letter from Rome

Color gets attention

Crystal physicists meet to chart progress in color center research

by Philip Dallas

Color centers occur in some crystals when atoms in the structure are knocked out of position and replaced by electrons. Heat or X-rays can do the job. The color centers, like colored cellophane, absorb most light and transmit only one color.

The possibilities and intricacies of color center crystallography have become increasingly interesting to physicists, and the recent Fifth International Symposium on Color Centers in Alkali Halides brought 220 scientists to Rome from 22 countries.

The attendees make up about a seventh of all the scientists in the world engaged in this kind of research—1,500 is the world-wide estimate. The study was begun about 40 years ago at Göttingen University in Germany. Currently it has major centers in most of Europe, and at Cornell University, the University of Illinois, Oak Ridge National Laboratory, the Naval Research Laboratory and Argonne National Laboratory in the United States.

The phenomenon occurs in alkali halides—lithium, sodium or potassium compounded with negative ions of fluorine, chlorine or bromine—when some of the negative ions in the crystal are knocked out of position, leaving vacancies. With the negative ion out, the positive charge in the area attracts an electron from elsewhere in the crystal and traps it in the vacancy. The trapped electron absorbs light coming near it and transmits it at a particular frequency, its color determined by the structure of the altered crystal lattice.

Study up to now has concentrated on sodium chloride and various fluorine compounds, but further diversification is beginning. Each substance has characteristics of its own. Lithium chloride, for instance, is a current center of attention.

Illumination with a laser beam can switch color centers back and forth between two distinct orientations, which could be used, for example, as yes and no responses in a binary information storage system. Such a storage element, if it could be manufactured, would have very high density—almost 100 million bits in a square centimeter of crystal (SN: 4/6, p. 322).

The Rome meeting was the first color center conference with Soviet participation, and it was a Ukrainian physicist, Prof. Solomon Pekar of Kiev University, whose fundamental studies on the behavior of electrons in crystals most excited those who heard him.

Prof. Pekar has found that electrons in color center crystals behave in more complex fashion than was thought earlier. Normally, alkali halides are insulators; they have no free electrons that in conductors and semiconductors form a conduction band. The crystals can be excited, however, by light or ultraviolet radiation, so that some of the electrons are moved from lower energy states into the conduction band and the materials may conduct electricity.

When there are color centers in the crystal, Prof. Pekar discovered, electrons at large distances from the centers, but below the level of the conduction band, have almost the same properties as free electrons in a conduction band. Those electrons do not have quite enough energy to put them in the conduction band itself, but nevertheless are in contrast to those in the centers which are bound in place.

Zambrelli

Kiev University's Dr. Solomon Pekar.

Furthermore, he found, this conduction band is more complex than previous theory would have had it: Instead of these electrons being at rest when they are in the lowest energy state permitted them by the crystal structure, it turns out that they have a certain minimum motion, which moreover appears to have a non-random direction within the structure of the crystal.

Out of work like Prof. Pekar's, a more general and detailed knowledge of electron behavior in these crystals is developing. The more completely such behavior is known, the better will scientists know what they can and cannot do with the crystals. "It may not shake the world," says Dr. C. C. Klick of the U.S. Naval Research Laboratory, "but it's important to people in the field."