PHYSICAL SCIENCES

Tunneling in solid-state sandwiches

A few years ago the discovery of superconductivity in solid compounds in which metallic layers were sandwiched with an organic material caused a certain stir. Theoretically, the phenomenon was explained as a result of quantum mechanical tunneling of the electrons that make the current from metal layer to metal layer through the intervening, insulating organic.

Now it appears that ordinary conductivity in such compounds at temperature ranges above the superconducting region may depend on the same phenomenon. The experiment was done by W. J. Wattamaniuk, J. P. Tidman and R. F. Frindt of Simon Fraser University in Burnaby, British Columbia. It concerns specifically the compound 4*Hb* tantalum sulfide, but the experimenters believe that compound may be a paradigm for a whole class. The report is in the July 7 PHYSICAL REVIEW LETTERS.

Tunneling is one of the effects typical of the uncertainties basic to quantum mechanics. Normally, an insulating layer represents an energy barrier to the conduction electrons. It is a kind of hill: If they do not have the energy to climb over it, they stay where they are, and that is why, most of the time, an insulator insulates. But if the insulator is thin enough, the uncertainties of quantum mechanics permit electrons that were on one side of the barrier to appear on the other without ever having had the energy to climb over it. Physically, it's hard to explain, but experiment confirms that it happens.

In this instance, the specific evidence for tunneling is a dependence of conductivity on the square of the temperature at temperatures below 35 degrees K.

Lasers, fusion and light harmonics

The successful development of thermonuclear fusion induced in solid targets by laser light depends on a number of factors, but important among them are efficient absorption of energy from the laser light by the target and efficient conversion of electrical energy to light by the laser. A step significant in both those directions is reported from the Institut National de la Recherche Scientifique—Energie at the Université du Québec in Varennes, Québec.

The achievement is the generation of second-harmonic light in the interaction of a beam from a transverse-excitation-atmosphere (TEA) laser with plasma produced from a polyethylene target. The lasing material is carbon dioxide. Its primary emission is at a wavelength of 10.6 microns; the second-harmonic backscatter comes at 5.3 microns. Generation of the second harmonic indicates the existence of "nonlinear effects probably related to the anomalous absorption required for efficient use of laser energy for fusion," the experimenters conclude.

They point out that although several laboratories have reported generation of second harmonics by plasma effects using more powerful 1.06-micron lasers, "our result is of interest for the possible use of the much more efficient CO_2 lasers in the thermonuclear fusion program."

The report, by H. A. Baldis, H. Pépin, T. W. Johnston and K. J. Parbhakar, is in the July 7 PHYSICAL REVIEW LETTERS.

Mysteries of transverse particles

In the usual, historic type of particle-physics experiment, in which a beam of accelerated particles is struck against a fixed target, the particles produced in the collision mostly come off in a narrow cone around the direction of the accelerated beam. But in recent experiments with colliding beams and in some fixed-target experiments at very high energy, significant numbers of particles come off more or less transverse to the beam direction.

These transverse particles are regarded as important because they are likely to carry information about the most intimate details of the collision and the internal structure of the particles involved in it. A major question is whether the existence of the transverse particles can be explained by known processes or whether exotic new phenomena lurk at their origins.

Many of the transverse particles are electrons and muons, and attempts are made to explain them in a more or less ordinary way as decay products of the particles called vector mesons, specifically the phi meson. It won't do, according to an experiment done at the Fermi National Accelerator Laboratory by J. A. Appel and 14 others from Columbia University and Fermi-Lab. The upper limits on the probability of this kind of production are just too low, so another origin must be looked for.

Maybe there are heavy leptons

The recent attempts to unify the theory of particle physics, to gather all its particles and interactions under the umbrella of a single theoretical formulation, predict a number of hitherto unseen phenomena. Some of these have already been discovered; the others are being eagerly looked for.

One of the as yet unconfirmed predictions is the existence of heavy leptons. Leptons are a class of particles intimately connected with the weak interaction, one of the four classes of force that physicists recognize in nature. Heavy leptons would be ones significantly more massive than the lightweight known members of the class (electrons, muons, neutrinos).

In the July 7 PHYSICAL REVIEW LETTERS Lay Nam Chang, Emanuel Derman and John N. Ng of the University of Pennsylvania suggest that evidence for heavy leptons already exists. The experiments they point to involve the production of pairs of muons after the collisions of neutrinos or antineutrinos with atomic nuclei. Chang, Derman and Ng propose that the muon pairs are decay products of heavy neutral leptons produced in the neutrino-nucleus collisions. They present calculations of relevant production and decay cross sections and claim a qualitative agreement with experimental data although they concede more data are needed for certainty.

Superfluids and glitchy pulsars

Pulsars, the celestial bodies that give off periodic pulses of radio waves, were at first thought to be extremely regular in their repetition cycles. Then it was found that, not only are they all gradually slowing down, but many of them are subject to "glitches," sudden sharp changes in repetition rate. Many attempts have been made to explain the glitches in the context of the usual theory of what pulsars are (rotating neutron stars). Now comes superfluid vortices, presented in the July 3 NATURE by P. W. Anderson and N. Itoh of Cambridge University's Cavendish Laboratory.

Superfluidity is a phenomenon known to the laboratory only at extremely low temperatures (within a few degrees of absolute zero) and only so far in two kinds of liquid helium. When it becomes a superfluid, the liquid loses all viscosity and is then capable of bizarre behavior.

The conditions inside a neutron star are physically extreme. The lower crust of the neutron star is composed of "fat" (neutron-rich) nuclei bathed in a gas of neutrons. This gas is believed to have superfluid properties.

One of the phenomena associated with a rotating superfluid is the formation of lines of vortices. These vortex lines like to move, but in the environment of the neutron-star crust they become "pinned" to the lattice of nuclei, which forms a kind of "solid." Anderson and Itoh propose that in stars that show smooth behavior, the vortex lines stay pinned. In others, they break loose from time to time and slide along in a bumpy, "noisy" fashion. This causes complications in the relations between "superfluid" and lattice and between core and crust that contribute to the shaky behavior of the star.