Fiber bridge connects Incan, student engineers

PHOTO / DAN BERSAK

Junior Allison Brown works on an Incan bridge built at MIT on Saturday, May 12. The Chaka Stata is an all-fiber suspension bridge of the type the Incas built to ford deep ravines in the high and rugged Andean mountains.

PHOTO / DAN BERSAK

Freshman Alice Chang works on Chaka Stata.

Ruth Walker
News Office Correspondent

A technology that once brought the bold conquistadores of Spain to their knees in fear in the jungles of South America has come to the dry moat behind the Stata Center.

Students in Course 3.094 (Materials in Human Experience) have built a fiber bridge in the style of the Incan Empire. They call it Chaka Stata—chaka being the word for bridge in Quechua, the native language of Peru.

The Incas had no wheel, no arch and no system of writing. But they knew how to twist and braid countless miles of grasses and slender branches into ropes—sometimes as thick as a wrestler's waist.

From these ropes they built a system of long-span fiber suspension bridges that connected 15,000 miles of road across a distance greater than the width of the Roman Empire. The bridges, appropriate to the vertical landscape of the Andes, made possible a system of messenger service unmatched until the 19th century.

But the bridges swayed under the weight of traffic—and that's what terrified the Spanish and their horses, even though, as one Spaniard observed, they were almost as "sturdy as the street of Seville."

John Ochsendorf, assistant professor of architecture, has been studying these rope bridges since his undergraduate days at Cornell. This semester, Heather Lechtman, professor of archaeology and ancient technology, and Linn Hobbs, professor of materials science, have been guiding their students in Course 3.094 in the construction of the 70-foot Chaka Stata.

The project made a few concessions to modernity, however: They used sisal twine from the Yucatan Peninsula instead of the grasses the Incas used. And whereas the Incas chiseled into stone to anchor their bridges, the MIT students anchored Chaka Stata by wrapping it around some massive concrete blocks contributed by A.J. Welch Corporation of Brighton.

The weekend's burst of activity was preceded by what the students estimated was 360 hours of rope-twisting as the 50 miles of sisal twine was turned into rope.

Working together as a group was part of the exercise. "A third of the time was spent learning to work together," one of the students said. "But after a while, we were banging those cables out."

PHOTO / DAN BERSAK

The Incan bridge builders are, background to foreground: left, off bridge, senior Daniel Arlow; right, off bridge, sophomore Zachary Jackowski; on bridge—junior Shane Treadway, junior Allison Brown, junior Megan Firko, sophomore Luke Johnson and junior Darren Verploegen.

Team discovers hottest planet

Zenaida Gonzalez Kotala
University of Central Florida
and
Elizabeth Thomson
MIT News Office

A team of scientists including one from MIT has measured the hottest planet ever at 3,700 degrees Fahrenheit, or 2,300 Kelvin.

Using Spitzer, NASA's infrared space telescope, the scientists observed the tiny planet disappear behind its star and reappear. Although the planet, known as HD 149026b, cannot be seen separately from the star, the dimming of the light that reached Spitzer told the scientists how much light the planet emits. From this they deduced the temperature on the side of the planet facing its star.

"This planet is so intriguing that it is changing the way we think about planet atmospheres," said Sara Seager, an MIT associate professor with appointments in the Department of Earth, Atmospheric and Planetary Sciences and the Department of Physics.

PHOTO / NASA/JPL-CALTECH

This artist's concept illustrates the hottest planet yet observed in the universe. The scorching ball of gas, a "hot Jupiter" called HD 149026b, is a sweltering 3,700 degrees Fahrenheit (2,040 degrees Celsius)—about three times hotter than the rocky surface of Venus, the hottest planet in our solar system.

The team's findings were published in the May 9 advance online issue of Nature.

"HD 149026b is simply the most exotic, bizarre planet," said Joseph Harrington (S.B. 1988, Ph.D. 1995), a professor at the University of Central Florida and leader of the work. "It's pretty small, really dense, and now we find that it's extremely hot."

Discovered in 2005, HD 149026b is a bit smaller than Saturn, making it the smallest extrasolar planet with a measured size. However, it is more massive than Saturn and is suspected of having a core 70-90 times the mass of the entire Earth. It has a comparable amount of heavy elements (material other than hydrogen and helium) to that contained in our whole solar system, outside the sun.

