Dietrick E. Thomsen reports from Stanford, Calif., at the Topical Conference on Particle Physics

Desert song

Certain theoretical physicists coined the term "desert" for the range of energies starting just at the highest capacities of present experimental equipment and ranging perhaps for many powers of 10 beyond, because they believed no interesting phenomena would be found there. Perhaps they may regret having done so. Experiments in which protons and antiprotons collide with and annihilate each other at the highest currently possible energies have already found new and fascinating phenomena.

These experiments, called UA1 and UA2, were done at the CERN laboratory in Geneva by collaborations of more than 100 physicists. They found instances in which the annihilation produces not only identifiable particles but also something undetectable that takes away a great deal of energy in a direction perpendicular to the axis along which the proton and antiproton met (SN: 5/5/84, p. 276). These phenomena are apparently no mirages. Carlo Rubbia of CERN and Harvard, speaking for UA1, and Alan Rothenberg of CERN, speaking for UA2, report that they persist. And now at the Stanford meeting Michel Davier of the Orsay Laboratory in France, reporting the latest from the PETRA storage ring at the DESY laboratory in Hamburg, where electrons and positrons collide, has listed a strange event seen by the CELLO detector there. Like the CERN experiment, this one revealed that unusual amounts of momentum and energy are carried away to the side, this time by a pair of muons. Such a configuration is currently inexplicable.

If you knew SUSY

In their quest for a theoretical unification of all of physics, theoretical physicists have proposed the so-called Super Symmetry theories (SUSYs) to unite particle physics with gravitational phenomena. SUSYs differ in detail, but they all propose a doubling of the number of known particles. Subatomic particles obey one of two statistical laws, Bose-Einstein statistics (bosons) or Fermi-Dirac statistics (fermions). SUSYs propose that every known fermion has a SUSY partner that is a boson and vice versa.

This gives physicists a lot to look for. Searches for SUSY particles, particularly the photino (partner to the photon), the gluino (partner to the gluon) and the selectron (partner to the electron), were reported from the PETRA storage ring at the DESY laboratory in Hamburg by Michel Davier of the Orsay Laboratory in France and from the PEP storage ring at the Stanford Linear Accelerator Center in Menlo Park, Calif., by Richard Prepost of the University of Wisconsin at Madison. No evidence for any was found—so we still don't know SUSY.

Breaking up is hard to do

High-energy annihilations of protons and antiprotons tend to yield high-energy quarks and gluons, the basic elements of which most subatomic particles are made. However, quarks and gluons cannot fly around free. Before they move farther than a proton's diameter, these particles must break up (fragment) into numbers of less energetic quarks which then form particles, such as neutrons or protons, that can be free.

There are three different proposed schemes for how the fragmentation takes place, depending in detail on whether or not each quark or gluon acts independently of the others. Physicists would like to know how fragmentation happens, as that could teach them details of the force that holds quarks together, the most fundamental force in the structure of matter. However, Pier Oddone of the University of California at Berkeley, reviewing recent evidence, concludes that experiments are not yet sufficiently fine to make a distinction among the schemes. "There's a lot yet to be done," he says, "but progress is possible."

Dietrick E. Thomsen reports from San Francisco at the 17th International Conference on the Physics of Semiconductors

Strangers in the night

The periodic table of the chemical elements is arranged in eight columns from zero to VII. The columns signify an element's chemical valence, its affinity to make compounds with other elements. In semiconductor physics, compounds of elements from columns III and V are common: The much used gallium arsenide is an example. Until recently, elements from column IV have been strangers to these arrangements. Now there is a technique for making III-IV-V alloys, and according to a theory developed by Kathie E. Newman of Notre Dame University in South Bend, Ind., they should have interesting properties, particularly the ability to sense infrared light, and so possibly to serve for photography or vision in the dark.

The technique for making such compounds was developed by Joseph Greene, Ken Cadien and Scott Barnett of the University of Illinois at Urbana. Using molecular beam epitaxy, a technique in which a beam of gaseous molecules is laid down on a proper substrate to form layers one molecule thick, Greene and collaborators deposit alternate layers of gallium arsenide and germanium, a column IV element. This is analogous to shaking oil and water together in a colloidal suspension. Eventually, like oil and water, this III-IV-V alloy will come apart, but by doing the epitaxy at low enough temperatures they can give it a long life, equal perhaps to that of the earth itself.

Newman's theoretical analysis shows that the band gap of the alloy depends on the proportion of germanium in it. The band gap is the energy necessary to promote electrons from the valence band—where they are occupied forming chemical bonds among the atoms—to the conduction band, where they can form an electric current in the material. At a particular concentration of germanium, the band gap has a sharp V-shaped minimum. This minimum may be low enough that the energy it requires can be supplied by a photon of infrared light. Thus infrared falling on the material could promote electrons into the conduction band and cause a current, making the material an infrared sensor.

*Un*happy wanderer

To make silicon do all the marvelous things it does in computers and similar technology, it has to be doped. Minute quantities of other substances, such as aluminum, are introduced to form subtle patterns within the silicon crystals. These alterations give rise to the various kinds of electronic behavior that make the technological applications possible. However, the atoms of silicon have a tendency to wander around the crystal, and as they do so, they destroy the patterns set up by the dopants and so degrade and destroy the usefulness of whatever circuit element has been made.

Now, with miniaturization and ultraminiaturization the vogue for making smaller and cheaper computers, the problem is especially acute. The dopant patterns have to be made smaller, and the smaller they are, the easier it is for moving silicon to destroy them.

Experiment shows that the warmer the temperature, the faster the silicon moves, which is in part understandable since thermal energy makes everything go faster. However, at the hottest temperatures the silicon moves faster than expected, and what is really "astonishing," according to graduate student Yaneer Bar-Yam and faculty member John D. Joannopoulos of Massachusetts Institute of Technology, is that at extremely low temperatures (−269°C), it can still move quite rapidly.

They have shown how, they say. The silicon goes by a kind of hand-over-hand: First it captures an extra electron, and the attraction moves it forward; then it releases an electron behind itself, and that moves it a little more. This mechanism has been considered for 10 years, they say, but only now has it been shown to happen. Knowing how the silicon moves, Bar-Yam says, may help physicists figure how to inhibit the motion.