Plasma Pipe for Intense Laser Pulses

When traveling through a gas, a light beam has a natural tendency to spread out. This flaring effect steadily weakens the beam as it progresses through the medium.

One way of maintaining a light beam's intensity for longer distances is to focus the beam into an optical fiber, which confines the light and keeps the beam from broadening as it travels along the glassy strand. This solution doesn't work for intense laser pulses, however, which interact so strongly with an optical fiber that they cause the fiber's destruction.

Now, researchers have demonstrated a new technique they can use to channel high-intensity laser pulses through a gas for surprisingly long distances. "We make a transient optical fiber," says Howard M. Milchberg of the Institute for Physical Science and Technology at the University of Maryland at College Park.

The researchers use a laser pulse to generate a long, thin cylinder of hot, ionized gas, or plasma. They can then guide a second laser pulse in the opposite direction down this tube of expanding hot plasma, enabling the pulse to travel a much longer distance through the gas than it would normally go by itself.

"This is a significant advance," says Philip H. Bucksbaum of the University of Michigan in Ann Arbor. "It provides a way of confining a light beam so that it has a high intensity over a long distance."

"It's a very important experiment, and it could have great practical implications," says Phillip Sprangle of the Naval Research Laboratory in Washington, D.C. Optical guiding of intense laser pulses may prove a crucial element in the development of tabletop X-ray lasers, compact particle accelerators, and practical nuclear fusion reactors that rely on powerful laser beams to initiate fusion.

Milchberg and C.G. Durfee III describe their experiment in a paper scheduled for publication in the Oct. 11 PHYSICAL REVIEW LETTERS. They will also present their findings at an Optical Society of America meeting next week in Toronto.

Milchberg and Durfee arrived at their discovery indirectly. To study the interaction of light pulses with electrons in a plasma, they sent two intense laser pulses through the same lens. The first pulse generated a spark in the gas, and the second, delayed pulse probed the electrons stripped from atoms by the first pulse.

"What we saw was that the spark due to the first pulse was lensing the light coming from the second pulse," Milchberg says. "It was acting just like a short length of optical fiber."

The researchers recognized that this effect might be used to channel laser pulses, but initially they had no idea how to make the spark longer. On a visit to a plasma laboratory in Russia, Milchberg discovered that scientists there had rigged up a special kind of lens – known as an axicon – that brought light to a long, narrow focus extending out from the lens in the direction of the light's path.

When he returned to the United States, Milchberg commissioned a local company to make a similar axicon lens. But when he and Durfee tried it, the experiment didn't work. It turned out that "the alignment [of the apparatus] wasn't quite right," Milchberg says. Once this problem was solved, getting a laser pulse to travel along a plasma tube proved remarkably easy.

"We do it regularly now, and we have lots of detailed measurements," Milchberg says. The latest results show that a laser pulse of 10^{14} watts per square centimeter can be guided for a distance of more than 70 Rayleigh lengths. A Rayleigh length represents the characteristic distance (typically ranging from a few hundred microns to a millimeter) that a focused light beam of a certain diameter can travel through a given medium before spreading out excessively.

"The technique causes a gaseous plasma to modify itself to just the right geometry to make a channel for guiding a light wave," Bucksbaum says. "What's nice about it is that it's fairly easy to do."

Milchberg and his co-workers are now looking into the possibility of using their novel light pipe for building an X-ray laser. The technique's potential value for other applications depends on whether it works for laser pulses more powerful than 10^{18} watts per square centimeter.

"We had done some theoretical work on this even before [Milchberg] carried out his experiment," Sprangle says. "Our simulations show that it should work at high intensities, but one needs to do an experiment to be absolutely sure. We have a laser that can go up to 10^{19} watts per square centimeter, so we'd like to test this."

"What's left is to demonstrate that you can use this [technique] to pump a laser or accelerate electrons," Bucksbaum notes.

