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

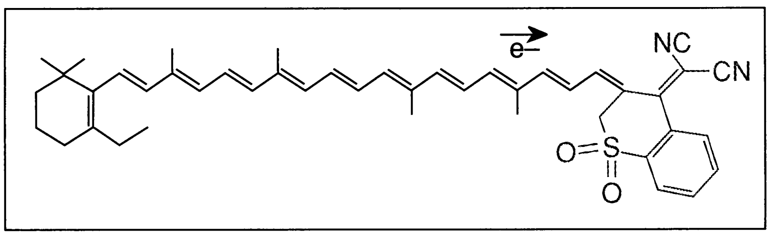
Nonlinear Molecules Trip the Light

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 materi-