Light stopped for a minute

DARMSTADT, Germany — At 186,000 miles per second, the speed of light is unparalleled, so slowing it down is a formidable challenge — and stopping it seems impossible. But physicists in Germany report using a glasslike crystal to stop light for about one minute, which could have important implications for light-based data processing.

Thomas Häffmann and colleagues at the Institute of Applied Physics at the Technical University Darmstadt achieved the record by combining various known methods. In addition to stopping light, they also stored images transferred by the light pulse into a crystal for the duration of a minute — a million times longer than previously possible.

Over the past decade, researchers have reported short stop times for simple light pulses in extremely cold gases using special crystals. The Darmstadt researchers used a glasslike crystal containing a low concentration of praseodymium ions in a setup that also included two laser beams.

The first (control) beam changes the optical properties of the crystal so that when the second beam comes into contact with the crystal and the first light beam, it decelerates. When the physicists switched off the first beam precisely when the second beam was within the crystal, the decelerated beam came to a stop. The team was able to store a simple image of three striped lines within the crystal. The information was read out by turning the control laser beam on again. How well the system works depends strongly on the parameters of the driving optical fields, magnetic fields and the high-frequency pulses, the researchers said. Computer algorithms optimized these factors so that the light wave formed by freezing the beam could survive inside the crystal for as long as possible.

They now intend to explore techniques that can store light significantly longer — perhaps for a week — and to achieve a higher bandwidth and data transfer rate for efficient information storage via stopped light. The work appears in Physical Review Letters (doi: 10.1103/physrevlett.111.033601).

Control made random lasers useful

VIENNA — Random lasers, with their very irregular angular emission pattern, are difficult to tune. But a team at Vienna University of Technology has theoretically shown that random lasers can be controlled by actively shaping the spatial pump distribution, giving these exotic light sources the potential to become useful.

Governed by random scattering, the light emitted by a random laser is as unique as a fingerprint; only recently have the mechanisms behind random lasing been understood.

In a conventional laser, light is reflected back and forth between two mirrors, amplifying it until a laser beam is formed that exits on one of the two sides. But a random laser “works without any mirrors,” said professor Stefan Rotter of the Institute of Theoretical Physics at TU Vienna. “It consists of a granular material in which light is randomly scattered and forced onto complicated paths.” The light is amplified along these paths; the position at which it eventually exits the laser depends on the randomly formed inner structure of the laser material.

“The essential point is the way in which the random laser is pumped,” Rotter said. “Our idea is to pump the laser not uniformly, but rather with a specific pattern, which is optimized such as to generate exactly the laser beam we want.”

The pumping pattern selectively stimulates certain regions of the random laser, which cooperatively produce light emission in a well-defined direction. The team used extensive computer simulations to determine the right pumping pattern for the desired laser beam. “We start with a randomly generated initial pumping pattern and calculate the resulting laser emission. The pumping pattern is then adjusted step by step until the laser sends out light in exactly the desired direction,” Rotter said.

Because all random lasers are different, this optimization process must be carried out individually for each device — but once the solution is known, the same laser beam can be created again and again. In principle, the laser beam could also be steered from a given direction to any other direction by changing the pumping pattern.

On-chip squeezed light could improve sensors

PASADENA, Calif. — A microchip-based way to create squeezed light could assist a range of precision measurements and provide a viable route toward real-world on-chip sensor applications and technology.

Monitoring a mechanical object’s motion, even with a touch as gentle as that of light, fundamentally alters its dynamics. Squeezed light, with its quantum fluctuations below that of the vacuum field, was proposed nearly three decades ago as a way of overcoming the standard quantum limits in precision force measurements.

Squeezed light was recently generated in a system of ultracold gas-phase atoms, engineered at the California Institute of Technology (Caltech); the system is a solid-state, optomechanical system fabricated from a silicon microchip and composed of a microcantilever resonator coupled to a nanoprecise cavity.

“We work with a material that’s very plain in terms of its optical properties,” said graduate student Amir Safavi-Naeini. “We make it special by engineering or punching holes into it, making these mechanical structures that respond to light in a very novel way.”

A waveguide feeds laser light into a cavity created by two tiny silicon beams in the new system. Once there, the light bounces back and forth because of the engineered holes, which in effect turn the beams into mirrors that vibrate when photons strike them. The particular nature of the light introduces quantum fluctuations that affect those vibrations.

“Typically, such fluctuations mean that, to get a good signal reading, you would have to increase the power of the light to overcome the noise. But increasing power introduces other problems, such as excess heat. In the new system, the light beams interact strongly with each other — so strongly that the beams impart the quantum fluctuations they experience back on the light. In the experiment, a detector measuring the noise in the light as a function of frequency showed that in a range centered around 20 MHz, the system produces