Yb or Not Yb? That Is The Question

One rare earth element was substituted for another in manuscripts of two key papers, confusing some who wanted to get a head start on making superconducting compounds

A typographical error in manuscripts of two key papers on superconductivity allegedly sent some physicists scrambling after the wrong compound in their attempts to duplicate the results. Paul Chu of the University of Houston submitted his papers on superconductivity to *Physical Review Letters* with the symbol Yb, for ytterbium, substituted for Y, for yttrium. Although Chu had requested that no details of his seminal papers leak before publication, some physicists heard through the rumor mill that ytterbium was part of the mysterious superconducting mixture.

A number of physicists suspect that Chu deliberately wrote Yb instead of Y to throw his competitors off the track. But Chu disputes the charge. "It was a typographical error," he says.

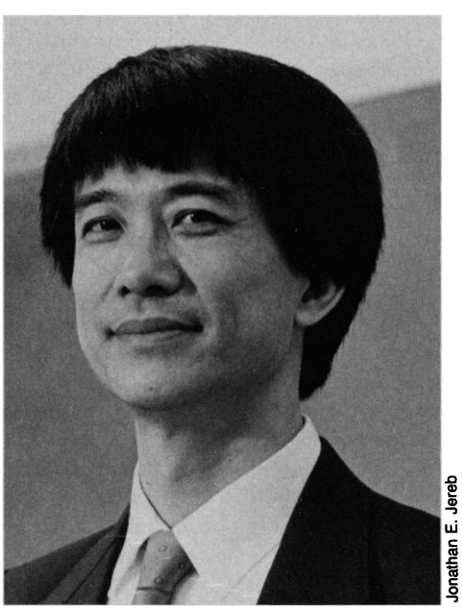
Because of the intense competition among physicists working on superconducting compounds, Richard Greene of IBM in Yorktown Heights, New York, says he would not blame Chu if he had, in fact, tried to hide the identity of his superconducting material. "Frankly, if I had been Chu, I would not have even put the compound in my paper until just before publication," Greene says. "People are people and a result like this is bound to leak out."

The story of the mistaken rare earth compound illustrates the high stakes riding on the new discoveries that materials can become superconducting at relatively high temperatures. Physicists see not only a Nobel Prize looming but also enormously profitable commercial applications. The excitement in the physics community is so great that "some people are not showing their most adult behavior," says Robert Cava of AT&T Bell Laboratories.

Chu says he first saw evidence of superconductivity at 93 K on 29 January. He and his eight colleagues, including three at the University of Alabama at Huntsville, led by M. K. Wu, were tremendously excited and Chu called the editor of *Physical Review Letters* the next day saying "we've got it." Then the three Alabama physicists returned to their university and Chu wrote the papers for the group.

Chu gave his manuscripts to a secretary to type and send, Federal Express, to the journal. None of the researchers saw the papers before they were mailed. The group also suggested reviewers for the papers and Chu requested that the composition of the superconducting material not be revealed before publication. A University of Houston secretary sent the papers to *Physical Review Letters* where they were received on 6 February.

In the meantime, Chu and his colleagues filed a patent application. In order to protect foreign rights, patent applications must be filed before publication, according to University of Houston attorney Scott Chafin.



Jonathan E. Jereb

Paul Chu. *"It was a typographical error."*

Chu says that there was no typographical error in the patent application—the superconducting material was correctly identified as being composed of an oxide of yttrium, copper, and barium.

On 16 February, while his papers were still in press at *Physical Review Letters*, Chu held a press conference to announce his discovery—but not the composition of his superconducting material. His announcement sent some physicists scurrying to discover what the superconducting material might be.

Although it is not clear who leaked the information that Chu and his colleagues used ytterbium, the information clearly got out. Several physicists say they heard the rumor, although none questioned by *Science* say they acted on it.

George Basbas, an editor at *Physical Review Letters*, says he cannot comment on the typographical error. "Our position is that anything that goes on before publication is part of the editor-author relationship. It's kind of like a doctor-patient relationship," he says.

Greene explains why some physicists were so eager to duplicate Chu's result that they could not wait for his papers to be published. "This is a field that is being driven by finding new materials. Since no one knows what materials might work, they will try any kind of hint." For that reason, he says, "People were trying all sorts of stuff." Still, Greene says, there is more to making a superconducting material than just knowing the compounds. "There is a little bit of alchemy in it. You might know the materials and still not know how to make it."

In the meantime, Chu says he was unaware of the typographical error in his papers until 16 February, just before his press conference, when he saw the proofs. When he saw the error, Chu says, he immediately corrected it changing the symbol Yb to Y every time it appeared. At no place in the papers did he spell out the name of the rare earth. Only the chemical symbols were used. Chu sent his corrections to *Physical Review Letters* on 18 February, the last day on which corrections could be made before publication. His papers appeared in the 2 March issue of the journal.

Chu says that at the time he made his discovery, he thought ytterbium would not work in a superconducting compound. Now some claim that it does. Shoji Tanaka's group at the University of Tokyo, for example, reported success with ytterbium and applied for a patent on the discovery. Edward Engler of the IBM Research Center in San Jose, California, and Jean-Marie Tarascon of Bell Communications Research in Redbank, New Jersey, also find that ytterbium works.

