RAMAN SPECTROSCOPY

Phone sensing

ACS Photon. **1,** 17–26 (2014)

A smart phone's image sensor is capable of detecting signals required for Raman spectroscopy, according to researchers in Turkey. Sencer Ayas and co-workers from Bilkent University integrated a smart phone into a confocal Raman microscope set-up that had been modified to enable the phone's camera to record wide-field Raman images. This modification involved placing a collimator and a dispersive optical element in front of the camera. The team was able to record Raman spectra from ethanol and silicon, the latter being excited by a focused beam from a green laser (wavelength, 532 nm; power, 10 mW). The scheme was also applied to nanostructured silver substrates, which are compatible with surface enhanced Raman spectroscopy. In this case, the researchers observed blink events on the phone's camera that were associated with a single-molecule sensitivity. This achievement was possible as a result of a large enhancement in the Raman signal on the order of 10^6 to 10^7 by the plasmonic substrates. The researchers say that the spectrum of the blink events can be observed at a rate of 30 frames per second. *DP*

GRAPHENE PLASMONS

Single-photon nonlinearity

Phys. Rev. Lett. **111,** 247401 (2013)

Michael Gullans from Harvard University in the USA and co-workers from the research institutes ICFO and ICREA in Barcelona, Spain, have theoretically predicted that graphene plasmonic nanostructures should be able to produce nonlinear optical effects when driven at the few- or single-photon level. Such effects usually require much stronger light signals, but the researchers say that the combination of plasmonic-induced electromagnetic field enhancement and the intrinsic nonlinearity of graphene can lower the threshold to the level that quantum nonlinear optics becomes possible. It is predicted that, under realistic conditions, deterministic interaction between two single plasmons will be possible; this may make it possible to realize a single-photon switch. The approach has implications not only for classical nonlinear photonics but also for quantum optics. *DP*

SPECTROSCOPY

Frequency comb power

Nature Phys. **10,** 30–33 (2014)

Optical frequency combs with high-intensity pulses are desirable for realizing a much wider range of capabilities and applications for ultrahigh precision, direct frequency comb spectroscopy. Now, Jonas Morgenweg and colleagues from VU University in the Netherlands have presented an approach that can achieve not only millijoule pulse energies, but also improved frequency comb resolution and accuracy. Their method of Ramsey-comb spectroscopy employs a series of excitations with two selectively coherently amplified pulses from a frequency comb laser. The delay between these pulses can be varied over a wide range without affecting the optical phase relationship. The coarse delay of the pulse pairs can be changed in steps of the frequency comb repetition time, whereas fine-tuning for a Ramsey scan is achieved by small adjustments of the repetition time. The capabilities of Ramsey-comb spectroscopy were demonstrated by investigating weak two-photon transitions in atomic rubidium and caesium. The team achieved frequency comb pulses with an energy of 5 mJ, which is orders of magnitude more energetic than previous studies. Furthermore, they realized a frequency accuracy that is up to 30 times better than that of traditional frequency comb spectroscopy. *RW*

MAGNETIC FLUIDS

Magnetic-field sensor

IEEE Photon. Tech. Lett. **26,** 217–219 (2014)

Researchers at Northeastern University in Shenyang, China, have demonstrated a compact optical-based magnetic-field sensor that has a high sensitivity of 0.0431 nm Gs^{-1}. It consists of an optical-fibre Fabry–Pérot interferometer whose cavity is filled with a magnetic fluid — a stable colloidal suspension of single-domain magnetic nanoparticles uniformly distributed in a carrier fluid by a surfactant. The refractive index of the magnetic fluid was found to increase linearly with increasing magnetic field strength, enabling it to be used in the magnetic-field sensor with optical read-out. This latest design is said to be simple, compact, easy to fabricate and yet provides a high stability and a high sensitivity. Further work is needed, however, to address the temperature dependence and packaging of this sensor. *SP*

TERAHERTZ OPTICS

Micropillar lasers

Opt. Express **22,** 274–282 (2014)

Michael Krall and co-workers from Vienna University of Technology in Austria have

QUANTUM OPTICS

Robust entanglement

Nature **504,** 415–418 (2013)

Entangled states are required for a wide range of tasks in quantum optics and quantum information processing, but are fragile and easily destroyed. Controlled unitary processes have so far been the most widely used method to create entanglement deterministically, but they are susceptible to decoherence and dissipation as a result of coupling to the environment. Now, Yiheng Lin and co-workers from the USA and Denmark have developed a scheme for producing an entangled state that is inherently stable against decoherence. A $^{9}Be^{+}$–$^{24}Mg^{+}$–$^{24}Mg^{+}$–$^{9}Be^{+}$ four-ion chain is confined in a linear radiofrequency Paul trap. The two $^{9}Be^{+}$ ions serve as qubit ions, whereas the two $^{24}Mg^{+}$ ions are used for sympathetic cooling. Two 313 nm laser beams are frequency shifted using acousto-optic modulators and applied to the ion chain to create sideband coupling between the two qubit spin states; this coupling is required to produce steady-state entanglement. To cool the $^{24}Mg^{+}$ ions, laser beams with a wavelength of about 280 nm are also used. Spin-state analysis revealed that the system reaches a maximally entangled steady state after a few milliseconds with a fidelity of 0.75 when a combination of optical pulses is applied to it. Stepwise application of these pulses with a duration of 220 μs can speed up the dynamics of the scheme and achieve a fidelity of 0.89 after approximately 30 repetitions. *NH*