Researchers have long desired the ability to tune the resonant modes of a photonic crystal cavity in real time. Leonardo Midolo and colleagues from Eindhoven University of Technology in the Netherlands have now demonstrated a flexible tuning range of ~10 nm around a central wavelength of 1,550 nm. They fabricated a two-dimensional coupled photonic crystal cavity using two parallel double-layer 180-nm-thick InGaAsP slabs, in which the bottom of the upper layer was n-doped and the top of the lower layer was p-doped to form a p–i–n junction. They grew InAs quantum dots emitting at 1,550 nm in the centre of the upper layer and separated the slabs by a 240-nm-thick InP substrate at one of the edges, resulting in a cantilever structure. The intermembrane distance — and hence the effective index of the cavity — was controlled mechanically by tuning the electric field. When a bias voltage of ~6 V was applied to the sample, the researchers observed a blue-shift of 4.8 nm from the symmetric modes (large effective index) and a red-shift of 4.4 nm from the antisymmetric modes (small effective index), giving a total tuning range of almost 10 nm. The tuning range can be increased by reducing the intermembrane distance.

Mohammad Piracha and colleagues from the University of Central Florida in the USA have demonstrated a light detection and ranging system that can perform range and Doppler velocity measurements simultaneously with submillimetre resolution. Their approach is based on the coherent detection of a train of oppositely frequency-chirped pulses generated from a 20 MHz mode-locked laser using chirped fibre Bragg gratings. One pulse train is Doppler-shifted in frequency and delayed in time relative to the reference pulse train, thus generating a beat signal that provides decoupled distance and velocity information. The pulses are also temporally stretched to allow high power levels for transmitting signals over long distances while minimizing fibre nonlinearities. The researchers report simultaneous ranging measurements at resolutions of more than 300 μm and velocity measurements of a target moving at 331 km h⁻¹, with a signal-to-noise ratio of more than 25 dB.

Quantum dots are promising single-photon sources that can be monolithically integrated into semiconductor-based photonic devices. Matthew Rakher and Kartik Srivivasan at the National Institute of Standards and Technology in the USA have now reported a subnanosecond modulation scheme that can shape single-photon wavepackets emitted from a quantum dot. The researchers first fabricated a single InAs quantum dot in GaAs/InGaAs quantum wells and etched the sample to create isolated mesas measuring 2.5 μm in diameter. They then excited the sample using 780 nm, 50 ps laser pulses, which produced single photons of wavelength 1.3 μm. The single photons passed through an LiNbO₃ electro-optic intensity modulator before being measured by a InGaAs/InP single-photon counting avalanche photodiode. A delay generator triggered by the excitation laser was used to overlap the timing of the electro-optic intensity modulator pulse with the arrival of the incoming photon. As a result, the researchers obtained a Gaussian-shaped waveform with a width of 520 ps — longer than the pulse’s radiative decay time.

Frequency pulling occurs when a mismatch between central frequency and maximum gain frequency causes a cavity to lase at a frequency slightly offset from resonance. Enrico Allaria and colleagues from Italy and Slovenia have now observed frequency pulling in a free-electron laser (FEL). The team used the seeded FEL on the Elettra storage ring to feed a coherent harmonic-generation scheme. The 391 nm FEL seed source was provided by the second harmonic of a Ti:sapphire laser and the FEL output was tuned to the second harmonic (195 nm). They used an ultraviolet spectrometer and CCD to measure the harmonic output frequency spectrum as a function of radiation gain frequency by detuning the peak frequency of the gain spectrum from that of the harmonic generation process. They observed a shift of 0.03 nm for each millimetre change in gap width, which corresponds well to theoretical predictions. The results suggest that the FEL community may need to find other ways of tuning FEL radiation over a broad range, as the frequency-pulling effect observed here is relatively weak.