– *I. Peterson*

Oldest known Maya burials found in Belize

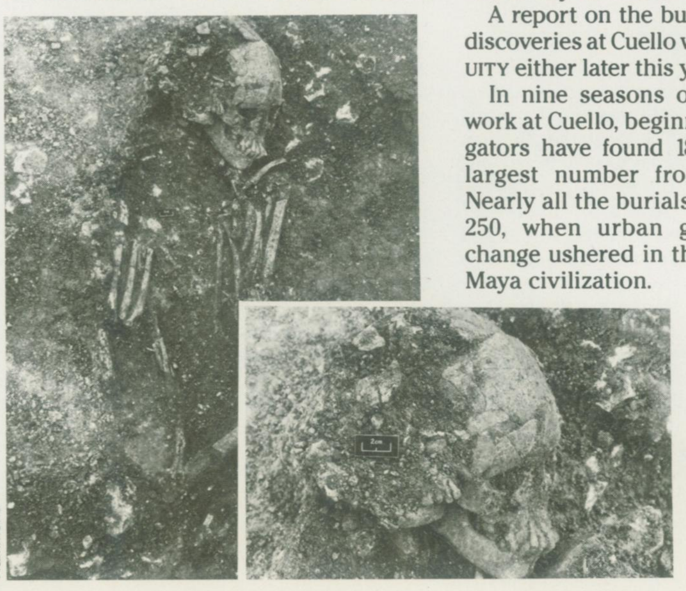
Archaeologists excavating an ancient village in Belize have uncovered the earliest known human burials from the Maya culture. The new finds consist of five individuals, lying side by side in shallow graves, who may have belonged to the same family at the time of their deaths, around 3,000 years ago.

"We regard this as a family burial plot," asserts Norman Hammond, an archaeologist at Boston University who directed the excavation. "No clues to the causes of death have been found so far, but these people probably all died at around the same time."

Hammond and his co-workers made their discovery in March at Cuello, a Maya site in Belize. The burials appeared in sediment layers that date to the earliest phase of occupation at Cuello, from 1200 B.C. to 900 B.C. More precise dates should emerge in the next few months, following radiocarbon dating of bone samples at the University of Oxford in England.

A report on the burials and other new discoveries at Cuello will appear in ANTIQUITY either later this year or in early 1994.

In nine seasons of intermittent field work at Cuello, beginning in 1975, investigators have found 180 burial sites, the largest number from any Maya site. Nearly all the burials date to before A.D. 250, when urban growth and social change ushered in the Classic period of Maya civilization.



Hammond

Cuello burial contains a woman holding a child in her right arm. Close-up shows the child's partly crushed skull lying against the woman's cheek.

One skeleton found this year, that of a middle-aged man, displays severe swelling on the leg bones and on one forearm. This type of bone thickening and distortion usually results from any of several related bacterial diseases, including syphilis, Hammond notes. Another individual buried at Cuello, previously dated to nearly 1100 B.C., shows similar bone swelling. Whether or not Spanish explorers spread syphilis throughout New World populations in the 16th century A.D., as some researchers argue, syphilis-like conditions afflicted the Maya long before Columbus entered the scene, the Boston archaeologist contends.

Another grave discovered at Cuello this year contained a young woman approximately 15 years old holding a 1-year-old baby in her right arm. The child's head rested against the woman's cheek; the youngster's fingers curled under the woman's chin.

All the skeletons except for that of the baby were placed in the same posture, with the knees drawn up to the stomach. In addition, all had their heads oriented to the north, the direction of the heavens in Maya cosmology.

Few associated artifacts, or "grave goods," accompanied these early Cuello burials. Excavation yielded a couple of pottery bowls inverted over two skeletons and a jade bead.

The number of grave goods increases dramatically among Cuello burials that date to between 900 B.C. and 600 B.C., including three unearthed this year, Hammond says. At that time, upper and lower segments of society developed, he maintains. A woman's skeleton found in March, which dates to at least 650 B.C., includes an elaborate necklace made of a tapering, narrow mollusk shell. And a child's burial from the same period, excavated in 1992, features strings of beads that marked royal or noble rank 1,400 years later among the Classic Maya.

Cuello survived into the Classic period, growing from a small village into a town of perhaps 3,000 people, but it failed to evolve into a major urban center, Hammond says.

"The paradox is that Cuello and the few other sites that are nearly as old were probably the least successful Preclassic Maya settlements," he holds. "Other very early Maya sites probably lie underneath structures erected during one or more building phases at major sites of the Classic period."

Cuello's distinctive pottery styles appear even among its oldest remains, Hammond adds. This suggests that the Maya may have first occupied the lowlands of Central America as early as the 16th century B.C., in his view.

