Amid a rock concert atmosphere, a late-night session at the March American Physical Society meeting draws a huge crowd to hear the latest on the new superconductors

THEY opened the doors to the meeting room at 6:45 p.m., and the huge crowd that had started to gather more than an hour earlier surged forward. Amid some shouting and considerable jostling, the first physicists through covered as many chairs as they could with coats, sweaters, and their bodies to reserve places for late-coming comrades. One person stopping to help a woman who had fallen down lost a seat for the courteous act.

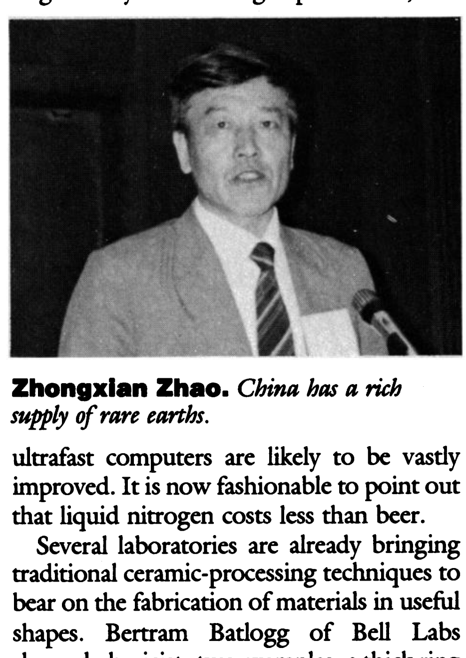
So began the "Special Panel Discussion on Novel Materials and High-Temperature Superconductivity" that was held on 18 March on the middle day of the March meeting of the American Physical Society in New York City. Hotel personnel estimated 3000 physicists either jammed into the meeting room or made do with remote video broadcasts of the proceedings in the corridors outside.

After the initial presentations beginning at 7:30 that evening by two invited panels, one of experimentalists and one of theorists, staccato bursts of 5-minute contributed reports interrupted at intervals by discussion periods lasted until 3:15 the next morning. At a press conference, theorist Michael Schlüter of AT&T Bell Laboratories said, "For someone of my generation, there is only one comparison for what happened last night; it was the Woodstock of physics."

Underlying the rock concert atmosphere of the New York superconductivity happening are the events of the last few months, culminating in the discovery that a whole class of rare earth–based oxide ceramics are superconductors at temperatures up to 100 K now and perhaps others will be much higher in the near future. Physicists describe the finding to be with no exaggeration revolutionary, both scientifically and technologically. Several researchers reported at the marathon late-night session that compounds containing any one of several rare earths together with barium, copper, and oxygen are superconducting and that the identity of the rare earth element has little effect on the superconducting transition temperature. Theorists are very open to the possibility that some altogether new mechanism may be responsible for the high-temperature superconductivity.

Because so much of modern technology from power generation and transmission to computing ultimately depends on electricity flowing in wires, transistors, and the like, materials that are superconducting at room temperature plainly would transform the industrial world. There was, in fact, at least one rumor of superconductitvity at room temperature in Japan. The highest temperature actually reported at the evening session was 125 K by Constantin Politis of the Karlsruhe Nuclear Research Center in West Germany, although the finding remains to be confirmed.

How far-reaching the effects of the new family of superconductors able to operate in liquid nitrogen (boiling point 77 K) rather than liquid helium (boiling point 4.2 K) would be is less certain, but the economics of such widely mentioned applications as nearly lossless electric power transmission, magnetically levitated high-speed trains, and ultrafast computers are likely to be vastly improved. It is now fashionable to point out that liquid nitrogen costs less than beer.



Zhongxian Zhao. *China has a rich supply of rare earths.*

Several laboratories are already bringing traditional ceramic-processing techniques to bear on the fabrication of materials in useful shapes. Bertram Batlogg of Bell Labs showed physicists two examples: a thick ring just big enough to fit on a finger and a flexible sheet. Batlogg noted, however, that the flexibility disappeared when the ceramic "green body" pressed together from small particles was sintered to make the ceramic superconductor.

Batlogg also pointed out that, despite their name, rare earths are relatively abundant elements. The same fact was also emphasized at the press conference by Zhongxian Zhao of the Institute of Physics of the Academia Sinica in Beijing, who added that China has a rich supply of rare earth containing minerals.

Thin superconducting films are more relevant than wires and tapes for electronic devices, such as high-speed microcircuits. K. Alex Müller of the IBM Zürich Research Laboratory, where the "low-temperature" 40 K lanthanum-barium-copper-oxygen superconductor that initiated the current frenzied activity was found, reported the fabrication of 400-nanometer thick superconducting films of the newer "high-temperature" yttrium-barium-copper-oxygen material at IBM's Yorktown Heights Laboratory but provided no details for what may be a commercially important fabrication process. Aharon Kapitulnik of Stanford University discussed measurements on thin films made there, but was likewise sparse with particulars as to how the films were made.

Physicists seem to be zeroing in on the identity and structure of the 90 K superconductor, which first appeared mixed in with one or more other nonsuperconducting phases. Reports from several laboratories, which have isolated the superconducting phase and in some cases grown single crystals, concur that the approximate composition for the material is $YBa_2Cu_3O_x$, where Y is a rare earth and x is a number near six that is not yet known exactly.

The details of the structure are also still to be resolved, but most researchers accept that it is a so-called triple layer or oxygen-defect perovskite, in contrast to the layered perovskite of the first family of 40 K superconducting oxides. The unit cell consists of three perovskite cubes stacked atop one another with barium atoms at the center of the top and bottom cubes and a rare earth in the middle cube, while copper atoms are on the cube corners. Some oxygen sites on cube edges are vacant, hence the term oxygen-defect, but which ones and how many is disputed. Laura Greene of Bell Communications Research suggested that pinning down the oxygen positions would play a key role in understanding the superconductivity. ■

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