Light comes to a stand still in a solid crystal

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Following the successful slowing of light in an atomic cloud last year, a research team has brought light to a stop inside a solid medium.

Professor Selim Shahriar carried out the work at the Massachusetts Institute of Technology with colleagues at Texas A&M University, the US Air Force Research Laboratory and the Electronics and Telecommunications Research Institute in Daejon, South Korea.

The team used an yttrium silicate crystal doped with the rare earth element praseodymium (Pr). The introduction of Pr ions into the lattice structure creates very sharp shifts in the index of refraction at different light wavelengths. At certain frequencies, the light speed is effectively reduced to zero.

Prof Shahriar said: "The Pr ions have an energy level structure that can absorb light at two different frequencies simultaneously.

"The light to be stored is at one of these frequencies. A strong pulse at the other frequency is used to transfer the information from the stored pulse to the Pr ions. Each Pr ion is magnetised in the process, and the magnetisation is patterned in a way so that the process can be reversed to recreate the pulse that was stored."

The second light frequency acts as the coupling medium. One pulse can lock light within the crystal structure, another releases it. The light energy is stored within the ions by raising the orbiting electrons' quantum energy states.

Storing light in a solid medium is a significant advance towards the development of quantum computers with photons acting as information bits. Compared with an atomic cloud, a solid crystal offers major practical advantages.

But there are many problems: storing information in this form is one challenge; processing it is another altogether.

"There are several possible ways to perform quantum processing of the information held via the photon storage process," said Prof Shahriar. "All are potentially challenging and we are working on deciding which would work best."

Another potential application is acoustic coupling, where the light is slowed to a speed comparable to that of sound. A team at Texas A&M is exploring the potential of this effect using a fibre doped with Pr.