

[HOME](#)

[HELP](#)

LOVE NOTES
Valentine's Message Page - \$3.50 per line
Write your ad online to run February 14 in

HEALTH | SCIENCE

E-mail to a friend
See what stories users are sending to friends

Archives

Sections

- PAGE ONE**
- NATION | WORLD**
- CITY | REGION**
- BUSINESS**
- SPORTS**
- LIVING | ARTS**
- EDITORIALS | OP-ED**

- Weekly**
- Health | Science (Tue.)
 - Food (Wed.)
 - Calendar (Thu.)
 - Life at Home (Thu.)

- Sunday**
- Automotive
 - Focus
 - Learning Magazine
 - New England
 - Real Estate
 - Travel

- Local news**
- City Weekly
 - South Weekly
 - Globe West
 - North Weekly
 - NorthWest Weekly
 - NH Weekly

- Features**
- Globe archives
 - Book Reviews
 - Book Swap
 - Columns
 - Comics
 - Crossword
 - Horoscopes
 - Death Notices
 - Lottery
 - Movie Reviews
 - Music Reviews
 - Obituaries
 - Special Reports
 - Today's stories A-Z
 - TV & Radio
 - Weather

[Send this story to a friend | Easy-print version]

The unbearable lightness of being - stopped

By David L. Chandler, Globe Staff, 2/6/2001

CAMBRIDGE - Danish-born physicist Lene Hau just seems to have no respect at all for light.



Physicist Lene Hau (center) observes gases flowing through light-stopping equipment at the Rowland Institute in Cambridge with colleagues (from left) Chien Liu, Cyrus Behroozi, Zachary Dutton, Michael Budde and Christopher Slowe. (Globe Staff Photo / John Tlumacki)

Stopping light in its tracks

According to conventional wisdom, light always travels at 186,000 miles per second. But, in separate experiments, two teams of Cambridge physicists were able to stop laser pulses dead in their tracks, and to start them up again on cue.

done is to push this natural slowdown to a very unnatural extreme. In Hau's case, by producing a tiny, dense cloud of sodium atoms that have been chilled to an astonishing one-millionth of a degree above absolute zero, and by using a specially-tuned laser beam to get these atoms into just the right state, she has been able to get a light beam passing through that cloud to move slower and slower. In 1999, she got it down to a pace slower than the bicycle riders along the Charles River just outside the lab's windows. She refers to the light-slowng cloud of gas inside her laboratory apparatus as "optical molasses."

She teases it, manipulates it and commands it at will to do things that no self-respecting light beam would ever do on its own. Now she's even taught it to play dead.

Last month in the respected international journal Nature, Hau and her colleagues at the Rowland Institute in Cambridge reported that they had succeeded in making a pulse of laser light slow down to a dead stop. Then, after a relatively long interval - about a thousandth of a second - they made it start up again, just as if nothing at all had happened.

Now, you may remember from physics class that the speed of light is supposed to be the most constant, unvarying quantity in the universe. You even might have seen bumper stickers and T-shirts with the catchy slogan: "186,000 miles per second: It's not just a good idea, it's the law!"

That's OK, don't panic. Hau and her crew, along with a separate team at Harvard that has been doing similar experiments, may be taking liberties with light, but they're not breaking any laws.

Light does in fact slow down, even under normal circumstances. The absolute, unvarying speed only applies when light is traveling through a vacuum, such as the vast reaches of interstellar space. As soon as it starts traveling through something - air, water, glass or anything else transparent enough to let it through - light slows down. But just by a tiny little bit.

What Hau and the other team, based at the Harvard-Smithsonian Center for Astrophysics, have



Come home to
YOURTOWN

Classifieds

Autos
BostonWorks
Real Estate
Place an Ad

In essence, what happens is that the photons, or particles of light, which have no mass at all, become so tightly entangled with the atoms in the gas cloud that the mass of the atoms begins to slow down the light, sort of like the proverbial ball-and-chain being dragged along. The more tightly coupled the light becomes with the atoms, the slower it moves.

And then comes the almost magical conclusion. Rather like the moment when a magician whips away the curtain to reveal that her assistant has vanished from a locked glass booth, Hau then turns off the laser beam that made it possible for the light to enter the normally-opaque cloud of atoms. Suddenly, amazingly, the light slows down to an absolute stop - and, in the darkened lab, dims to total darkness. The beam has simply vanished; it was not absorbed by the atoms, because this would be clearly revealed as a measurable heating of the cloud by the light's released energy. It's just gone.

And when the beam is switched back on, the light pulse reappears - exactly the same as it was originally. As it exits the tiny cloud of atoms, it resumes its normal speed, intensity, and even polarization (roughly speaking, the direction of the light waves' vibration) and goes on its way. The magician's assistant has reappeared - unchanged, unharmed and still smiling.

But stopping light is more than just a parlor trick. A number of scientists are looking for ways to control the speed of light and to stop and start it at will, which could be extremely useful in designing the computers of the future. At virtually the same time as Hau's breakthrough, the Harvard-Smithsonian team accomplished exactly the same feat using a slight variation on her method. That team published its results last week in the journal *Physical Review Letters*.

