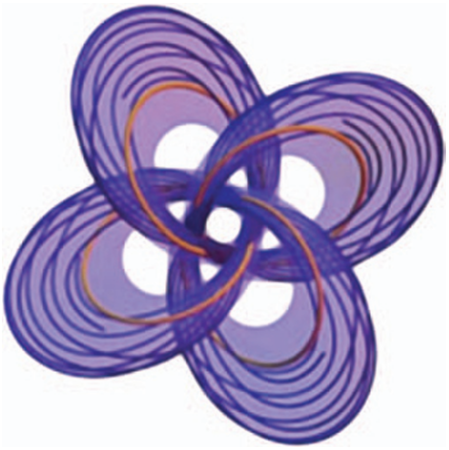
MAXWELL'S EQUATIONS

Knot theory

Phys. Rev. Lett. **111,** 150404 (2013)



Hridesh Kedia and colleagues from the USA, Poland and Spain have presented a family of exact knotted solutions to Maxwell's equations in free space. In these analytical solutions, the electric and magnetic field lines 'encoding' all torus knots and links persist in time. Knot theory has been around for a long time, and is applicable to a wide range of scientific fields, ranging from fluid dynamics to quantum field theory. The researchers describe the knotted structure of the field lines, and compute the set of conserved currents, the helicity and charges for the family of solutions. The evolution of the fields is analogous to a shear-free, compressible flow along the Poynting vector. The scientists raise the question of whether similar solutions exist for nonlinear systems such as the Euler flow of ideal fluids. It will be interesting to see if researchers can realize such solutions experimentally in systems such as plasmas and quantum fluids. *DP*

SENSORS

Light slows DNA

Nature Nanotech. **8,** 946–951 (2013)

Passing molecules, including DNA, through nanopores in membranes is an active area in sensor research, as it allows sensitive detection of chemicals and molecules. However, it is not simple to control the passage of molecules through pores, because of the range of forces involved. Now, Nicolas Di Fiori and colleagues from the USA and Israel claim that tightly focusing low-power, visible laser light on a pore can assist with controlling the flow through the pore. They show that such light can be used to manipulate the surface charge on solid-state pores, and hence affect electro-osmotic flow through them. For example, light can be used to reduce the translocation speeds of double-stranded DNA and small globular proteins by one and two orders of magnitude, respectively. The effect is also reversible. The researchers consider pores with diameters from 4 nm to 20 nm in a silicon nitride membrane. The team used a green (532 nm) laser diode with just a few milliwatts of power; this is strong enough to induce the desired effect, but small enough that any thermal effects are insignificant and can be neglected. A common problem with nanopore devices is that the pores can become blocked; the researchers show that illumination with 5 mW of laser light can also be used to unclog blocked pores. *DP*

FREQUENCY COMBS

Fast spectro-imaging

Nature **502,** 355–359 (2013)

Researchers in Germany and France have developed a coherent anti-Stokes Raman spectroscopy system that can perform spectroscopic imaging over a broad spectral bandwidth within a few microseconds. The approach taken by Takuro Ideguchi and co-workers is to use two laser frequency combs with repetition frequencies of $f + \delta f$ and f to interrogate a sample. A train of pulses in the first frequency comb periodically excites the molecular vibration, which is then probed by the pulses of the second frequency comb with a linearly increasing time delay. The resulting filtered anti-Stokes radiation forms a temporal interferogram, which is recorded by a single silicon photodiode. The thus obtained spectra span Raman shifts from 200 cm^{-1} to 1,400 cm^{-1}. A resolution of 4 cm^{-1} was achieved using δf = 100 Hz and 5 Hz and measurement times of 14.8 μs and 295.5 μs, respectively. The researchers say that the use of a single photodetector ensures that the spectra are recorded consistently. However, they admit that the present experiment is limited by the low duty cycle time (the ratio between the time it takes to measure an interferogram and the time before the next interferogram is measured). The scientists say that the approach will enable new applications in nonlinear microscopy and nonlinear spectroscopy. *RW*

LASER PHYSICS

QASER unveiled

Phys. Rev. X **3,** 041001 (2013)

Anatoly Svidzinsky and co-workers in the USA have proposed a new scheme for obtaining quantum gain without generating a population of excited-state atoms. Their scheme involves quantum amplification by superradiant emission of radiation (QASER). The researchers say that the approach holds promise for amplification of coherent extreme-ultraviolet radiation and is many orders of magnitude more efficient than nonlinear multiphoton processes. The team considered a medium composed of two-energy-level atoms and analysed the evolution of a superradiant pulse at the atomic transition frequency, which is periodically modulated by a coherent driving field. They found that amplification by the QASER is possible if one eliminates the time-independent

OPTICAL MATERIALS

Perfect absorber

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A hyperbolic metamaterial consisting of a stack of tilted graphene sheets can potentially form an ultrathin light absorber that is 100% efficient, according to calculations by scientists in Finland and Russia. Igor Nefedov and co-workers say that by tilting graphene sheets, it is possible to create an asymmetry and an effective relative permittivity of −1, so that neither upwards nor downwards propagating waves are reflected. In principle, this result implies that all light incident on the structure will be completely absorbed. The proposed design has two significant limitations, however. First, it is narrowband, having an absorption bandwidth of only about 100–200 nm. Its centre wavelength depends on the design — reducing the intersheet spacing shifts operation to longer wavelengths in the infrared region. For example, designs with intersheet spacings of 5 nm, 3 nm and 1.5 nm are predicted to absorb radiation with wavelengths around 1.85 μm, 2.2 μm and 2.7 μm, respectively. A second limitation is that the approach is only effective for transverse-magnetic polarized light waves; it does not work for transverse-electric polarized waves. Although the design will be challenging to make, the researchers say that it should be possible to fabricate it using current technology. *OG*