Lastly, the similaritons were compressed in a single-mode fibre. At the output of the scheme, the team obtained 4.1-nJ, 75.6-fs pedestal-free pulses, with a peak power of 54 kW and a spectral width of 51 nm without any spectral spikes. With higher pump power, the researchers say that a higher peak power, comparable to solid-state lasers, can be achieved. *RW*

OPTOMECHANICS

Beam-splitter Hamiltonian

Phys Rev A **86,** 021801 (2012)

The transition between the quantum world of subatomic particles and atoms and the macroscopic world of everyday objects is a fascinating regime to consider, and can be investigated by transferring quantum states between ultracold atomic systems and mechanical oscillators. Swati Singh and colleagues from the University of Arizona in the United States have now found that under appropriate conditions, some hybrid optomechanical systems are described by an effective beam-splitter Hamiltonian. This is welcome news in the community because the beam-splitter Hamiltonian is a well-understood model for state transfer between systems. The researchers considered an atomic Bose–Einstein condensate trapped inside a Fabry–Pérot cavity with a suspended end mirror. By adiabatically eliminating the dynamics of the optical field within the cavity, they were able to describe the effective Hamiltonian for the coupling between the mirror and the condensate. The coupling arises because the condensate acts as a Bragg mirror as a result of density oscillations induced by the cavity field. Transfers of two different states were simulated under realistic experimental conditions. An exotic Schrödinger cat state was reported to achieve a lower fidelity of overlap than a standard coherent state. This is due to this state's higher susceptibility to the quantum noise of the optical field, which results in a faster decoherence. The authors suggest that by using squeezed quantum fluctuations, the fidelity of overlap could be improved. *SA*

SUPER-RESOLUTION IMAGING

Capturing dynamics

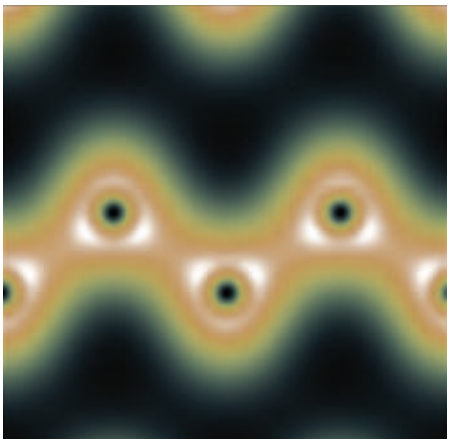
Proc. Natl Acad. Sci. USA **109,** 13978–13983 (2012)

Imaging membranes in live cells with nanoscale resolution helps reveal the structural dynamics of organelles, such as mitochondria, the endoplasmic reticulum and lysosomes. Now, by performing stochastic optical reconstruction microscopy and exploiting small-molecule probes that have high probe densities and which directly bind to membrane structures, Sang-Hee Shim and colleagues from the USA and China have demonstrated dynamic imaging of specific membrane structures in living cells. A 30–60-nm spatial resolution at temporal resolutions down to 1–2 s was achieved. The researchers identified the photoswitching capabilities of eight small-molecule probes commonly used for labelling the plasma membrane, mitochondria, the endoplasmic reticulum or lysosomes and showed that the different spectral properties of the probes allow for multicolour imaging of mitochondria and the endoplasmic reticulum. *RW*

X-RAY OPTICS

Mixing X-rays and light

Nature **488,** 603–609 (2012)

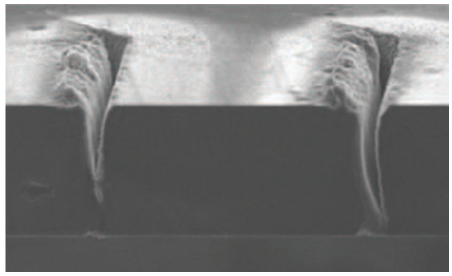


The interactions between light and matter are still poorly understood at the microscopic level, despite being of paramount importance in a wide range of research fields. Proposed over 40 years ago, the mixing of X-rays and optical waves can serve as a probe of light–matter interactions on the atomic scale. Thornton Glover and researchers from the United States and France have now demonstrated X-ray and optical sum-frequency generation in a diamond sample. The process may be interpreted as optically modulated X-ray diffraction. A 2-ps-duration optical pulse is fired at the diamond, redistributing the polarizable charge density in a time-varying manner. The 80-fs X-ray pulses are fired simultaneously and mix with the optical wave in the diamond. Some X-rays interact with the temporally oscillating part of the charge density and are inelastically scattered; the frequency of the optical waves is added to that of these X-rays. Most X-rays, however, are elastically scattered, such that their frequency is unchanged. As in standard X-ray crystallography, this enables a reconstruction of the crystal's charge density. Although this demonstration was performed for one crystal orientation of the diamond only, an extension to different orientations would reveal a three-dimensional charge-density variation. The researchers report that such light-induced measurements of atomic-scale charges and fields will contribute to a better understanding of materials. *SA*

LASER MACHINING

Along a curve

Appl. Phys. Lett. **101,** 071110 (2012)



Laser ablation techniques for fabricating micro- and nanoscale structures on and within a sample are well established. However, machining curved surfaces and trenches can be a challenging task because it requires precise beam steering, sample rotation and translation simultaneously. Now A. Mathis and co-workers from Université de Franche-Comté in France have developed a convenient scheme for making curved profiles in both transparent and opaque materials. Essentially, they exploit the non-diffracting and accelerating characteristics of an Airy beam — a special type of laser beam that possesses a strongly localized intensity lobe and has a propagation trajectory with a curvature transverse to the direction of propagation. They generated the accelerating beams by using a spatial light modulator to apply appropriate spatial phase to 100-fs-duration Gaussian laser pulses from a 5-kHz Ti:sapphire laser operating at a wavelength of 800 nm. The beams were used to make surfaces with curvatures of 70 μm in 50-μm-thick diamond and 120 μm in 100-μm-thick silicon. Curved trenches in silicon were also fabricated. Because different pulse durations can be used to create different structures with different curvatures, the team anticipates a diverse range of applications for the approach. *RW*

Written by Seiji Armstrong, Noriaki Horiuchi, David Pile, Rachel Won and Oliver Graydon.