Liquid Crystals Slow Light Pulses to a Snail's Pace

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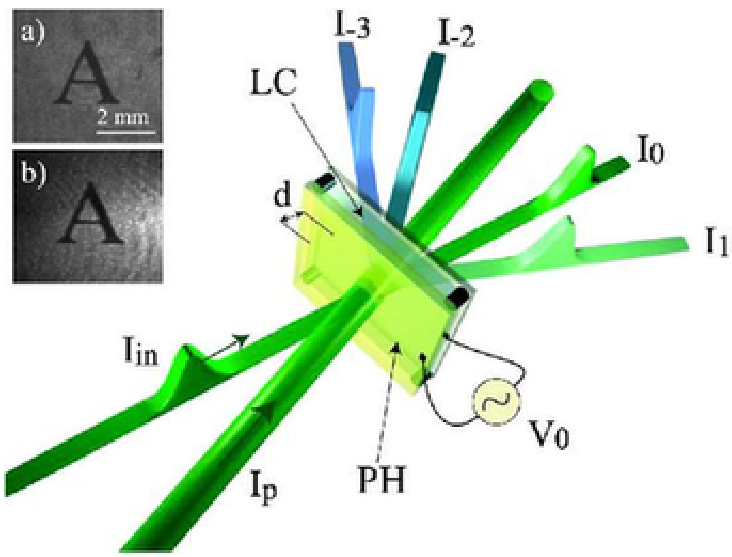

When a weak intensity and high intensity beam are aimed at a liquid crystal valve, the output pulse is split into different diffracted pulses, each showing a different group velocity. The images at left demonstrate image delay: image (a) is an original image imposed on the input pulse, and image (b) is the image from an output pulse delayed by several milliseconds. Credit: S. Residori, et al.

In a vacuum, the speed of a light pulse is always a constant at 186,000 miles (300,000 km) per second. But by changing the medium through which light travels, physicists can slow down light pulses, and possibly create highly sensitive light interferometers, among other devices.

Over the past decade, researchers have demonstrated several methods that can slow light, such as using ultracold atoms, silicon waveguides, or the quantum coherence effect. But now, for the first time, researchers have shown that liquid crystals can also slow light, and can provide group velocities of less than 0.2 millimeters per second – the slowest so far achieved.

The study, performed by physicists Stefania Residori and Umberto Bortolozzo of the Institut Non Lineaire de Nice, and Jean-Pierre Huignard of Thales Research and Technology, both in France, appears in a recent issue of *Physical Review Letters*.

The key to liquid crystals' ability to slow light is the large dispersion properties associated with two-photon wave mixing. When the researchers aimed two beams – one with weak intensity and one with higher intensity – at a liquid crystal valve, the liquid crystal acted like a hologram and split the beam into several beams that went off in different directions. Each of these diffracted beams had a different delay or no delay at all, depending on the direction of their path within the liquid crystal.

"The main point is that slowing down optical pulses is equivalent to making the pulses travel inside a medium that has a very large refractive group index," Residori explained to PhysOrg.com. "Thus, even though the light pulse travels over a small distance, its effective path becomes very large. Since the precision of an interferometer is given by the difference of the optical path between the two arms, then by inserting the slow light device on one arm, it will be possible to reach unprecedented sensitivity."

The researchers also used the technique to demonstrate image delay. They imposed a 1-cm^2 image on the low-intensity beam for a pulse duration of 180 milliseconds, and illuminated the image with the high-intensity beam. The output beams showed that the image was delayed by

82 milliseconds as it traveled through the liquid crystal. The image, which had a spatial resolution of 15 micrometers, appeared without any significant distortion due to the crystal's homogeneity.

The ability to achieve both fast and slow light in a single device could have many optical uses. As the researchers explained, there is an optimum trade-off between amplifying the slow light pulses and reducing the intensity of the fast light pulses to achieve a good balance. In addition to optical communication networks, ultraslow group velocities could be useful for greatly increasing the sensitivity of light interferometers, testing fundamental laws of physics, and for precision metrology measurements.

"Liquid crystal technology is very well developed and liquid crystal devices could be easily commercialized," Residori explained as some advantages of the technique. "Moreover, the device is very compact and of small size (20x20x1 mm), and the experimental apparatus is relatively simple compared to other techniques."

More information: Residori, S.; Bortolozzo, U.; and Huignard, J. P. "Slow and Fast Light in Liquid Crystal Light Valves." *Physical Review Letters* 100, 203603 (2008).