PHYSICS

Hopes for Exotic New Particle Fade

Nothing is surer to rouse the field of high-energy physics than hints of a new particle. That helps explain the intense interest in a recent announcement by researchers at the Deutsches Elektronen-Synchrotron in Hamburg, Germany, who had data from particle collisions that might have signaled the brief appearance of an exotic new beast called a leptoquark (*Science*, 28 February, p. 1266). This week, however, the field is standing down a bit. A group at the Fermi National Accelerator Laboratory has made an extensive search through its data for evidence of leptoquarks resembling the ones hinted at by the DESY results—and come up empty.

The negative search does not strictly rule out the possibility of someday finding these particles, which would combine properties of the two basic kinds of matter, says Carla Grosso-Pilcher of the University of Chicago, a member of the multinational Collider Detector at Fermilab (CDF) collaboration. But Grosso-Pilcher, who reported on the analysis last week during a workshop at Vanderbilt University in Nashville, Tennessee, says that if leptoquarks do exist, they must either have a mass greater than Fermilab can detect, or decay into elusive particles like neutrinos, which the search could have missed. "The CDF [analysis] leaves almost no room for the simplest leptoquark solution," says Herbi Dreiner, a theorist at the Rutherford-Appleton Laboratory in the United Kingdom.

The original announcement came after two detectors at DESY's HERA accelerator—which smashes antimatter particles called positrons into protons—had seen more "hard," or violent, collisions than expected under physicists' current theory of the fundamental structure of matter, called the Standard Model. One possible explanation was that the collisions were spawning a particle that combines the properties of quarks—the building blocks of the proton—and leptons, such as the positron and the electron. By briefly materializing, then decaying in a spray of ordinary particles, a leptoquark might explain the seemingly violent collisions.

"The HERA results came out, and we really moved fast," says Henry Frisch of the University of Chicago, co-convener of CDF's "exotics" group. The group analyzed data on the debris from 3 trillion collisions in Fermilab's Tevatron accelerator, which smashes together protons and antiprotons, their antimatter counterparts. These collisions could sometimes produce pairs of leptoquarks, as the proton's building blocks tangled with their counterparts in the antiproton. The leptoquark pairs would then decay into ordinary particles, leaving a recognizable signature. That signature wasn't seen, says Frisch.

That still leaves the HERA group mulling over the anomalous collisions. "We'll continue to compare our … data to Standard Model predictions," says Bruce Straub of Columbia University, a HERA collaborator. The answer, when it finally comes, could be as mundane as minor tweaks in physicists' understanding of proton structure—or as electrifying as another new particle.

–James Glanz

MATERIALS SCIENCE

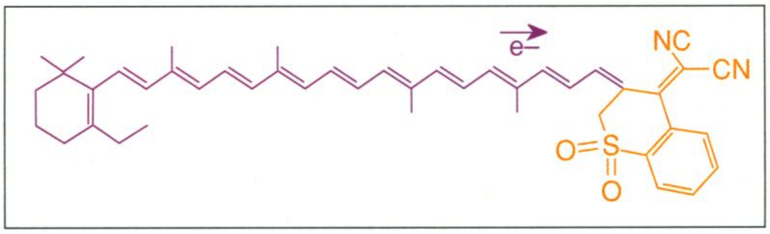
Nonlinear Molecules Trip the Light

As high-speed information carriers, photons of light are hard to beat. They travel at, well, the speed of light, and can be packed close together without interacting, allowing many streams of information to be transmitted together. No surprise, then, that many of today's long-distance messages—phone calls, faxes, e-mails—are converted from electronic signals to pulses of light and beamed over long-distance optical fibers.

But like expressways that end at sluggish intersections, fiber-optic systems rely on low-speed electronic components for switching, routing, sending, and storing the information. Visionaries foresee speeding up these intersections by controlling the flow of light with other light. These all-optical switches are still mostly on the drawing boards, however, because few optical materials allow one light beam to manipulate another. Now, on page 1233, an international team of researchers led by chemist Seth Marder at the California Institute of Technology (Caltech) reports a development that could bring the all-optics vision a step closer to reality.