But nothing in this new field of high-temperature superconductivity is straightforward. One person's superconducting material may not perform for the next person. For example, Cava at Bell Laboratories says he cannot get ytterbium to work. Cava, in fact, finds that ytterbium is one of the few rare earth elements that does not work as part of a superconducting compound. "I've never been able to make ytterbium work,"

he says. "We've made 12 other things work, since early March but, as far as I know, we don't have ytterbium working." On the other hand, Cava points out that others have been unable to make compounds work that, in his hands, are superconducting. And even when two groups agree that a compound is superconducting at a high temperature, they more often than not disagree on the transition temperature.

Despite Chu's assurances that the typographical error in his papers was purely accidental, the stories that it was not persist. Chu's colleague Pei Hor of the University of Houston says he is upset by these charges. "I've been too naïve. I believed doing science is doing science. It should be fair. It should have dignity. I was very very surprised. I really don't know where this rumor originated, but it hurts a lot," he says.

Cava explains that incidents like this are to be expected when a discovery is as monumental as Chu's. "You have to realize that this is the biggest thing to happen in most physicists' lives. Period," he says. "There are lots of egos around and there are lots of people who are happy to believe something bad about someone just because he did something good." ■ **GINA KOLATA**

Some of the information in this report was contributed by Arthur L. Robinson.

Superconductor Race Heats Up

Who is going to be number one in superconductors? Last week, the House Republican Task Force on High Technology and Competitiveness sponsored a conference titled "Breakthrough in Superconductivity: The Race to Commercialize." Participants were asked what it will take to prevent the revolutionary new high-temperature superconductors from falling into the now familiar pattern of U.S. leadership in research but Japanese domination of the marketplace.

The initial discovery of these wondrous new materials, which are the first to operate in liquid nitrogen and therefore promise to take superconductivity from a largely esoteric technology to a household word, was announced on 16 February. Although the composition of the compound was kept secret until formal publication in a scientific journal (see story p. 663), the Japanese immediately began to marshal their considerable resources, including the establishment of two government-coordinated committees.

One, organized by the Agency of Industrial Science and Technology and made up of leading-edge researchers from a broad spectrum of laboratories, is to plan a research strategy to improve the new superconductors. The other more industrially oriented group, set up by the much-feared Ministry of International Trade and Industry, aims at finding commercial applications for them. "When it comes time to make something out of it," the *Wall Street Journal* quoted Shoji Tanaka of the University of Tokyo, "the Japanese will have the upper hand."

American researchers and federal funding agencies have not been slow to jump on the bandwagon. At a recent meeting of the Materials Research Society, for example, a speaker showed a lengthy list of familiar names from his laboratory and said, "These people are all doing what they have always done, but now they are doing it on superconductors." The Department of Energy (DOE) has redirected some research money into the high-temperature superconductors and now has about $10 million specifically directed toward these materials, although "the figure is changing monthly," according to a report at the conference by Louis Ianiello, the DOE's materials chief.

The National Science Foundation (NSF) has also reacted and in the last 2 months has doubled its superconducting materials budget to $5 million. Moreover, NSF has just initiated two efforts, one that will distribute $1 million to three of the agency's Materials Research Laboratories at the University of Illinois and at Northwestern and Stanford Universities, and one that will distribute $600,000 to researchers with ideas for processing the superconductors into useful forms.

Up for discussion at the conference was whether a more coordinated effort along the lines of the Japanese approach would be necessary to keep the United States in the lead. The conference organizer, Representative Donald Ritter (R–PA), clearly thought that it was and that the time available to make a move was short: "Japan is out of the starting block and we are going to have to hit our stride in our own way, and hit it soon, if we are going to be a factor in the global race."

Earlier, in response to the Japanese moves, Senator David Durenberger (R–MN) introduced legislation in late March and Ritter followed in early April with an identical bill to create a national commission on superconductors. The bills would require the appointment of members to the commission by the President within 15 days and a report from the commission within 4 months. The report will recommend ways to speed up the improvement of the superconductors and to expand their use in commercial and defense applications. Specifically included on the list of items for the commission to consider is the partial exemption of private companies from antitrust laws to allow them to coordinate research and product development.

At the conference, which was chaired by Ritter, Durenberger explained his thinking, "Many people believe we should not 'copy' Japan and develop a coordinated government, industry, and university approach to developing superconductors," but "I am convinced we must have a national strategy to encourage the development of this important new technology."

The conference itself included presentations by two panels of researchers from academic, industrial, and government laboratories. The most forceful statement came from H. Kent Bowen, a ceramic materials expert from the Massachusetts Institute of Technology. Bowen has watched as the Japanese have taken over leadership in advanced ceramics for both structural and electronics applications, despite most of the advanced ceramics science having come from the United States in the last two decades. He fears the story will be repeated in the high-temperature superconductors, which are themselves ceramics.

Bowen specifically proposed an immediate $100-million—"the price of one airplane"—initiative that would last 2 years. About $25 million would go to university centers for both basic and applied research, while the largest part would be dedicated to the support of manufacturing implementation, including pilot plants, at selected companies. Robert Laudise, a research director at AT&T Bell Laboratories, also underscored the importance of ceramics processing. He noted that the difference between success and failure in the past has often been the extent to which an industry paid close attention to the science of materials processing. ■ **ARTHUR L. ROBINSON**