physical sciences

Gathered at the International Conference on the Science of Superconductivity last week at Stanford University

PARACONDUCTANCE

Partial superconductivity confirmed

Materials that are superconducting have a so-called transition temperature. Below this level electrical resistance ceases, and persistent electric currents will flow in the material without needing a voltage to drive them.

Investigation is beginning to show that the change from ordinary conductor to superconductor is not so abrupt as was once thought. Remnants of superconducting behavior exist at temperatures well above the transition temperature.

A contribution to the conductivity that is related to superconductivity and is called paraconductance can be detected at temperatures up to twice the transition temperature, says Dr. R. E. Glover III, of the University of Maryland.

Theoretically, he says, paraconductance is attributed to fluctuations in the state of the material that allow small bits of it, say a few pairs of electrons, to behave in a superconducting way even though the temperature of the material is above the transition temperature.

According to theory paraconductance in films several hundred angstroms thick should increase in inverse proportion to the change in temperature as the films are cooled toward the transition temperature.

The latest experiments confirm this theory, says Dr. Glover.

TUNNELING JUNCTIONS

Semiconductor is photosensitive

Superconducting tunneling junctions consist of two superconducting films separated by a thin insulating layer of some oxide. In such a device electrons may tunnel, as it is called, between the two superconductors so that a small current flows through the oxide.

Drs. Ivar Giaever and H. R. Zeller of the General Electric Research and Development Center have prepared a junction that uses the semiconductor cadmium sulfide as the central layer instead of an insulator. Such a junction shows an increase in the tunneling current when exposed to light, they say.

JOSEPHSON JUNCTIONS

Radiation detected

A Josephson junction is a unit in which two superconductors are joined by an electrically bad connection. That is, there may be some insulator between them, or a narrow air gap, or their surfaces may be rough so that there is only contact at certain points and not over the whole surface.

If a driving voltage is applied to such a junction, an oscillating current will flow across it, and it will emit microwave radiation.

In practice, attempts to generate millimeter-wave radiation from coupled arrays of Josephson junctions have not been successful, says Dr. T. D. Clark of the Mullard Research Laboratories in Redhill, England.

Now, however, he describes a successful experiment in which two arrays of one-millimeter-sized tin spheres were used, one array as transmitter and the other as detector. The two arrays were spaced one millimeter apart.

When the two arrays were properly tuned to each other the detector responded with changes in its conductance as the voltage of the emitter was varied. This is what should have happened if radiation was being transmitted between them, and Dr. Clark draws the conclusion that radiation was in fact present. The power transmitted between the two arrays was one 10-millionth of a watt, he says.

MICROWAVES

Counteracting thermal fluctuations

An experiment in 1966 found that thin superconducting films with constrictions in them have two transition temperatures, one associated with the wide part and one with the narrow. The narrow region had a transition temperature about 10-thousandths of a degree lower than the wide part.

The lower transition temperature in the narrow part was attributed to thermal fluctuations in the material.

Drs. A. G. F. Wyatt and D. H. Evans of the University of Nottingham in England now report that irradiating the film with microwaves can raise the lower critical temperature by about five-thousandths of a degree. This, they say, shows that the microwaves are counteracting the thermal fluctuations.

TRANSITION TEMPERATURES

Small particles differ from bulk samples

Tunneling junctions, in which two superconductors are separated by a thin insulating layer, offer a good way to study the superconducting properties of very small particles of superconducting materials.

The small particles are embedded in the insulating layer. Most of the electrons that cross the junction will go into and out of the embedded particles, say Drs. H. R. Zeller and Ivar Giaever of the General Electric Research and Development Center. When the embedded particles go superconducting, the current and voltage characteristics of the junctions change, and from this the superconducting characteristics of the embedded material can be determined.

In this way Drs. Zeller and Giaever have examined particles not more than 25 angstroms in diameter. For tin particles they find the transition temperature slightly higher than the value for bulk tin. The critical magnetic field, that is, the field strength that will destroy the superconducting state, is much larger than would be predicted from simple theories of what happens to superconductivity in small grains.

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