A handful of other physicists around the world, including some at Stanford University and the University of Colorado, have worked on similar techniques, and a group at Texas A&M University hopes to go one better by not just stopping light, but then reversing its direction. But, so far, only these two teams have succeeded in bringing light to an absolute stop. For the moment, Cambridge can safely be regarded as the light-stopping capital of the world.)

In fact, Hau's work on cold atoms is a direct outgrowth of research at both MIT and the University of Colorado on creating an ultracold state of matter - something called a Bose-Einstein Condensate, in which a cloud of atoms is chilled to a point so close to absolute zero that they become, for all practical purposes, a single superatom.

Hau became intrigued by the optical properties of such exotic forms of matter, and continued to refine the techniques to chill the clumps of atoms. As she shows off the relatively simple devices that produce this chilled cloud, she marvels that "you can have the coldest place in the universe in your lab, and everything around it is at room temperature."

And because the cooling is achieved through special techniques involving laser manipulation of atoms rather than heavy insulation, and the atoms are suspended in a magnetic field so they never contact the chamber's walls, the chilled cloud can be clearly viewed through glass windows in the tiny chamber. "We can stick a magnet in and make the ultracold atoms dance," Hau said. "Then we send a laser beam in, and we can probe and massage these atoms with this beam." And because the light in the cell becomes "entangled" with the atoms, controlling the atoms makes it possible to control the light. "We can trick this light pulse," Hau said.

But, it turns out, supercold atoms are not the only way to accomplish this amazing trick. The Harvard-Smithsonian group achieved exactly the same feat using a cloud of atoms - in this case, atoms of the element rubidium - that are as warm as a fresh cup of coffee.

The key common element, it turns out, is that the atoms have to be held very still. Rather than extreme cold, the Harvard-Smithsonian group used a dense "packing" of the inert gas helium to surround the rubidium atoms that do the work, in effect holding them in place rather like the Styrofoam peanuts in a shipping carton.

"The fact that it can be done in cold gas and in warm gas speaks to the ubiquity of the phenomenon," said Ron Walsworth, a member of the Harvard-Smithsonian team. Because the same results can be achieved in such different systems, he said, it is likely that other groups will soon produce similar results. Eventually, someone will come up with a version of the experiment that can be carried out inside a solid-state chip, both teams said, opening the possibility for a host of practical applications inside advanced computers of the future.

"There might be this very interesting application to linking quantum computers together," said Mikhail Lukin of the Harvard-Smithsonian team, whose paper last year with team members Susanne Yelin and Michael Fleischauer laid the theoretical foundation for the group's recent results.

Most reports about the new work have focused on its potential application for quantum computers, but so far nobody in the world has the slightest idea of how a quantum computer could ever be built or what it would look like. But, theoretically, such machines could carry out some very complex computations that are virtually impossible for today's computers.

In concept, quantum computers could tackle problems that involve trying out vast numbers of different possibilities at once - for example, cracking the toughest encryption systems now in use for secure data transmission. Rather than storing data in the form of "bits" that can have one of



Buy a Globe photo

Help

E-mail addresses
Send us feedback

Alternative views

Low-graphics version
Acrobat version (.pdf)

Search the Globe:

Today
 Yesterday

two possible values - either 0 or 1 - quantum computers, in theory, could superimpose millions of different possibilities in a single "quantum bit," or q-bit.

But, at the moment, Yelin said, quantum computers are just an idea that has not been shown to be possible: "If you had all the money in the world, could you build it? The answer is no."

Walsworth said, however, that the two Cambridge teams' results might one day be compared to the Wright brothers' first flight, referring to the rickety contraption flown at Kitty Hawk that began the long process toward putting men on the moon.

And though the physicists involved are still largely focused on the basic science, the distant hope of quantum computers is not the only possible application. Much sooner than that, perhaps in years rather than decades, it might lead to devices for controlling beams of light in fiber-optic cables that form the basis for much of the world's telecommunications, and for the super-high-speed Internet of the future.

Hau said the ability to stop light also might produce new insights in basic physics. "When you can manipulate nature to this extent, it's absolutely fascinating. We expect to find new effects, new physics, new applications."

This story ran on page C01 of the Boston Globe on 2/6/2001.
© Copyright 2001 Globe Newspaper Company.

[[Send this story to a friend](#) | [Easy-print version](#)]



A horizontal advertisement banner. On the left is a red ribbon tied in a bow. To the right, the text "LOVE NOTES" is in large, bold, black serif font. Below it, in smaller black font, is "Valentine's Message Page - \$3.50 per line" and "Write your ad online to run February 14 in". On the far right is a small logo for "The Boston Globe" in a white box with a black border.

© Copyright 2001 Globe Newspaper Company

The Boston Globe
EXTRAnet
Extending our newspaper services to the web

[Return to the home page of The Globe Online](#)