In such cases, torques are also created, enabling OET to both position and align nanostructures (Fig. 1). Furthermore, the forces depend on the properties of the material and can thus be exploited to sort objects by material class.

The ability of OET to exploit these features simultaneously for sorting and assembly represents an important result in the field of optical manipulation. To demonstrate the potential of the technique, Wu and colleagues show that by performing OET in a photocurable liquid, arrangements of sorted wires can be 'locked' into place by flood exposure to UV light after assembly.

The results of Wu *et al.* are valuable for at least three reasons. First, they appear to provide new tools with which researchers can manipulate wires and other nanomaterials. Second, these types of ideas for assembly and integration are critically important for turning nanoscience into practical nanotechnologies. Lastly, their work provides many interesting opportunities for further development. For example, by simultaneously creating and controlling a million or more tweezers, large-scale arrays of semiconducting wires can possibly be assembled to form active channels of transistors for display circuits.

Many important questions remain to be investigated. Is it possible to extend the current two-dimensional capabilities of OET to three dimensions? Can similar approaches be used for manipulating molecular-scale objects such as DNA or single-walled carbon nanotubes? These and many other lines of inquiry might lead to fruitful directions for new research, with important scientific and technological implications.

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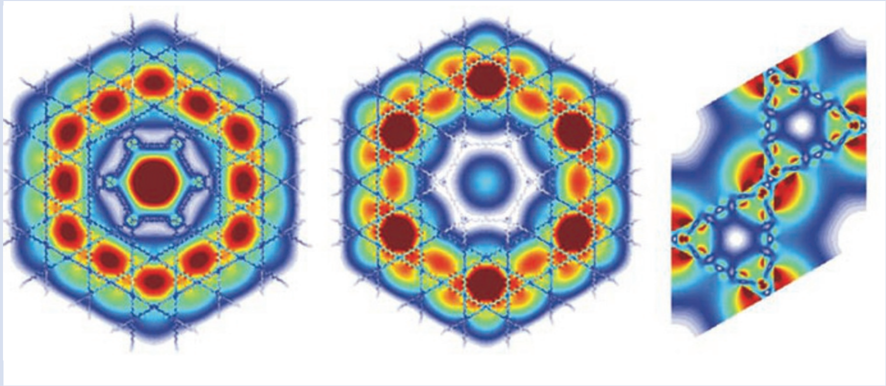
OPTICAL FREQUENCY GENERATION

A route to new combs



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The creation of broad, coherent optical combs is important for attosecond science and the study of ultrafast physical processes. Now researchers in the UK, Denmark and the USA describe the design and fabrication of a type of photonic-crystal fibre that can be used to generate optical-frequency combs spanning several octaves, with much less power than previous techniques (*Science* **318,** 1118–1121; 2007).

François Couny *et al.* studied the detailed properties of a hollow-core photonic-crystal fibre (HC-PCF) that is filled with molecular hydrogen. Hollow-core PCFs can bring together gases and light into tiny modal areas (on the order of square micrometres) and keep them confined over long length scales (up to several metres). The increased confinement distances maximize the level of interaction with incoming light and provide access to nonlinear responses in gaseous materials at unprecedentedly low light powers. So far, however, the bandwidth of the generated spectra has been limited to about 70 THz, which is much smaller than the 1,000-THz bandwidth needed to generate attosecond pulses that range from the infrared to the UV.

The team uses an infrared pump laser of wavelength 1,064 nm to generate higher-order stimulated-Raman-scattering spectra in the hydrogen-filled fibre. Their fibre is made from silica glass struts that are 290 nm thick, with a pitch of about 12 μm. This structure provides wide high-transmission bands, which maximizes the bandwidth for frequency generation, and reduces the dispersion.

The paper describes frequency combs that are 1,000 THz wide, being successfully generated and guided along the fibre. This bandwidth corresponds to a three-octave spectral comb with wavelengths ranging from 325 nm in the UV to 2,300 nm in the infrared. Compared with previous techniques, pumping is done with a longer wavelength and peak powers that are six orders of magnitude lower (around 10 kW), making the approach more practical.

The confinement of light in the HC-PCF relies on a new mechanism in which light is guided not by a photonic bandgap, but by the fact that there is inhibited coupling between the core and cladding modes of the fibre. The fibre-guided core modes and the cladding modes interact only weakly, as a result of the strong mismatch in the transverse field of the two modes. This very weak mode overlap has been observed before but was not fully understood until now. Because very little field penetrates into the cladding, the core mode undergoes little propagation loss (about 0.5 dB m^{-1}).

By using the HC-PCF in other Raman excitation regimes, the authors say they will be able to improve the conversion efficiency and further reduce the pumping powers needed, while providing better control over the phases of the various spectral components. These findings should open up a new route for the design of next-generation, broadband HC-PCFs.

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