The relationship between charge, spin and orbital arrangement in manganites such as LaₓSr₁−xMnO₃ is not well understood because these attributes are interdependent degrees of freedom that evolve on ultrafast timescales and nanometre length scales. To investigate these competing properties, Henri Ehrke and co-workers from the UK,
Germany and France extended resonant soft-X-ray diffraction to the sub-10-ps timescale and synchronously irradiated an La$_{0.5}$Sr$_{1.5}$MnO$_4$ crystal with trains of 100 fs, 800 nm pulses. They discovered that the photon-energy dependence of the diffraction peak intensity was different before and after photoexcitation. At 25 K, the crystal exhibited a charge-exchange-type of antiferromagnetic phase, where charge, spin and orbitals form a characteristic domain pattern. It is known that irradiating La$_{0.5}$Sr$_{1.5}$MnO$_4$ with 800 nm light induces electron transitions only between Mn$^{3+}$ and Mn$^{4+}$. However, when the laser fluence rose above 5 mJ cm$^{-2}$, the diffraction peak corresponding to magnetic reflection vanished, while that corresponding to orbital reflection slightly decreased. The disappearance was on the sub-10-ps timescale, which is too fast to be caused by thermal diffusion. This indicates the possibility of a photoinduced phase transition in magnetism without the presence of Jahn–Teller distortion.

**SENSING**

**Self-repairing capability**

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Optical strain sensors are ideal for a wide range of engineering applications that require the continual monitoring of loads under extreme conditions, such as bridges, wind turbines and other critical structures. Networks of sensors can be reconfigured when one or more sections become damaged, but often the sensors located nearest to the point of impact — those likely to sustain the most damage — are also those that potentially provide the most information about the current integrity of the system. Help could now be at hand thanks to Young Song and Kara Peters from North Carolina State University in the USA. The two researchers have developed a self-repairing optical strain sensor waveguide that consists of a photopolymerizable resin sandwiched between two multimode fibres. Ultraviolet light causes the resin to photopolymerize, thus creating a waveguide in the form of a region of higher refractive index. The ultraviolet light then propagates further into the sample, where it exits the waveguide and photopolymerization begins in a new region. This process allows the sensor to re-bridge the gap between the two fibres after damage has occurred. Sensor interrogation is performed at infrared wavelengths, which ensures that the repairing and sensing light beams do not interfere. The researchers also demonstrated that the strain responses are very similar between the original sensor and the self-repaired sensor.

**OPTICAL PHYSICS**

**Rotational recoil**


An international collaboration of scientists from the USA, Finland, Japan and France has observed experimental evidence for rotational Doppler broadening in a molecular system. The effect — caused when molecule rotation spreads the kinetic energy of ejected photoelectrons — is sometimes even larger than the better-known collision-induced Doppler broadening effect. In their experiments, the researchers bombarded nitrogen and krypton gas mixtures with 60–900 eV X-ray photons from Spring-8 (Japan), MAX II (Sweden) and SOLEIL (France). They measured the energy spectra of the ejected valance electrons to determine the instrument resolution and the translational Doppler broadening. The results agree with both the researchers’ own classical model and quantum-mechanical predictions made in 2010 by another group. The results agree particularly well if the electron was assumed to be ejected from a specific atom, even though its wave function may be spread over the entire molecule. The agreement between theory and experiment also suggests that there are probably no other major sources of broadening not yet taken into account.

**OPTOELECTRONICS**

**Nanoscale photodetectors**


Scientists in Israel and the USA have designed and fabricated an on-chip nanoscale photodetector that operates at telecommunications wavelengths. They fabricated their device by locally oxidizing silicon on a silicon-on-insulator substrate and incorporating a 30-μm-long surface plasmon waveguide as a Schottky contact. They used photonic waveguides to deliver light into the device and an integrated Y-branch splitter to monitor and calibrate the detector’s performance. The detector demonstrated a responsivity of 0.25 mA W$^{-1}$ and 13.3 mA W$^{-1}$ for incident wavelengths of 1.55 μm and 1.31 μm, respectively. The researchers estimate the maximum power of the detector to be of the order of 15 μW, after various coupling losses are taken into account. In the future, such detectors could be integrated with other nanophotonic and nanoplasmonic structures to realize monolithic nanoscale on-chip circuitry.