Sharp lasers

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One of the fundamental principles of lasers is the Schawlow–Townes limit, which states that the linewidth of a laser line is always above a value determined by factors such as laser cavity losses and variations in refractive index caused by electron density fluctuations. Following theoretical work by Yamashini *et al.*, Saverio Bartalini and colleagues have now studied the linewidth of quantum cascade lasers (QCLs). They observed that the intrinsic linewidth of a QCL is smaller than suggested by the standard Schawlow–Townes limit. In comparison with conventional semiconductor lasers, QCLs operate by intersubband transitions within the conduction band. For these, the upper laser state has a much shorter non-radiative lifetime than for the radiative spontaneous emission. Consequently, the noise associated with the laser transition is smaller than assumed by standard laser theory, so that the linewidth of a QCL can be narrower than the limit set by the Schawlow–Townes formula. As well as suggesting attractive uses in for example sensing applications, these results show even 50 years after the first demonstration of a laser this month, fundamental insight into lasers can still be gained.

Watching the drugs

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Metal carbonyl compounds are increasingly being studied for use as anticancer agents. An important aspect of the work is to look at the intracellular distribution of the compound and establish how this changes over time. Konrad Meister and colleagues have now used three-dimensional Raman microspectroscopy to image the uptake and distribution of $[Mn(tpm)(CO)_3]Cl$ (tpm = *tris*(1-pyrazolyl) methane) by human colon cancer cells. Frequently, X-ray fluorescence or atomic adsorption spectroscopy have been used to study metal complexes in cells; however, these suffer from drawbacks including the use of labels, cell damage and unwanted photochemical reactions. The advantage of Raman microspectroscopy is that it detects the inherent C≡O vibrations of the complex, negating the need for any fluorescent or isotopic labelling. Furthermore, the technique is non-invasive and does not harm the cell. The complex exhibits photoinduceable antitumour activity, and the team show that it targets the nucleus and nuclear membrane. It is likely that the technique will be useful for probing other medicinal metal carbonyl compounds, allowing new insights into the mechanisms of drug uptake and cellular targeting.

On-demand delivery

Biomaterials
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Many materials-based approaches have been investigated for controlled drug release. However, designing a technique that combines repeated drug release with a non-invasive way to trigger it has proven challenging. Now, Epstein-Barash *et al.* have developed an injectable multicomponent material for use as a repeatable, ultrasound-triggered drug-release system. Liposomes with encapsulated model drugs (dyes) are embedded within a crosslinked hydrogel matrix. In the next stage, gas-filled lipid monolayers, termed microbubbles, which are already known to enhance release in response to ultrasound, are added to the composite. The composite maintains ultrasound-triggered release of the encapsulated dyes for at least 14 days, both *in vitro* and *in vivo*, and shows promising biocompatibility. The multicomponent nature of the system offers many ways to tune drug content and release: for example, by varying drug loading, liposomal and microbubble concentration and the intensity or duration of the ultrasound pulse. The researchers predict that the material could be well suited for drug delivery when high concentrations are required, such as in local anaesthesia.

Colloidal assembly

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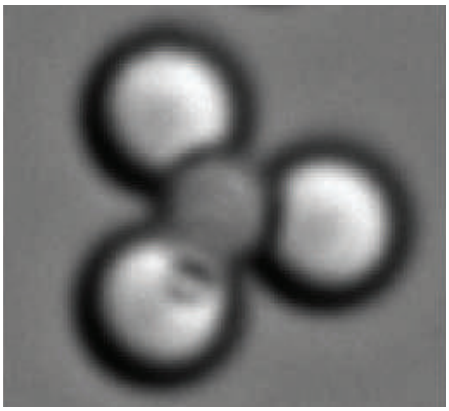

The programmable assembly of nanometre- and micrometre-sized particles has, so far, largely focused on DNA hybridization to bring particles together into an ordered structure. Now, Sacanna *et al.* have shown that the assembly of colloidal particles can be achieved, in a highly selective and reversible manner, by using recognition effects based on the geometric shapes of the constituent particles, rather than their composition or surface chemistry. The method uses the lock-and-key principle: colloidal particles with a spherical cavity are the lock and colloidal spheres that will fit into the cavity are the key. The driving force for the assembly is depletion interaction — a mechanism that relies on the presence of a water-soluble polymer (the depletant) and the favourable entropic interactions that result. Binding and unbinding of the particles can be controlled by changing the depletant concentration and, if an appropriate depletant is used, by varying the temperature. Sacanna *et al.* show the versatility of the method by making dimers, trimers (pictured) and chain-like assemblies.

Dotted wires

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The atomic-like optical emission from self-assembled quantum dots (QDs) embedded in semiconductor devices is promising for several applications in optoelectronics. QDs are usually nanoclusters of one semiconductor embedded in a matrix of a different material. However, Nika Akopian and colleagues have now demonstrated that QDs can also be obtained in a structure composed of a single material, namely InP nanowires. A nanowire can exhibit both wurtzite and zinc-blende segments. Interestingly, the valence and conduction bands are misaligned in the two phases, so that small sections of zinc-blendes within wurtzite are effectively QDs for electrons. The team showed that such 'crystal phase' quantum dots can work as single photon emitters, when confined electrons recombine with holes in the adjacent wurtzite matrix. The possibility of using clean QD structures, free from defects and with sharp interfaces will be very beneficial for various optoelectronic applications.