

Photons are persuaded to stop and take a light siesta

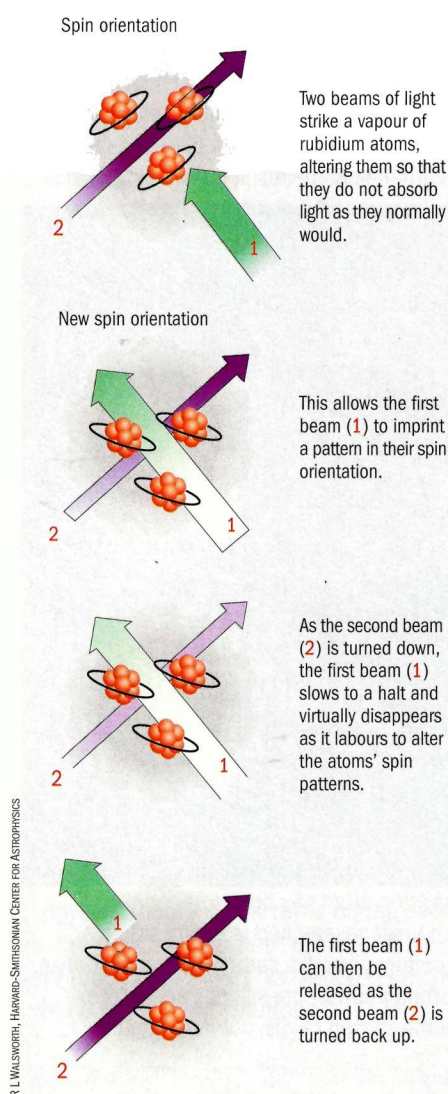
In a groundbreaking feat by two independent research teams (Harvard-Smithsonian and Cambridge), visible photons have been slowed to a dead stop for a period in which they would otherwise have travelled some 200 km.

A cluster of supercooled ($1\ \mu\text{K}$) atoms exploits a phenomenon known as electromagnetically induced transparency. In this cooled ground state, atoms readily absorb light from a probe laser, the frequency of which corresponds to any of its excited energy states, thus becoming opaque at those frequencies. Light in the vapour interacts with atoms changing their spin states coherently and forms an atom-photon system (polariton).

To obtain an unusual quantum superposition of the ground and excited states, another (coupling) laser that is carefully tuned to two hyperfine energy levels in the atom is shot in. The probe laser tuned to the original energy level can no longer be absorbed, thereby stimulating the stopped beam, which emerges with its initial properties intact – opening a new vista for "light storage" and transmission.

This experimental landmark promises a step forward in quantum communication and computation, which in turn could be used to connect ultrafast computers in a large network, comparable to the Internet.

In another development (Kocharavskaya *et al.* 2001 *Phys. Lett.* 22 January) a novel technique for making light not only stop moving, but reverse its direction has been discussed, albeit theoretically. (Phillips *et al.* 2001 *Phys. Rev. Lett.* 29 January.)



Silicon lasers to work with microchips?

Storing zeros with photons? The dream of processing signals encoded with light, so that photonic technology replaces electronics, could revolutionize communications.

Driven by tiny, cheap microlasers integrated into a microchip, the fantasy is drawing closer to becoming reality. The problem is that there is a lack of light emission from silicon.

While microelectronics uses transistors dedicated to silicon components, light-based information processing requires microlasers. Silicon, rather than gallium arsenide (GaAs) lasers are needed, but matching the GaAs crystal lattice to that of silicon to build a miniature laser has turned out to be a challenging and expensive task.

It has been shown that compounds grown on silicon (cerium silicate) glow when stimulated by another laser. Silicon etched into tiny quantum wires emits yellow, green and blue light (depending on the thickness of the wire) when a current passes through it.

A number of groups are contributing to the development of silicon microlasers. An MIT team has created "virtual materials" with exactly the right lattice match and infrared emission using sophisticated computer modelling. An Italian team has fashioned "quantum dots" of silicon that emit red light, and stimulated emission has been observed. At PSI in Switzerland an unconventional quantum cascade laser has been made using polysilanes – silicon and hydrogen polymers with chain-like molecules – thus avoiding the lattice match problem. Meanwhile a team at Queen Mary and Westfield College, London, has succeeded in making a two-layer diode by using two different non-crystalline materials. The first carries current from the silicon base to the infrared light-emitting second layer which is made of molecules with an erbium atom at their core.