For now, evidence from Cuello "shows for the first time the early origins and rapidly developing complexity of the society that evolved into Classic Maya civilization," Hammond contends. – *B. Bower*

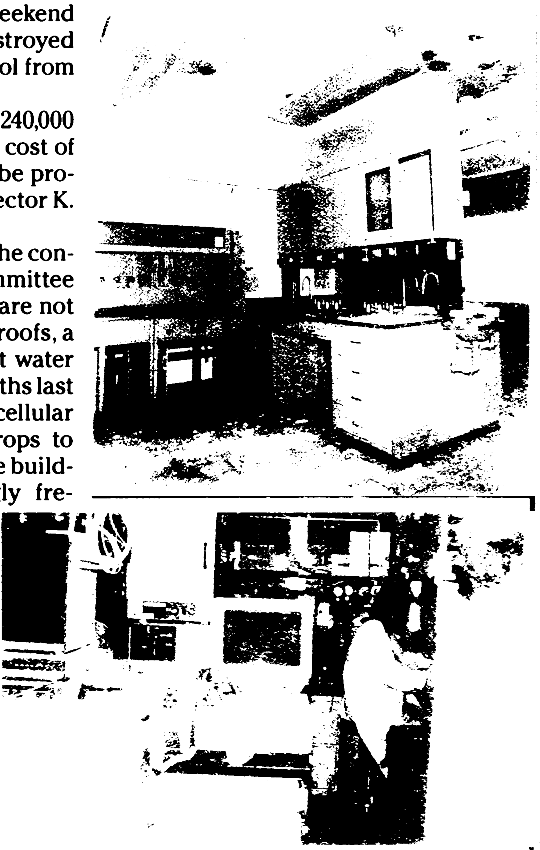
Run-down labs hamper federal research

Earlier this year, backup electrical generators failed during a power outage at the Beltsville (Md.) Agricultural Research Center (BARC). The weekend loss of power to freezers destroyed samples of blood, urine, and stool from a major nutrition study.

While BARC scientists spent $240,000 to collect these specimens, "the cost of repeating this human trial may be prohibitive," according to BARC Director K. Darwin Murrell.

Moreover, he testified before the congressional Joint Economic Committee (JEC) last week, such incidents are not that unusual at BARC. Damaged roofs, a steam-line problem, and a burst water pipe forced a closing for two months last fall of the BARC lab that studies cellular and ecological responses of crops to climate stress. Indeed, "complete building shutdowns are increasingly frequent," Murrell said, owing to the deterioration and obsolescence of BARC facilities – 77 percent of which are at least 50 years old.

Nor is BARC's situation unique. According to a new General Accounting Office (GAO) study, decades of widespread underinvestment in the nation's federal research infrastructure have allowed major facilities across the United States to deteriorate badly.


GAO

NIH

Top: BARC lab slated for repair. Bottom: Advanced equipment crowds NIH lab designed for simpler studies.

GAO studied 220 labs owned by eight federal agencies, including NASA, the National Institutes of Health (NIH), and the Departments of Agriculture, Defense, and Energy. It found that most of the space devoted to research was at least 30 years old and that needed repairs could cost more than $3.8 billion.

Some labs – a former Army barracks or converted cow barn – never were more than makeshift. Others evolved into makeshift operations, such as a Wright-Patterson Air Force Base lab in Ohio, where scientists finally solved the problem of a 10-year roof leak by building a second, indoor building – complete with roof and walls – around their instruments.

In some instances, the design of the deteriorating structure limits needed improvements. For instance, air-exhaust capabilities at NIH's 38-year-old clinical center in Bethesda, Md., "cannot satisfy even current user demands," notes Stephen A. Ficca, associate director of NIH. So the center cannot add new fume hoods – which limits research there. Moreover, Ficca told the JEC, deficiencies in the current system "result in potential exposure of NIH personnel to hazardous fumes."

"Infrastructure deterioration is not a problem limited to just one or two of these government-owned facilities, but appears to be a system-wide problem," observes JEC vice chairman Sen. Paul S. Sarbanes (D-Md.), whose state contains the largest concentration of federal labs. "We hope to use this new study as ammunition to help [labs] defend budget increases for research infrastructure investments – both within their agencies and before the congressional committees that oversee federal spending," he told SCIENCE NEWS.

But "let's look at each lab and see whether it's even needed before we fix its roof," argues Joseph P. Martino, a senior scientist at the University of Dayton (Ohio) Research Institute.

A spate of studies indicates that many federal labs do "very poor research," says Martino, who has been analyzing research management. Even among quality programs, he notes, many – like NASA's aeronautical studies – exist merely to support civilian industries. Why, he asks, shouldn't industry consider picking up the costs of these labs?

– *J. Raloff*