There are more than 230 known extrasolar planets, but this is only the fourth to have its temperature measured directly. It is simple to explain the temperatures of the other three planets. However, for HD 149026b to reach 3,700 degrees, it must absorb essentially all the starlight that reaches it. This means the atmosphere must be blacker than charcoal, which is unprecedented for planets. The planet would also have to re-radiate all that energy in the infrared spectrum.

"The high heat would make the planet glow slightly, so it would look like an ember in space, absorbing all incoming light but glowing a dull red," said Harrington.

Drake Deming, of NASA's Goddard Space Flight Center in Greenbelt, Md., and a co-author of the Nature paper, thinks theorists are going to be scratching their heads over this one.

"This planet is off the temperature scale that we expect for planets, so we don't really understand what's going on," Deming said. "There may be more big surprises in the future."

Other members of the team include Statia Luszcz of the University of California at Berkeley and Jeremy Richardson of NASA Goddard.

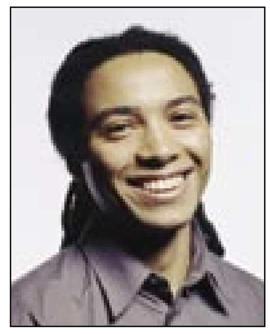
NMR advance relies on microscopic detector

Technology could vastly improve diagnostics

Anne Trafton
News Office

Detecting the molecular structure of a tiny protein using nuclear magnetic resonance (NMR) currently requires two things: a million-dollar machine the size of a massive SUV, and a large sample of the protein under study.

Now, researchers from MIT's Center for Bits and Atoms report the development of a radically different approach to NMR. The highly sensitive technique, which makes use of a microscopic detector, decreases by several orders of magnitude the amount of protein needed to measure molecular structure.



Yael Maguire

The new technology could ultimately lead to the proliferation of tabletop NMR devices in every research laboratory and medical office. Among other things, such devices could prove invaluable in diagnosing a variety of diseases.

"It's revolutionary," said Shuguang Zhang, one of the authors and associate director of MIT's Center for Biological Engineering. "It's not just incremental progress."

The research team reports the work in the online and print editions of the Proceedings of the National Academy of Sciences this week. Lead author Yael Maguire, who earned his MIT Ph.D. for this work, will give a talk on it today at the VII European Protein Symposium in Stockholm.

NMR, along with X-ray crystallography, is commonly used to determine the structure of proteins and other molecules. NMR probes normally consist of a coil that surrounds the sample being studied. The coil creates a magnetic field that interacts with the nuclear spin of atoms in the sample, and those interactions reveal how the atoms are connected.

With current NMR machines, you need about 10^{17} (more than a million billion) molecules of a protein to determine its molecular structure. Some researchers have tried to make tiny coils to study smaller samples, but it has proven very difficult to scale these to small sizes to analyze tiny samples and to create high throughput methods.

Instead, research originally aimed at improving quantum computing led the MIT researchers to a completely different approach based on guiding waves.

"We were trying to get away from coils and see if we could find a new way to look at it," said Maguire, now a visiting researcher at MIT and chief technology officer of Cambridge-based ThingMagic.

How it works

The new approach starts with technology similar to the Wi-Fi antennas found in laptop computers. These antennas consist of a flat strip of metal. Using a laser, the MIT team made a microscopic defect (a slot) in such a conducting structure, known as a strip line. In that location a

See **NMR**
Page 6

PHOTO / DONNA COVENEY

Rosalind Picard, professor of media arts and sciences, discussed 'Technology-Sense and People-Sensibility.'

PHOTO / DONNA COVENEY

Author Michael Chorost, who is deaf, describes his cochlear implant.

PHOTO / DONNA COVENEY

President Susan Hockfield and MIT Media Lab director Frank Moss opened the May 9 symposium, 'H2.0: New Minds, New Bodies, New Identities.'

MEDIA LAB

Continued from Page 4

sense of the visual world," Sacks said. "You have to learn to see."

Other speakers described MIT research initiatives for augmenting mental and physical capabilities to improve human life. Many gave deeply personal accounts. Writer Michael Chorost ("Rebuilt: How Becoming Part Computer Made Me More Human") explained—and showed—what he could hear with his cochlear implant. Deb Roy, AT&T Career Development Professor of Media Arts and Sciences, who is videotaping every waking moment in his home, demonstrated ways to cull specific information from the "ultra dense" data of recording, including his son's vocal progress from saying "ga-ga" to "water."