Marder and his colleagues have developed polymers with an enhanced version of an effect seen in practically every optical material: Beam in sufficiently intense light, and it will change the way the light itself or another beam propagates. Usually, this effect—called a third-order nonlinear optical (NLO) effect—is vanishingly small. But the Caltech team found that by manipulating the electronic character of small molecules embedded in the polymers, they could elicit unrivaled third-order effects—in one case 35 times better than ever before.

"It's outstanding," says University of Pennsylvania optical physicist Anthony Garito, who helped develop some of the basic principles behind the new work. "This will have implications for a huge number of applications," ranging from optical switches to data storage. Garito, Marder, and others caution, however, that the new materials themselves are not likely to be technologically useful, because they break down under even modest light and heat. But they think that the success will show the way toward developing more robust materials with equally strong NLO properties.



Long-distance migration. Charge shifts from donor to acceptor segments on a chromophore that dramatically changes its optical properties in response to light.

An optical material qualifies as nonlinear if an electric field or light itself can change its optical properties. Marder explains that in any optical material, light's oscillating electric field causes electric charges to vibrate, generating a secondary field. If this field is strong enough—or is supplemented by an external field—it can feed back to influence the vibration. More photons can then interact with the material in pairs (a second-order effect) or even trios (a third-order effect), producing light frequencies that are harmonic overtones of the original, much like the overtones that give violins their rich sound.

These overtones can alter the original light's color. They can also change the material's refractive index or transparency—effects that can be used to manipulate a light beam. Change a material's refractive index, for example, and it can act as an optical switch, steering a light beam from one fiber-optic line to another. In second-order NLO materials, this switch can be tripped only by applying a voltage. But in third-order materials, one light beam can switch another.

The third-order effect is inherently much weaker than its second-order cousin, however, as it is harder to coordinate the interaction of trios of photons than pairs. In recent years, hopes for improving third-order materials have rested on optically active organic molecules known as chromophores. Chemists can easily tailor these molecules and incorporate them into transparent host polymers. In 1989, Garito and his colleagues proposed a strategy for developing chromophores that have strong third-order NLO properties: create molecules that can sustain large separations of electric charge.

These researchers knew that many chromophores can essentially shuttle negative charges to one end of the molecule, leaving the other end positively charged, and that this separation increases in response to light. They calculated that the greater this light-driven charge separation, the greater the material's light-changing NLO properties would be. As Marder's collaborator George Stegeman, a physicist at the University of Central Florida in Orlando, explains, the charge separation alters the electronic structure of the molecule, making it easier for trios of photons to interact in the material.

In 1993, Marder and his colleagues improved a class of small chromophores to more than double their NLO properties. In the current experiment, the team turned to longer molecules whose charges could separate even farther. The researchers started with a batch of β-carotene, a well-known third-order NLO chromophore consisting of a long, narrow chain of carbon atoms capped on either end by ring-shaped groups. One of the rings is an electron-hungry "acceptor" group that snags an electron from the other end of the molecule, giving β-carotene its NLO properties, among the strongest yet observed.

To enhance these properties, Marder and his colleagues replaced the β-carotene's acceptor with successively stronger electron grabbers. When Stegeman and his colleagues at Central Florida added these chromophores to a polymer known as poly (methyl methacrylate) and spun it into films, they found that the films made with chromophores that had the strongest electron grabbers produced an NLO effect 35 times stronger than the starting molecule. For many applications, says Garito, that is "very close" to what's needed for commercial success.

The chromophores break down when they are exposed to light and heat, ruling out their use in light-based communication devices, says Nasser Peyghambarian, an NLO expert at the University of Arizona, Tucson. But he and others believe that the same charge-separation strategy could improve the NLO properties of other types of molecules, among them more robust chromophores made from chains of linked rings or compounds containing stable metal complexes. "It's fairly wide open," says Garito. If so, more and more communications visionaries are likely to see the light.

