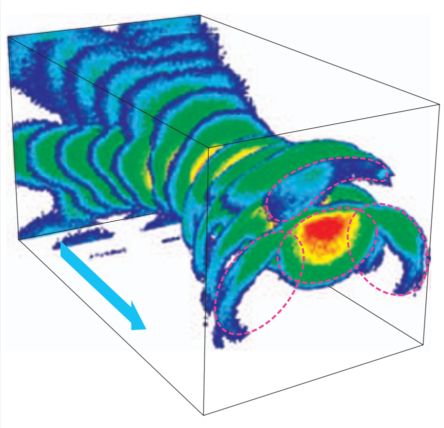
LASER FUSION

Seeking symmetry

The National Ignition Facility — the USA's flagship laser fusion experiment — is getting close to achieving the goal of laser fusion, with its director Mike Dunne predicting that ignition will be reported before the end of 2012. For fusion to take place, however, it is crucial to achieve symmetric compression of the deuterium–tritium fusion fuel, which is a considerable challenge given the demands it places on the timing and spatial control of the 192 incident laser beams.

Now, writing in *Nature Physics* (*Nature Phys.* **8,** 344–349; 2012) a collaboration of scientists from Lawrence Livermore National Laboratory, Los Alamos National Laboratory and the firm General Atomics report a scheme that may be able to help. Their idea is to harness efficient power transfer between multiple laser beams to provide a means of controlling the compression symmetry. Simulations and experiments at the National Ignition Facility show that four-wave mixing in a plasma can change the flow of power between multiple beams, resulting in a much brighter, uniform central beam that propagates deeper into the target (see image).



Inter-beam power transfer occurs because overlapping laser beams generate an interference pattern that creates an electron density modulation in the plasma. This causes a subsequent modulation in the refractive index grating that redirects the flow of incoming laser light from one beam to another. The amount of power transfer between the beams can be controlled simply by changing their respective wavelengths. The team use three tunable wavelengths to create two successive stages of power transfer. In the first stage, power transfer from the outer to the inner beams provides axial symmetry control. In the second stage, power transfer within the inner beams provides azimuthal symmetry control. According to the researchers, the technique could also be used to explore high-intensity physics by combining several beams at the NIF into a single 240 TW pump beam for driving Raman amplification and yielding laser intensities of 10^{22}–10^{23} W cm^{-2}.

OLIVER GRAYDON

NONLINEAR PHOTONICS

Compressing light and sound

Using stimulated Brillouin scattering to achieve extremely high optical gain in silicon nanostructures may allow the realization of new integrated chip-scale photonic devices.

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Over the past decade there has been significant interest in applications that utilize the frequency-dependent amplification associated with the nonlinear process of stimulated Brillouin scattering (SBS). SBS involves the interaction between two optical fields — a pump wave and a Stokes wave — that are coupled via an acoustic wave in a medium, typically an optical fibre. This interaction amplifies the lower-frequency (Stokes) field when the frequency difference between the two optical waves is close to that of the acoustic wave. The large optical gain associated with this process allows for the realization of devices such as Brillouin amplifers and generators[1,2].

SBS gain has a narrow bandwidth (centred around the Stokes wave) and is accompanied by a rapidly varying frequency-dependent refractive index. The result is a large group index and a corresponding reduction in the group velocity of the Stokes wave. This approach to creating slow light using SBS has been used for a variety of tasks, including the realization of tunable optical delays[3,4], stopped light[5] and Brillouin cooling[6].

Now, in a recent publication in *Physical Review X*, Peter Rakich and co-workers from Sandia National Laboratories, Massachusetts Institute of Technology and the University of Texas at Austin predict that SBS gain coefficients in silicon nanowaveguides could theoretically be four orders of magnitude larger than those of conventional silica fibres[7].

Extensive investigations have been performed into both the suppression and enhancement of the Brillouin effect, particularly in optical fibres. For example, materials such as germanium, bismuth oxide, tellurite and chalcogenide have all been explored for their ability to increase or reduce SBS gain. Nearly all such research is based on the Brillouin effect arising from the process of electrostriction; that is, the tendency of a medium to become compressed in the presence of an electric field. Electrostrictive SBS is a microscale effect whose strength is largely determined by the material, is independent of geometry, and typically requires relatively long interaction lengths (hundreds of metres of fibre) in order to produce appreciable effects for sub-watt pump fields. As a result, researchers have so far struggled to observe SBS in highly compact, integrated waveguide structures that have short interaction lengths. Although SBS was recently demonstrated in chalcogenide chip-based waveguides[8] owing to the typically large SBS gain coefficients of chalcogenide glasses, observing SBS effects in chip-based platforms such as silica or silicon is difficult because they often have small electrostrictive SBS gain coefficients.