Although as yet they are far from being efficient and practical optoelectronics devices, such developments hold promises of a quantum jump for information technology.

Japanese find alternative superconductor

Magnesium diboride, a cheap, "off-the-shelf" chemical compound, can be made into a superconductor, according to reports from Japanese researchers. Below a certain critical temperature, superconductors lose their resistance to electrical current flow, but a major limitation is that the elusive superconducting properties only occur either at

extravagantly low temperatures or in complex and expensive materials.

Magnesium diboride becomes superconducting at $-234\ ^\circ\text{C}$ (39K) – much higher than previously observed in relatively simple and readily available compounds. Magnesium diboride may have a bright future as an affordable superconducting compound.



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SQUIDs are multiplexed for low-temperature sensors

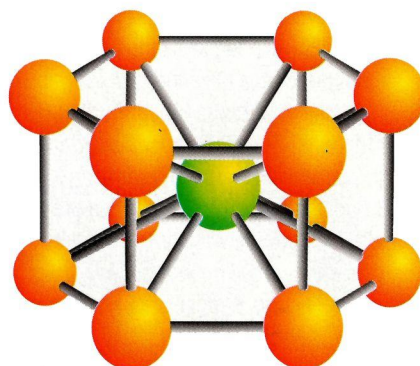
Superconducting quantum interference devices (SQUIDs) have already shown their worth, but a new development suggests a way to link these useful devices together.

Looking for a "cool" sensor? Take a superconducting loop, interrupt it at two points with a thin insulator gap (permitting electron "Cooper" pairs to pass through) and maintain a current flow. The result is a working SQUID. Any magnetic flux threading the circuit will cause a voltage increase across the gap, and tiny changes can be detected. Thus a SQUID operates as a flux-to-voltage converter for

measuring magnetic fields, and it can also be used to read small currents.

A SQUID-based multiplexer that can simultaneously interrogate arrays of many such low-temperature sensors has been developed by physicists at UC Berkeley. These find applications in sensors for the detection of ultraviolet light and x-rays. Magnetoencephalography – mapping of the magnetic fields from brain activity – also uses SQUIDs, as do arrays of several thousands of voltage-biased superconducting bolometers, employing tens of multiplexers.

Tungsten is confined in a silicon trap



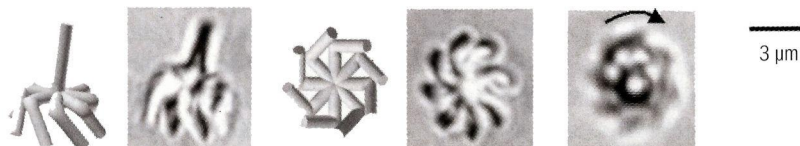
After weaving a web with 12 silicon atoms, a tungsten atom has been trapped by Japanese researchers, forming stable structures just like carbon fullerenes. Unlike carbon atoms, pure silicon cannot form stable, closed cages, but new research

reveals that silicon can gather around a central metal atom and settle into basket-like arrangements called silicon cage clusters.

A particularly low-energy, and therefore stable, configuration consists of 12 silicon atoms forming a regular hexagonal cage that surrounds a tungsten atom. The choice of a central metal atom affects the chemical behaviour of cage clusters, thus enabling the tailoring of the clusters to create novel nanodevices and catalysts.

Clusters efficiently isolate their guest metal atoms from the surrounding environment – a feature that could permit a cluster to act as a dynamic "qubit" in a quantum computer by storing a single bit of information in the spin state of the trapped metal atom. (H Hiura *et al.* 2001 *Phys. Rev. Lett.* 26 February.)

Micromachines – the optical windmill?



Illuminated by a laser beam, a 5 μm wide resin structure, shaped like a propeller, rotates merrily in the optical wind. Micromechanical systems (MEMS) could

one day be powered by tiny rotors like this, which could in turn be used to twist molecules, giving a measure of their mechanical properties.