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Wizardry at Harvard: Physicists Move Light

By KENNETH CHANG

It's like three-card monte. Now you see it. Now you don't. Then you see it — over there.

In a quantum mechanical sleight of hand, Harvard physicists have shown that they can not only bring a pulse of light, the fleetest of nature's particles, to a complete halt, but also resuscitate the light at a different location and let it continue on its way.

That ability to catch, store, move and release light could be used in future computers to process information encoded in the light pulses.

"It's been a wonderful problem to try to wrap your brain around," said Lene Vestergaard Hau, a professor of physics at Harvard and senior author of a paper describing the experiment that appears today in the journal Nature. "There are so many doors that open up."

In 1999, Dr. Hau headed a team of scientists that slowed light, which travels a brisk 186,282 miles a second when unimpeded, to a leisurely 38 miles an hour by shining it into an exotic, ultracooled cloud of sodium atoms. At temperatures a fraction of a degree above absolute zero, the atoms coalesce into a single quantum mechanical entity known as a Bose-Einstein condensate. Shining a laser on the cloud tunes its optical properties so that it becomes molasses when a second light pulse enters it.

Then, in 2001, Dr. Hau and a second team of physicists, this one from the Harvard-Smithsonian Center for Astrophysics, brought light to a complete halt by slowly turning off the laser. The Bose-Einstein cloud turned opaque, trapping the light pulse inside. When the laser was turned back on, the trapped light pulse flew out.

The latest results add an additional twist: transporting the pulse to a second Bose-Einstein cloud and regenerating the light there. "That's the sort of stuff we find really sexy in this business," said Eric A. Cornell, a senior scientist at the National Institute of Standards and Technology.

In the new Harvard experiment, when the initial pulse slammed into the first Bose-Einstein cloud, the collision caused 50,000 to 100,000 of the sodium atoms to start spinning, almost like small tops, and pushed this small clump forward at less than a mile an hour.

Dr. Hau described the clump of atoms as a "metacopy" of the light pulse. Although it consisted of sodium atoms instead of particles of light, it exactly captured the characteristics of the light pulse.

The clump floated out from the rest of the cloud, traveled about two-tenths of a millimeter and burrowed into a second Bose-Einstein cloud. When a laser was shined on the second cloud, the atom clump transformed into a new pulse of light identical to the original pulse.

It was refinements to the 2001 experimental technique that extended the time the particles maintain quantum collective behavior. This allowed the clump to reach the second cloud.

Transforming a light signal into a clump of atoms could be a way of storing information. (“You could put it on the shelf for a while,” Dr. Hau said.) It could also enable a way of performing calculations in future optical computers that employ quantum algorithms to speed through certain types of calculations.

But one hurdle to building a computer that calculates with light is that it is difficult to grab onto and manipulate a quick-moving light pulse. Performing calculations with atomic clumps would be much easier with the result changed back into light and then sped to the next step.

“That has been a missing link,” Dr. Hau said.

The advance could also find applications in quantum cryptography, which can hide messages in codes that cannot be broken.

Dr. Hau said the current apparatus was just a proof of the concept and far from anything that could be used practically for any applications.

But that has not stopped other physicists from starting to ponder what the applications might be, just as her earlier experiments have spurred physicists and engineers in a new active field of research, looking for ways to harness slow light for use in optical networks.

Currently, optical signals need to be changed into electronic ones for processing and then changed back into light. All-optical devices could save on costs and power use.