# Optical solitons from a laser

A soliton is a solitary wave, a single undulation proceeding along in whatever medium supports it. Ordinary waves usually come in trains and lose their shape as they proceed. Solitons maintain their shape. These properties of solitariness and shape maintenance make solitons, which were first observed in water nearly a hundred years ago, important in several branches of physics.

In 1973 Akira Hasegawa of AT&T Bell Laboratories predicted that optical solitons could exist, not in a vacuum, but in a transmission medium such as glass fibers. Now Linn Mollenauer and Roger Stolen of AT&T Bell Laboratories in Holmdel, N.J., have demonstrated such solitons. The ultimate hope for this work is a soliton communications system. This would mean better transmission of information than in current optical communications systems, and also a system that is all optical, having no electronic components.

Mollenauer and Stolen have made what they call a soliton laser. The lasing material is a solid known as Neodymium: YAG (Yttrium-Aluminum-Garnet). It is set into a loop of glass fiber so that pulses leave the laser, go around the loop and reenter the laser. Solitons are made by playing the forces that usually degrade pulses running through the fiber against each other. One of these effects is dispersion. The light pulses consist of a mixture of frequencies centered on 1.5 micrometers in the infrared. As a pulse moves in the glass, the higher frequencies travel faster than the lower, so the pulse spreads out and loses its shape. However, if the intensity of the waves is high enough, the waves in the center of the pulse tend to slow. This compresses the waves in the trailing end of the pulse, raising their frequency in consequence, and spreads waves and lowers frequency in the forward end.

The dispersion effect, speeding up the high frequencies, causes the trailing end continually to try to catch up with the leading end. With the two effects working together, the ordinary effect of dispersion is reversed, and the pulse tends to maintain its shape. The compressed pulse returns to the laser where it is amplified and sent back to the fiber to be compressed some more.

The laser was especially made for the experiment. However, Mollenauer told SCIENCE NEWS that a commercial version is about to go on the market. The fiber is a single-mode polarization-maintaining fiber. The polarization maintenance is important as the laser will not respond if the light is depolarized in passage. The work is reported in the January OPTICS LETTERS.

Quite short pulses can be made this way. The shortest one so far is 210 femtoseconds (210 x $10^{-15}$ second), but Mollenauer expects they will get down as far as 20 femtoseconds.

For now, the emphasis is on experiment. Mollenauer wants to study the nature of the solitons themselves. The method can make first-order solitons, which keep the same shape, and second-order solitons, which go through cyclic changes of shape, returning periodically to their original shape. Theory predicts forces between solitons, attractive or repulsive according to the relation between the phases of the waves. In the realm of very short pulses, one of the fundamental equations of modern physics, the nonlinear Schrödinger equation, may not hold exactly. These short pulses can also be used as probes of chemical and physical processes that go at femtosecond speeds, particularly in commercially important semiconductors.

*—D.E. Thomsen*

# Goats in sheep clothing, and vice versa

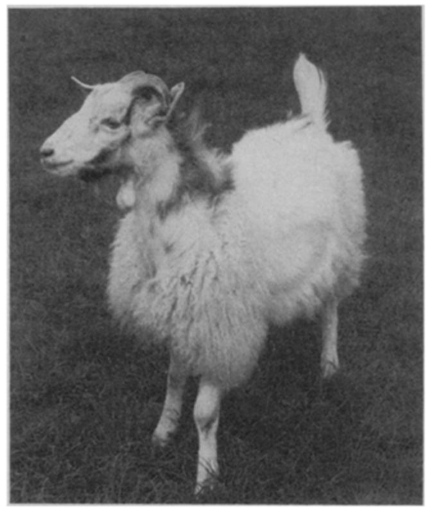
It's getting harder to tell the sheep from the goats. Biologists have now produced goats with regions of woolly fleece and sheep with areas of straight goat-like hair. These patchwork animals — some call them geep — are the result of experiments combining embryonic cells. The engineers of this feat also fostered for the first time the birth of lambs from goats and kids from ewes.

Any practical outcomes of this work, reported by two groups in the Feb. 16 NATURE, are more likely to appear at the zoo than on the farm. Livestock giving goat's milk and cheese, wool and mutton is still considered improbable. But zookeepers are excited by the prospects of using the procedures to produce young of endangered species in common animals.

More than 50 combination goat-sheep embryos produced eight chimeras in experiments at the Institute of Animal Physiology in Cambridge, England, Carole B. Fehilly, S.M. Willadsen and Elizabeth M. Tucker report. Only one of the chimeras has blood proteins of both sheep and goat. This animal behaves like a male goat, but it does not produce normal sperm. Previously, the only successful mammalian chimeras produced by embryo manipulation were hybrids of two closely related mouse species (SN: 12/8/79, p. 389).

The Cambridge researchers' embryo transplantations produced, in addition, three lambs born of goats and one goat kid born of a sheep. Birth of a kid from a sheep is also reported by Sabine Meinecke-Tillmann and B. Meinecke of Justus Liebig University in Giessen, West Germany.

The success of the recent sheep-goat work is thought to be due to the distribution of tissue derived from the different species. In the successful pregnancies, the scientists suggest, crucial parts of the placenta match the species of the surrogate mother, whether the fetus matches or not.



*Sheeplike goat chimera with mixed blood.*



"I don't see a big application in creating new domestic animals," says Robert Foote, who does embryo transfers at Cornell University, in Ithaca, N.Y. "But there may always be a startling and unexpected finding."

"I think this is a very exciting technique for the zoo field," says Janet Stover, who led researchers at the New York Zoological Society in a successful transfer of the embryo of a rare wild ox, called a gaur, into a common dairy cow (SN: 8/22/81, p. 116).

Currently the drawback of the hybrid embryo technique, as Stover sees it, is the intriguing potential for producing chimeras. "We are not interested in producing new animals that are half one thing and half another," she says. "We are having enough trouble preserving the ones we have now." *— J.A. Miller*

# 800-GeV protons

The energy doubler ring at the main synchrotron of the Fermi National Accelerator Laboratory in Batavia, Ill., has now doubled the usual maximum running energy of the original synchrotron. The original accelerator usually ran at a maximum of 400 billion electron-volts (400 GeV). On Feb. 15 the combination of the original synchrotron and the energy doubler accelerated a beam to 800 GeV. On Feb. 17 operations shut down to permit installation of new, higher-energy experiments. In mid-March the laboratory expects to begin running routinely at a maximum of 800 GeV. Construction of the doubler began almost as soon as the original machine was completed (SN: 1/4/75, p. 11; 9/25/82, p. 196). □