During a talk by Hugh Herr, NEC Career Development Professor of Media Arts and Sciences, about breakthroughs in building adaptive gait prostheses, Herr reached down and rolled up his pant leg to show the latest prototype, adding that he often forgets to mention he is an amputee himself. "This is the strongest ankle in the world—when I walk up steps it pushes me up," he said, provoking an Arnold Schwartzenegger imitation from Hockenberry. (Herr lost his legs in a climbing accident as a teenager.)

Another symposium high point came when Aimee Mullins, a Paralympic athlete and model, strutted on stage with her prosthetic legs tucked into four-inch stiletto heels. Not only does she compete in sports events, often on unusual, curved "cheetah legs," Mullins, a stunning, slender blonde, has modeled her "legs" as fashion accessories. "People say I have no legs, but, in fact, I have 10 pairs," she remarked.

Rosalind Picard, professor of media arts and sciences, demonstrated software that recognizes human emotions (which may help those with autism), while Cynthia Breazeal, LG Career Development Professor of Media Arts and Sciences, introduced the robot Leonardo, which can work through classic "false belief" scenarios.

The symposium also was punctuated by short films in which Hockenberry—in deadpan, Stephen Colbert fashion—visits various MIT luminaries to demand an "upgrade." The clips showed images of MIT's research from robots to voting screens to spray-on clothing.

Famed architect and designer Michael Graves, who suffered a mysterious illness in 2003 that paralyzed his legs, discussed new home product designs, such as adjustable tub rails, easy-grip shower heads and reversible walker/wheelchairs—all increasingly attractive to an aging baby boomer population, as well as the disabled.

"This is a business opportunity," Hockenberry noted. Indeed, "There are things that are simple to do and they don't cost more; you just have to use your mind and your convictions," Graves said.

Receiving a standing ovation was a performance of "My Eagle Song," by Dan Ellsey, who has cerebral palsy, on a computer designed by Tod Machover and Adam Boulanger that allows him to both compose and play. Machover, professor of media arts and sciences, heads the Opera of the Future group, currently examining the use of music in therapy.

The symposium ended with a flourish as Herr nimbly scaled a climbing wall erected on stage (he said he had been told he would never climb again) and Hockenberry showed off his "upgrade," a "hacked" Segway wheelchair.

"You see how we're changed. How have you changed?" he asked the audience.

MIT urged to educate 'geeks' and 'chiefs'

Lois Slavin
ESD Communications Director

Resilience is important to Professor Yossi Sheffi, best-selling author of "The Resilient Enterprise: Overcoming Vulnerability for Competitive Advantage." An international expert in supply chain management, Sheffi recently turned his attention to resilience in engineering education at MIT and its impact on U.S. competitiveness.

"Southeast Asia produces 10 times more engineers annually than the U.S., many comparable to our highest quality professionals. If MIT and other U.S. schools continue to generate a large number of 'traditional' engineers, trained for a manufacturing economy, then engineering will become a commodity," Sheffi warned a standing-room-only audience at the sixth annual Charles L. Miller lecture.

Co-sponsored by MIT's Engineering Systems Division (ESD) and the Department of Civil and Environmental Engineering (CEE), the series is named for Miller, who was MIT CEE department head from 1962 to 1969. Miller died in 2000.

Sheffi, professor of engineering systems and civil and environmental engineering and director of the MIT Center for Transportation and Logistics, referenced recent reports by the National Academy of Science and the National Academy of Engineering to build his argument for how to address the "Sputnik challenge" of the 21st century. He identified the current challenge as the design and operation of complex systems aimed at health care provision, education, security and energy independence.

He said the important challenge is to educate engineers who can go beyond designing complicated technical systems (such as airplanes). They need to be able to design complex systems of which new technologies are part (like air transportation systems), where technology intertwines with environmental, political, economic, managerial and other systems. These engineers will lead complex systems design, whose objectives include flexibility, compatibility and safety.

Sheffi advocated a two-pronged approach for MIT: continuing to educate world-class technical experts—the geeks—to be practicing engineers who design complicated systems, while preparing world-class leaders—the chiefs—to design complex systems.

