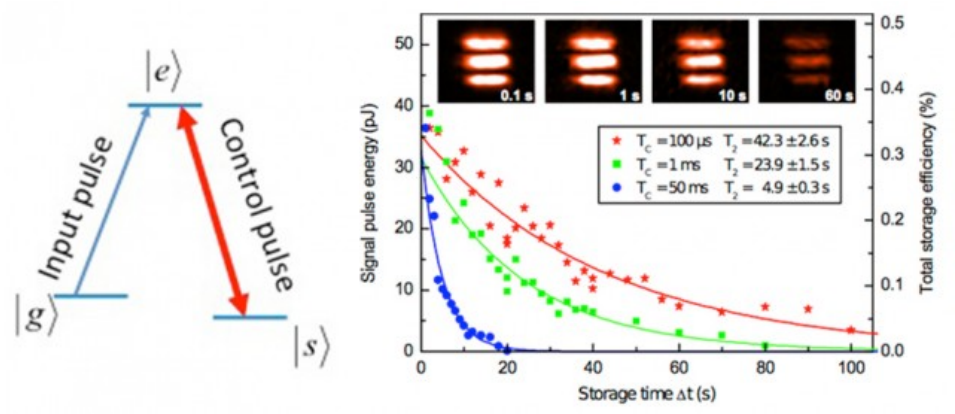
Light stopped completely for a minute inside a crystal: The basis of quantum memory

By Sebastian Anthony on July 25, 2013 at 6:49 am | 9 Comments

Scientists at the University of Darmstadt in Germany have stopped light for one minute. For one whole minute, light, which is usually the fastest thing in the known universe and travels at 300 million meters per second, was stopped dead still inside a crystal. This effectively creates *light memory*, where the image being carried by the light is stored in crystals. Beyond being utterly cool, this breakthrough could lead to the creation of long-range quantum networks — and perhaps, tantalizingly, this research might also give us some clues on accelerating light beyond the universal speed limit.

Back in 1999, scientists slowed light down to just 17 meters per second, and then two years later the same research group stopped light entirely — but only for a few fractions of a second. Earlier this year, the Georgia Institute of Technology stopped light for 16 seconds — and now, the University of Darmstadt has stopped light for a whole minute.

To stop light, the German researchers use a technique called electromagnetically induced transparency (EIT). They start with a cryogenically cooled opaque crystal of yttrium silicate doped with praseodymium. (The image above is unrelated; sadly there isn't an image of the actual crystal that was used to stop light.) A control laser is fired at the crystal, triggering a complex quantum-level reaction that turns it transparent. A second light source (the data/image source) is then beamed into the now-transparent crystal. The control laser is then turned off, turning the crystal opaque. Not only does this leave the light trapped inside, but the opacity means that the light inside can no longer bounce around — the light, in a word, has been stopped. (Read: IBM creates first cheap, commercially viable, electronic-photonic integrated chip.)



With nowhere to go, the energy from the photons is picked up by atoms within the crystal, and the "data" carried by the photons is converted into atomic spin excitations. To get the light back out of the crystal, the control laser is turned back on, and the spin excitations are emitted at photons. These atomic spins can maintain coherence (data integrity) for around a minute, after which the light pulse/image fizzles. In essence, this entire setup allows the storage and retrieval of data from light memory (or should that be optical memory?)

In the image above, you can see that the scientists successfully stored a simple image (three horizontal lines) in the crystal for 60 seconds. It should be possible to store data for longer periods, too, using other crystals — such as europium-doped yttrium silicate — and by using specially tailored magnetic fields. (Read: The first quantum entanglement of photons through space and time.)

Light-based memory that preserves quantum coherence (such as polarization and entanglement) is vital for the creation of a long-range quantum network. Just as with conventional, electronic routers, quantum routers must be able to store incoming packets, and then retransmit them — which is exactly what today's discovery allows. Even so, though, there are still a few barriers to overcome before we can roll out a quantum internet — namely, we must find a method of coherently storing light that introduces so little noise that single photons can still be reliably stored/retrieved, and we need to do it at room temperature, too. Cryogenics might be acceptable at the data center level, but I can't imagine having a cryogenically cooled router in my house.

Now read: DARPA creates hollow-core optical fiber for faster networks, more accurate sensors

Research paper: DOI: 10.1103/PhysRevLett.111.033601 – "Stopped Light and Image Storage by Electromagnetically Induced Transparency up to the Regime of One Minute"

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Guest · a day ago

Cool. And I'm not just saying that because it was 4:20 pm somewhere in the world not too long ago.

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Sipho Mfungi · a day ago

But have you actually stopped the light, or merely trapped photons in some atoms to be released later?

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convolution ↗ Sipho Mfungi · 15 hours ago

Is that the same thing? If we treat light as particles, if we make it's velocity 0, then we have essentially "stopped light". From what I've read, it seems like the photons gets trapped in the crystal and comes to a crashing halt, wherein the kinetic energy would be transferred to the surrounding crystal atoms.

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James Riendeau ↗ Sipho Mfungi · 10 hours ago

I gave up trying to argue physics long ago, but I had the same idea. It reads more like a localized energy transfer than a dead stopping of photons, with the cooling needed to minimize energy dissipation due to increased atomic jiggle.

1 | Reply Share ›

ac1dra1n · 15 hours ago

This had me hooked at the opaque/transparent part

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Dustymack · 15 hours ago

I see some use from this for solar panels.

3 | Reply Share ›

surya rao akella ↗ Dustymack · 10 hours ago

Yes, there is a great scope not only in solar panels but also in many other fields including space travel and if research continues, it could be used as alternate lighting source.

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Tanooj Shah · 13 hours ago

All they're doing is storing the information contained in a light beam for a minute. This is a very sensationalized title.

| 1 Reply Share ›

Qprime · 11 hours ago

great, now we dont have to see ugly people anymore!!

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