Large interaction between two light pulses traveling at equally slow velocities

Barry C. Sanders (e-mail: bsanders@qis.ucalgary.ca, phone: +1 403 560 8288)
Zeng-Bin Wang
Karl-Peter Marzlin
Institute for Quantum Information Science (iqis.org) , University of Calgary, Alberta T2N 1N4, Canada

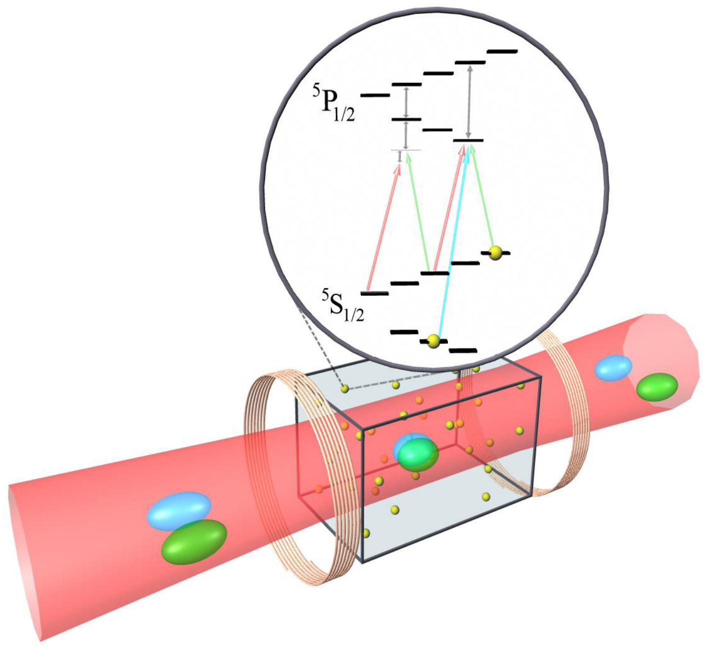
Author Summary of Paper N43.00001
Wednesday, March 15, 2006, 8:00 AM, Baltimore Convention Center 346

One of the best ways to send information is to encode a beam of light and send it through air or through optical fibers. Not just ordinary information, but quantum information can be sent via light beams as well. Quantum information is especially important because it may be used for applications that the non-quantum world can never achieve.

For example, quantum computers can solve some problems that cannot be solved on non-quantum computers, including cracking internet security protocols. On the other hand quantum cryptography provides a level of security that is unobtainable without exploiting the quantum side of nature.

Quantum information with light requires very weak beams, typically at the level of single photons, which are the smallest units of light. Light is especially attractive as a quantum information technology because it is fast, travels a long way intact, and the technology of sources and detectors is so advanced.

But there is a problem: light controlling light is a weak effect. In optical communication, this problem hinders development of optical switches, and much slower electronic switching is usually used instead. Fortunately light can be slowed down by exploiting so-called electromagnetically induced transparency. If we can slow two beams of light down, then their weak interaction is amplified by spending more time together. In this way one beam can significantly delay the other, even if the beams are so weak that each has one photon.



Proposal to generate a large interaction between two weak light pulses (green & blue): a pump laser (red) shone on Rubidium atoms slows the pulses down, and a magnetic field (coils) induces the desired coupling between the two pulses.

Theorists have studied this problem, but so far strong interaction between two weak light beams has not been demonstrated in the laboratory. The light beams have to be slow, travel at almost the same speed, and be feasible in a typical medium.

We have discovered how to meet all the requirements using Rubidium gas as the medium to slow light and make the two beams interact (see figure). This scheme works at the single photon level and will significantly advance progress into overcoming the most important obstacle to quantum information processing, namely the excessively weak interaction between two beams of light.