in a laser pulse with respect to the longer ones, and this longer pulse length keeps the intensity low (Fig. 1). For example, in the very popular Ti:sapphire laser amplifiers, a seed pulse with a typical length of 40 fs is stretched to around 200 ps, decreasing its intensity by almost four orders of magnitude. This chirped pulse, the intensity of which is well below the damage threshold of the Ti:sapphire crystal, is then amplified. After amplification, the chirping process is reversed in a compressor, which retards the longer wavelength with respect to the shorter one and thereby restores the short temporal pulse profile. The result is a very short and extremely intense optical pulse.

Oliva *et al.*[4] realized that an adaptation of CPA could also solve their problem. If an X-ray pulse can be stretched such that it is long compared with the recovery time of the gain, then the whole seed pulse can be amplified and a total number of 10^{15} photons in the amplified seed becomes a possibility.Just as in CPA, the pulse is recompressed after amplification to restore the short pulse profile, which is vital to keeping the intensity high. To support their claim, they performed time-dependent Maxwell–Bloch simulation of the amplification scheme, showing a potential improvement in intensity of three orders of magnitude over previous records.

The potential benefit of this idea is beyond doubt, but its implementation is not trivial. The proposed technique is in principle the same as CPA, but here it must be adapted to much shorter wavelengths, deep in the extreme-ultraviolet part of the electromagnetic spectrum, where the manipulation of light is a more complicated affair. Although the optics required in the scheme they outline have been reported in the literature, producing a working amplifier will require a great deal of experimental finesse. Nevertheless, with a potential intensity that rivals those of large-scale free-electron lasers such as FLASH, the race is on for the first implementation. ❒

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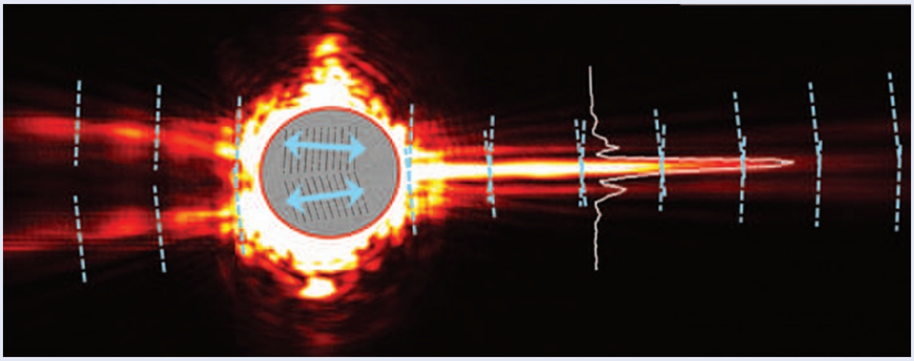
PLASMONICS

Diffraction-free surface waves



P. GENEVET

Waves of all types inevitably spread out while propagating, owing to diffraction. Under certain strict conditions, however, waves can be made to propagate without diffraction. Although this has been explored in free space, little attention has been devoted to waves confined to surfaces, such as surface plasmon polaritons (SPPs).

Now a new type of surface wave that travels in a straight line without diffracting has been introduced by Jiao Lin and researchers from the USA, Singapore and France (*Phys. Rev. Lett.* **109,** 093904; 2012). This 'cosine-Gauss plasmon beam' will be of potential use in next-generation optical interconnects.

SPPs are electromagnetic waves that are guided along metal–dielectric interfaces. Owing to their strong subwavelength confinement of light, they could find application in plasmonics by acting as a bridge between electronics and photonics. Any diffraction directly results in loss as the spreading of the wave reduces the coupling between the components.

Lin and colleagues overcome the diffraction problem by exploiting the interference effects of a metallic grating formed by two sets of grooves on a gold film. The grooves are 10 μm in length and have a period designed to match the wavelength of SPPs so that under vertical illumination by a laser the SPPs can be resonantly excited to form two plane waves. The two sets of grooves are tilted toward each other such that the two plane waves can constructively interfere with a half-angle between them of 5°. Diffraction-free beam propagation over a distance of up to 80 μm at the interface between gold and air is reported.

The researchers formulate the surface plasmon wave by deriving a new surface-wave solution of Maxwell's equations starting from first principles. The wave solution contains a cosine component, which the researchers consider to be the two-dimensional counterpart of a Bessel beam. A true Bessel beam is non-diffractive but cannot be created because it contains infinite energy, in the same way that an ideal plane wave does. This is remedied by modulating the propagating wave using a Gaussian envelope. In practice, this is achieved by the normal illumination of the metal grating using the fundamental Gaussian beam of a laser with a wavelength of 740 nm and a waist size of 8 μm.

The researchers say that highly localized straight-line propagation for a distance of 80 μm is considerably more than has been achieved using plasmonic Airy beams, after adjusting for wavelength and beam width. The researchers also points out that the maximum distance the cosine-Gauss plasmon beam can propagate without diffracting is limited by the waist of the Gaussian beam and the angle between the grooves. These factors geometrically determine the distance over which the plane waves constructively interfere.

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