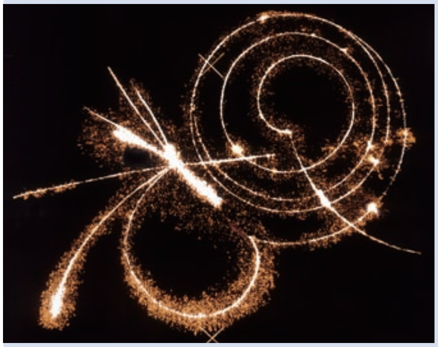
LASER FIELDS

Manipulating muons



CERN

Phys. Rev. Lett. **98,** 251803 (2007)

The decay rate of muons, short-lived subatomic particles that are important to our understanding of the universe, can be tuned by the presence of an intense laser beam, according to researchers from the Institute of Science and Technology of China and the Martin-Luther-Universität Halle-Wittenberg in Germany.

The team investigated the influence of a linearly polarized, monochromatic, spatially homogenous laser field, on the decay of a muon into an electron, a muonic neutrino and an electronic antineutrino. The findings indicate that strong laser-field amplitudes and low frequencies can strongly influence the muon decay rate. As to why this should be the case, momentum-conservation considerations and numerical solutions for the decay rate suggest that the electron is accelerated as it leaves the decay region as if 'swept' away by the laser field, thereby increasing the muon decay rate.

In the presence of a CO_2 laser field with a photon energy of 0.117 eV and field amplitude of 10^6 V cm^{-1}, Jamal Berakdar and co-workers calculated a decrease by an order of magnitude in the muon lifetime. As their calculations are based on a very general framework, the researchers hold the opinion that their results can be extended to all laser fields.

OPTOACOUSTIC IMAGING

Striking gold

Nano Lett. **7,** 1914–1918 (2007)

Laser optoacoustic imaging, a promising and non-invasive technique for cancer detection, could become even more sensitive thanks to research by scientists in the USA. The method works by firing short laser pulses at the area to be imaged. Tissue absorbs this light, rapidly increasing in temperature and generating expansion shock waves, which travel through the surrounding material and can be detected using sensitive microphones. The technique has the advantage over conventional optical imaging that it can detect objects deep within biological tissue.

Scientists have been thinking about how nanotechnology can be used to improve the contrast of the imaging technique. The latest idea is to use gold nanoparticles to target tumours, and Mohammad Eghtedari and co-workers from the University of Texas Medical Branch, the Mayo Clinic College of Medicine in Florida and the University of Michigan have now shown that this is a promising approach. The team took tiny rods of gold, 50 nm by 15 nm in size suspended in a solution, which they injected 1 mm under the skin of a mouse. Illuminating the mouse with a broad laser beam, the researchers could clearly identify a change in the acoustic signal when compared with the same experiment without the nanoparticles. This proof-of-principle raises hopes that this method could soon be important in cancer detection and diagnosis.

PHOTON-NUMBER DETECTORS

Counting photons

Phys. Rev. A **75,** 062325 (2007)

A detector that can measure the number of photons in a very-weak light pulse but doesn't need to be cooled to cryogenic temperatures is the brainchild of researchers at the Massachusetts Institute of Technology in the USA. The approach relies on using optical components to spread the pulse over an array of detectors. Each detector is sensitive enough to detect a single photon, but is not capable of measuring how many photons hit it — it either detects photons or it doesn't. However, if the number of array elements is large enough, in this case 1,024, then it is probable that each photon will hit a different detector, meaning the number of photons in the pulse can be calculated.

The device that Leaf Jiang and colleagues have come up with incorporates a microlens array, where the incoming light is focused onto each of the detector elements, a 2-GHz counter that records the time a given pixel fires and a thermoelectric cooler that reduces the temperature to −27 °C. The result is a compact and practical device. Designed to operate at a wavelength of 1.06 μm, it detects with an efficiency of 33%, although this drops as the number of photons in the pulse increases. Such detectors that can resolve the number of photons are useful for laser radars and in quantum optics and communication.

FIBRE LASERS

Rare success

Opt. Lett. **32,** 1797–1799 (2007)

Fibre lasers with a wavelength around 2 μm that can produce short pulses at a high-repetition rate are needed for applications such as material processing, light detection and ranging for imaging and high-efficiency nonlinear conversion. Unfortunately, current approaches are limited by their bulky design and a tendency for chaotic pulsation. Now, Min Jiang and Parviz Tayebati from Spectrode LLC, USA, have carefully designed a thulium-doped fibre laser to eliminate these problems. Their source is pumped using a laser diode at a wavelength of 1,550 nm, which enables fast gain switching to regulate chaotic spiking. The result is a laser capable of producing stable output pulses with a width of just 10 ns at a maximum repetition rate of 500 kHz. Over a kilowatt of peak power and a slope efficiency of about 50% are also achieved. The researchers claim that, in terms of repetition rate, peak power and pulse width, these are the best results obtained so far from a gain-switched thulium-doped fibre laser, and yet, by optimizing the thulium fibre and the pump source, they are optimistic that further improvements are possible. Work to integrate this fibre laser with a thulium-doped fibre amplifier for optical parametric generation is ongoing.

SILICON CHIPS

Solitons welcome

Opt. Express **15,** 7682–7688 (2007)

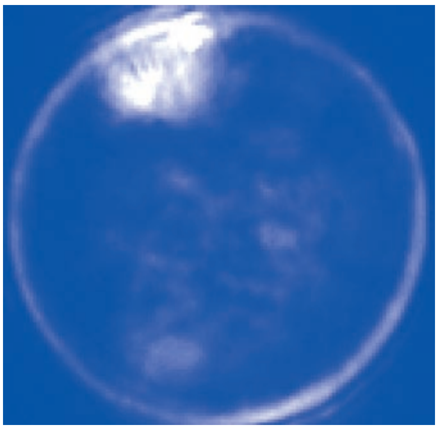
Solitons are optical waves that form as a result of the subtle interplay of nonlinear physics and dispersion effects in the medium through which they travel. Although they have been observed in silica fibres, up to now relatively long fibres have been required owing to silica's weak nonlinearity. Now, scientists working at the University of Rochester in the USA have observed solitons inside a short silicon-on-insulator waveguide for the first time, thanks to careful pulse-launching and waveguide design.

