"The question before the subcommittee is whether U.S. industry and U.S. employees will share in that bounty."

In the hearing, Markey asked for the relevant federal agencies and the American electronics industry, through its trade associations, to submit "action reports" to Congress by 4 January, outlining how best to ensure an American presence in the coming HDTV industry. Industry observers say the choice of HDTV standard could have a big effect on how well the American electronics industry can compete in this market. A standard that depends on American-developed technology could give American companies a head start, or at least an even start, in the race against Japanese and European countries to market HDTV in the United States. (Japanese companies have marketed HDTV equipment for several years for specialized uses, and the Japanese company NHK plans to begin broadcasting in HDTV by 1990. NHK's system, however, is not compatible with NTSC.)

Markey said that because it is not the FCC's job to preserve American jobs, Congress will probably want to take the lead in developing a HDTV policy and that will hurry Congress to start work on it soon after the action reports arrive. That policy, electronics industry observers say, might well include a cooperative effort among many American companies to develop an HDTV system. The fruits of a successful HDTV industry are likely to be plentiful enough for all to share. ■ ROBERT POOL

A Testable Theory of Superconductivity

New calculations from a theory based on magnetic interactions predict superconductors will never reach room temperature

IS THE DREAM of room-temperature superconductivity over? News reports around the country last week suggested that it is, after theoretical physicist William Goddard of the California Institute of Technology announced he has developed a theory describing high-temperature superconductivity. Speaking at the 196th American Chemical Society National Meeting in Los Angeles, Goddard said the highest critical temperature for any of the copper-oxide superconductors now under development is likely to be around 225 K, or −54°F.

The announcement received extensive press coverage, but superconductivity researchers seemed surprised by the attention. After all, much of Goddard's theory had appeared 7 months earlier, in two research reports in the 19 February issue of *Science*. Further, the result that interested the press—that room-temperature superconductivity may not be attainable in copper-oxide superconductors—was not surprising to scientists in the field. Many researchers had concluded from phenomenological considerations that the materials' maximum critical temperature would be 200 to 300 K.

Goddard himself downplayed any predictions about room-temperature superconductivity and instead emphasized his ability to make numerical predictions from first principles. "The magnon-pairing theory that we have developed at Caltech is unique in that it starts from fundamental quantum-mechanical principles and makes very specific predictions," he said. "This means that if there is something wrong with the theory, experiments will disprove it very quickly."

Using his model, Goddard has calculated explicitly several properties of various copper-oxide superconductors, including their critical temperatures, critical fields, coherence lengths, penetration depths, and specific heats. There are no undetermined parameters in his model, he says—no numbers that must be determined experimentally and put in by hand.

The search for a theory to describe high-temperature superconductors started with the discovery in early 1987 of materials that become superconducting at liquid-nitrogen temperatures (above 77 K). Since these materials lose electrical resistance at much higher temperatures than earlier superconductors, observers predicted many valuable commercial applications, from superpowerful magnets to ultrafast computers. If a room-temperature superconductor could be found—one that needed no expensive refrigeration—it could turn out to be one of the most valuable materials ever made by man.

But although researchers have learned to fabricate these materials and know their atomic structures, no one has perfected a theory to explain high-temperature superconductivity. Scientists now know about three classes of high-temperature superconductors, based on yttrium (or various other rare earths), bismuth, and thallium. All three have layers of copper and oxygen atoms that are essential to their superconductivity.

The mechanism leading to superconductivity in high-temperature materials apparently is fundamentally different from that of low-temperature superconductors. The Bardeen-Cooper-Schrieffer theory, or BCS, explains low-temperature superconductivity as a result of interactions between conduction electrons and phonons, or vibrations in the material's atomic lattice. According to BCS, interactions between the electrons and phonons cause the electrons—which normally repel each other—to travel in pairs, and this pairing coupled with a second mechanism allows the electrons to travel through the material without resistance.

Early experiments on high-temperature superconductors showed that their electrons also traveled in pairs but that the pairing was not caused by an electron-phonon interaction. One possible explanation was that high-temperature superconductivity was caused by a BCS-like mechanism using something besides electron-phonon interactions to pair the electrons.

Goddard's theory is such an explanation. He describes electron pairing as being caused by magnetic interactions between electrons and pairs of copper atoms—"magnon pairing." His papers in the 19 February issue of *Science* (pp. 896 and 899) laid out the theory, explaining how some of the oxygen atoms in the copper-oxygen planes lose electrons, which gives them a net magnetic moment, which in turn causes the copper atoms on either side to align their own magnetic moments. The resulting magnetic fields cause an attraction between electrons, creating electron pairs.

Since February, Goddard has applied the theory to make numerical predictions for various properties of superconductors, and his numbers agree relatively well with experiment. If the theory proves correct, he says, it may point out a way to maximize the critical temperature at around 225 K, or 100 K higher than it is now. It remains an open question whether other superconductors than copper-oxide might someday surpass room temperature. ■ ROBERT POOL