The new curriculum may include engineering and social science classes taught jointly by the School of Engineering (SOE) and the School of Humanities, Arts, and Social Sciences; engineering courses with embedded managerial concepts and case studies taught by SOE and the Sloan School of Management; mandatory studies abroad; and a leadership curriculum. (He referenced the leadership course offered by ESD's logistics program as an example.)

Sheffi acknowledged the many hurdles to implementing a new curriculum alongside "MIT Classic"; he asserted, however, that MIT presently has an unprecedented opportunity. A new president, new senior administration and new incoming deans may provide the opportunity for profound changes.

In concluding the event, ESD Professor Daniel Roos called on the audience to "work together to ensure that this issue gets exposure—and action—within MIT now."

NMR

Continued from Page 5

little bit of the magnetic field leaks out of the line, creating a uniform, concentrated magnetic field. That field allows the slot to be used as an NMR probe, in place of a coil.

The detector described in the PNAS paper is a plastic card about one-third the size of a credit card and is easy and inexpensive to produce. To get structural information, the new detector must still be placed in a massive machine housing a superconducting magnet, just as the coil probes are. However, the MIT researchers anticipate that the microslot's small sample volume will allow much smaller tabletop spectrometers to be developed.

Zhang said such NMR devices could prove especially valuable in diagnosing diseases caused by misfolded proteins, such as Alzheimer's and Huntington's, or prion diseases like Cruetzfeld-Jakob disease. It could also allow early detection of glaucoma and cataracts, which could be diagnosed by testing a single teardrop. "You could detect it so early it will become treatable," Zhang said.

The new technology could dramatically improve the rate of biomedical research, because it can take up to a year to obtain enough material for an NMR study using the coil probes, said co-author Professor Neil Gershenfeld, director of MIT's Center for Bits and Atoms. That is "a major limiting step in drug discovery and studying biological pathways," he said.

The probes could also be used to make portable devices for diagnostics or soil analysis. And because the smaller devices are cheaper to make, they should be affordable even in developing countries where NMR machines are now rare, said Zhang.

Asking big questions

Maguire got the idea for the project after talking to Zhang and asking him what kind of new device would make the biggest impact in biology. For Zhang, the answer was immediate: improving NMR.

Elucidating structure is critically important for biologists because structure determines function, said Zhang. The goal for the project was to create an NMR detector sensitive enough to detect structural information using the amount of protein in a spot on a two-dimensional gel used for electrophoresis (about 10^{14} molecules).

The task was daunting. "Nobody in their right mind would try to take one spot from that gel and get a molecular structure from it," said Zhang.

However, Zhang said that he believes in the sentiment expressed by Francis Crick, the legendary biologist who determined the double helix structure of DNA along with James Watson: You need to ask big questions in order to get big answers.

Zhang adds that the project probably never would have happened without interdisciplinary collaboration: "Biologists would never have thought of this type of machine, but a physicist would never have asked the question," he said.

Before starting this project, Maguire and Gershenfeld, with co-author Isaac Chuang, had already used NMR to create early quantum computers. Their effort to improve the computing capabilities turned out to be surprisingly relevant to detecting molecular structures, an "unexpected spin-off," said Gershenfeld.

"We were not at all thinking about biology, but this turned out to be exactly what was needed to improve biological sensitivity," Gershenfeld said.

The research was funded by the National Science Foundation.

Materials science contest starts

The Department of Materials Science and Engineering (DMSE) launched the MIT and Dow Materials Engineering Contest (MADMEC), co-sponsored by Dow Chemical Company and DMSE. The theme of MADMEC's first year is alternative energy: The contest invites groups of students to design and build devices that harness, store or exploit sources of alternative energy through principles of materials science. The top three teams will win $5,000, $3,000 and $2,000 prizes. Proposals for entry in MADMEC are due May 18. Semifinals are scheduled for Aug. 8, and the MADMEC finals will be held on Sept. 25.

For more information, go to dmse.mit.edu/madmec.

TECHNOLOGY

Continued from Page 3

quent visit that locals had improved the design and were teaching it to other communities.

However, such innovations, Smith insisted, do not eliminate the need for governments to provide clean water. Why, she asked, should those who make $1 to $2 a day be required to purify their own water? The water purification bags are, she acknowledged, a "transition technology."

Smith also overturned the old saw about "teaching a man to fish" by adding these caveats: "Unless there's no river nearby"; "Until the fishing pole breaks"; and "Maybe you should ask if he likes fish."