Using photolithography and reactive ion etching, Jidong Zhang and colleagues fabricate a 5-mm-long silicon-on-insulator waveguide. The tight confinement of optical modes in the waveguide introduces a large anomalous dispersion, more than 100 times larger than that of standard silica. Even with such a high dispersion, however, the input pulses still have to be ultrashort — about 115 fs long — to reduce the dispersion length down to the order of a millimetre.

With an input pulse power of just 0.5 pJ, the team generated solitons inside the waveguide and mapped their evolution over several soliton periods. They found that the width of the output spectrum depends on the input wavelength; it narrows when the dispersion is anomalous and broadens when the dispersion is normal. This work shows that soliton-based signal-processing techniques can be transferred to silicon chip-based devices.

RAMAN LASING

Drops of light



Opt. Lett. Doc. ID: 81429 (2007)

It is known that cavity-enhanced Raman scattering can occur in streams of microdroplets. However, the phenomenon is not so easy to achieve in a stationary microdroplet on a surface, owing to the difficulty in optimizing the surface characteristics and maintaining a sufficiently high *Q* factor. Now, however, by placing a glycerol–water droplet on a superhydrophobic surface coated with silica nanoparticles, a team from Koç University in Turkey have demonstrated what they believe is the first Raman lasing from stationary microdroplets. On excitation by a 532-nm Nd:YAG laser, the researchers observe both cavity-enhanced Raman scattering and Raman lasing in a 12.4-μm-diameter droplet. The reported Raman lasing signal is centred at 632.3 nm and is higher than the background by 30 dB. The researchers reveal that the lasing is induced by the large Raman gain of glycerol in the 620–660 nm spectral window. However, they also observe an 'on/off' behaviour, typical of Raman lasing in microdroplets. This phenomenon is attributed to the thermally induced fluctuations during lasing. By increasing the rate of convective cooling, the researchers show that the lasing performance can be improved. The team foresee that the system can be used as a light source for short-haul communications systems.

LASERS

Ultrasmall, ultra-useful

Opt. Express **15,** 7506–7514 (2007)

How tiny can practical lasers get? Very tiny, if the latest work of Japanese researchers is anything to go by. Kengo Nozaki, Shota Kita and Toshihiko Baba have now built a nanoscale photonic-crystal-based laser that can operate at room temperature in a continuous-wave mode.

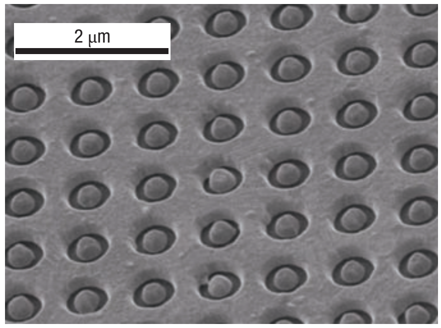
The size of lasers has dropped significantly, and modal volumes are approaching the diffraction limit of light. Smaller lasers offer a number of advantages — a lower lasing threshold, the possibility of integration into optoelectronic devices and the opportunity to exploit various cavity quantum electrodynamic effects.

Scientists have already successfully used photonic crystals to build nanometre-sized lasers. However, until now these photonic-crystal-based devices could only operate in a pulsed mode, because of their high thermal resistance (as high as a million kelvins per watt) and short non-radiative recombination lifetimes (about one nanosecond).

Now Nozaki and colleagues have expanded on previous work to produce a nanolaser with a very low lasing threshold of just 1.2 microwatts and a quality factor of about 20,000. The laser consists of two lattice points shifted in a photonic-crystal slab with a GaInAsP/InP quantum well. Through improvements in the fabrication process of the laser (namely the etching process involved), the lasing threshold has been reduced dramatically, making continuous-wave operation possible. Further studies show that nearly thresholdless lasing is possible even with a cavity that has a relatively low quality factor (about 1,500), which could be useful for applications such as single-photon emission.

EXTRAORDINARY TRANSMISSION

Ring enhancements



Appl. Phys. Lett. **90,** 251107 (2007)

Whether the extraordinary optical transmission of an array of apertures is attributable to surface plasmons (electromagnetic waves that exist at the interface between a metal and a dielectric) or shape and diffractive effects has been the subject of much debate. Now, through the study of coaxial apertures, Shannon Orbons *et al.* have confirmed the role of surface plasmons in transmission enhancement.

Previous investigations into extraordinary transmission have focused on the excitation of planar surface plasmons, which propagate across the surface of the array. Although these plasmons enhance the electromagnetic field at the apertures of the array, the field remains evanescent — confined to within nanometres of the surface. However, it has been predicted that coaxial apertures can support cylindrical surface plasmons, modes that propagate along the cylindrical surfaces of the holes in the array, and these could play a key role in extraordinary transmission.

Using finite-difference time-domain techniques, Orbons and co-workers simulated the transmission of light through an array of submicrometre-sized coaxial rings in a thin metal film, modelling the film first as a perfect conductor and then as silver. The researchers also measured the transmission enhancement experimentally. The measured and simulated results for the silver array showed a transmission peak at wavelengths of 1,659 nm and 1,638 nm respectively, which correspond to the peak at 1,656 nm predicted by theory for a cylindrical surface plasmon.