little in the temperature range –30 °C to 20 °C. The team experimentally measured the secure key rate realized using the APD as a function of fibre length and obtained rates of 1.79 Mbit s^{-1} and 1.2 kbit s^{-1} for fibre lengths of 40 km and 100 km, respectively. *NH*

METAMATERIALS

Changing phase

Sci. Rep. **4,** 3955 (2014)

Tun Cao and colleagues from Dalian (China), Bristol (UK) and Singapore have numerically predicted a design of metamaterial structure that should be able to absorb ~97% of incident visible light. The proposed structure consists of a 25-nm-thick $Ge_2Sb_2Te_5$ layer sandwiched between two 100-nm-thick gold layers, all on a BK7 glass substrate. The top gold layer is patterned into an array of gold rectangles that are 140 nm wide and deep and have a period of 300 nm. As well as studying the strong overlap between the transverse-electric and transverse-magnetic absorptions in the structure, the team incorporated heat transfer into their simulations to determine the temperature distribution in the structures. They predict that an incident optical intensity of just 95 nW μm^{-2} should increase the temperature from room temperature to 474 K within 0.56 ns. This is of interest because $Ge_2Sb_2Te_5$ is promising as a data storage medium, and it undergoes an amorphous-to-crystalline phase transition at ~433 K. The metamaterial design may be useful for improving the speed and reducing the power requirements of non-volatile phase-change random-access memory. *DP*

DIODE LASERS

Ultrastable frequency

Appl. Phys. Express **7,** 022705 (2014)

A compact, single-frequency laser with a sub-hertz linewidth and a low frequency-drift rate would be useful for applications involving optical clocks and high-resolution laser spectroscopy. Ultralow-expansion (ULE) glasses are promising for use in the cavity of such a laser, but they shrink as they age. Now, researchers from Tokyo University of Science in Japan have realized an external-cavity diode laser with an extremely stable frequency output. They achieved this by exploiting a prediction that the age-related expansion rate of ULE glass will decrease with decreasing temperature. Their laser had a high-finesse (3.8×10^5) rigid cavity made of a ULE glass with a low zero-crossing temperature (the temperature at which the specific thermal expansion is zero) of –3.3 °C. It exhibited a linear frequency drift of just 25 mHz s^{-1}, which the team claims is the lowest ever reported for a cavity made from a ULE glass. Its length reduction rate caused by ageing is estimated to be two to three times lower than those of ULE glasses with zero-crossing temperatures close to room temperature, in agreement with theoretical predictions. *SP*

ANIMAL VISION

Colour perception

Science **343,** 411–413 (2014)

The mantis shrimp possesses one of the most complex eyes of all animals, having 12 photoreceptor types — more than any other animal. This ocular complexity has mystified scientists, as theoretical analysis indicates that this level of sophistication is far greater than that required to distinguish the colours of the visible spectrum. Researchers in Australia and Taiwan have recently gained new insight into the reason why. They first trained mantis shrimps to respond to light of a particular wavelength by offering them a food reward. They then presented individual animals with light from two optical fibres — one emitting light of the trained wavelength and the other light at a slightly different wavelength — to test whether they were able to distinguish the two colours. Surprisingly, the mantis shrimps exhibited poorer spectral discrimination (~25 nm) than other animals with only three types of photoreceptors. The researchers postulate that the mantis shrimp employs a different mechanism for processing visual sensory data — one that favours processing speed over wavelength discrimination ability. Instead of performing multiple dichromatic comparisons like other animals, the mantis shrimp appears to bin colours into 12 separate channels. *SP*

LASER ACCELERATORS

Treating tumours

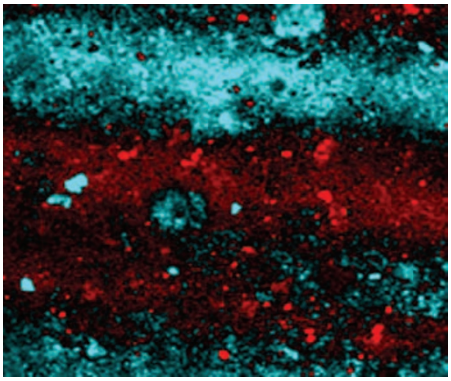
Appl. Phys. B http://dx.doi.org/10.1007/s00340-013-5747-0 (2013)

Maria Nicolai and a team from Germany claim to have conducted the first *in vivo* irradiation of tumours in mice using laser-accelerated particles. The experiments used the JETI laser system in Jena, Germany. The 40 TW Ti:sapphire laser system was used to generate 30 fs pulses, which provided an energy of ~700 mJ at the target. Focusing produced a 13-μm-diameter spot that had a very high average intensity of 8×10^{18} W cm^{-2}. The target was a 2.4-mm-long supersonic hydrogen gas jet, which was ionized by the laser pulses to produce a plasma with an electron density of ~10^{19} cm^{-3}. The electrons were subsequently accelerated and directed to cancerous mice. During a four-week campaign, human tumours grown onto the ears of over 50 mice were treated by bombarding them with a stream of electrons equivalent to prescribed doses of 3 Gy and 6 Gy. The team was able to maintain the threshold dose rate of 1 Gy min^{-1} for tumour irradiation by increasing the repetition rate of the electron bunches from 0.5 Hz to 1 Hz over the campaign duration. The demonstration shows the feasibility of using laser-accelerated particles for treating tumours. *DP*

NONLINEAR IMAGING

Artwork analysis

Proc. Natl Acad. Sci. USA **111,** 1708–1713 (2014)



Studying the layered structure of a painting is useful for checking its authenticity and learning more about its creation. This generally requires physically removing a cross-sectional sample from the artwork, which is a destructive process. Non-destructive macroscopic methods such as X-radiography can be useful, but the information they provide is limited. Now, Tana Elizabeth Villafana and colleagues from the USA have applied the concept of femtosecond pump–probe microscopy, which is popular for biological imaging, to non-destructive three-dimensional imaging of paintings. The team shows that a combination of multispectral and multi-delay pump–probe spectroscopy can generate virtual cross-sections of paintings with molecular and structural contrast, even for pigments with linear absorption spectra that are broad and relatively featureless. Increased spectral ranges of the pump and probe beams (from the near-infrared to the visible range) and the variable time delay of the pump–probe pulses are keys to addressing the complexity introduced by the large range of possible pigments in the paint layers; they permit the *in situ* three-dimensional imaging of paintings with molecular specificity. The team says that the method can be applied to a wide range of cultural objects, making it of interest to conservation science. *RW*

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