–Robert F. Service

AIDS VACCINE

Looking for Leads in HIV's Battle With Immune System

BETHESDA, MARYLAND—When officials at the National Institutes of Health (NIH) tapped Nobel laureate David Baltimore last December to head its newly formed AIDS Vaccine Research Committee, they hoped he would give a much-needed boost to a floundering field. It is too early to tell whether Baltimore's committee will live up to those expectations. But a 4-day meeting* on AIDS vaccine development held here at the NIH last week suggests that it will have plenty of new leads to follow.

AIDS vaccine development has been limping along since 1994, when NIH decided not to push ahead with large-scale tests of the leading vaccine candidates because they didn't look promising enough (see sidebar). The organizers of last week's meeting—the ninth in a series of these annual gatherings—tried to give the field a booster shot by adding reports of cutting-edge basic research on how HIV causes disease to the standard AIDS vaccine fare. This strategy seemed to pay off. Several reports—including one by Baltimore—on the protective role played by the immune system's killer cells, called cytotoxic T lymphocytes (CTLs), sparked much discussion. A presentation on the possible capture of a long-sought factor that provides some protection against HIV sent a ripple through the meeting, as did a suggestion that a goat virus might provide the basis for an HIV vaccine.

> **"I'm convinced that we will have a vaccine ... in a reasonable period of time."**
>
> **—Anthony Fauci**

Although the 550 attendees heard no headline-grabbing talks, veterans in the field came away moderately encouraged. "Pessimism is destructive," said Anthony Fauci, director of the National Institute of Allergy and Infectious Diseases (NIAID). "I'm convinced that we will have a vaccine and that we'll have it in a reasonable period of time."

For many AIDS vaccine researchers, the most troubling roadblock has been teasing out which immune responses a vaccine should trigger to protect a person from HIV. Most viral vaccines work by stimulating the immune system to produce antibodies that bind to a virus, preventing it from infecting cells. But it's not clear that antibodies offer much protection against HIV. "As I try to understand the role of antibodies, ... I keep coming up with a blank," said Baltimore, hence the focus on CTLs.

Like smart bombs, CTLs search out and destroy cells that a virus has infected. They play a key role in the body's natural defenses, and many traditional vaccines stimulate their production along with antibodies. "Cytotoxic T lymphocytes are at least very important, if not the most important, thing [for protection from HIV]," said Baltimore.

However, an AIDS vaccine that stimulates CTLs would face hurdles too, as Baltimore's own work shows. When a cell is infected by HIV, it typically puts a piece of the virus on its surface. CTLs are trained to pulverize any cells that display these viral peptides. Baltimore and his Massachusetts Institute of Technology colleague Kathleen Collins, collaborating with HIV CTL guru Bruce Walker of the Massachusetts General Hospital, have new evidence that HIV escapes the deathblows of CTLs by preventing cells from displaying viral peptides.

Building on work first published in the March 1996 *Nature Medicine* by the Pasteur Institute's Olivier Schwartz and co-workers, the Baltimore group focused on the HIV protein Nef. As the Schwartz group showed, Nef can prompt cells to yank down from their surfaces a molecule known as the major histocompatibility complex (MHC), which displays viral peptides to the immune system. The group predicted that this "down-regulation" of MHC would make HIV-infected cells resistant to CTL killing—just what the Baltimore group's new data now show. Baltimore says these findings imply that if researchers hope to base a vaccine on stimulating CTLs, the timing is critical: Unless CTLs flood the bloodstream shortly after an infection occurs, HIV may undermine their utility by dispatching Nef.

That may be a tall order, but one heartening talk at the meeting, by Duke University's Kent Weinhold, suggests that the down-regulation of MHC by Nef does not completely shut down CTL activity. "I don't think it's an all-or-none phenomenon," says

* Conference on Advances in AIDS Vaccine Development, 4–7 May, sponsored by NIAID, Bethesda, Maryland.