NONLINEAR OPTICS

Quantum switching

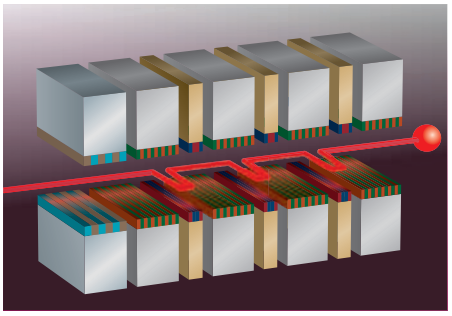
J. Opt. Soc. Am. B **28,** 2007–2013 (2011)

Using a Bogoliubov Hamiltonian two-mode approximation approach, Bin Chen and colleagues from Shanghai Jiao Tong University in China have theoretically proposed a tunable all-optical Kerr switch in an optomechanical cavity with a Bose–Einstein condensate (BEC). For a BEC of ^{87}Rb atoms trapped in a Fabry–Pérot cavity by a crossed-beam dipole field, the researchers say that the collective motion of the BEC is analogous to a moving mirror through the optomechanical system. The study shows that modulation of the pump beam power switches the transmitted intensity by modifying the cross-section of a Kerr-type nonlinearity in the BEC–cavity system. The optical Kerr effect disappears quickly when the pump beam is switched off. The researchers say that a significant nonlinear response can be expected for low-power pump beams, and they hope to carry out experiments to confirm these predictions. *DP*

FREE-ELECTRON LASERS

Mode-locking X-rays

New J. Phys. **13,** 063012 (2011)



Researchers have now improved a recent proposal for mode-locking free-electron lasers. In the original concept, placing magnetic chicanes between magnetic undulator sections imposes an axial-mode structure on the generated radiation, and the adjacent modes are locked in phase by appropriately modulating the electron beam energy. Now, Eugene Kur and colleagues from the USA and the UK have proposed that the lasers could be mode-locked by modulating the beam current instead of the beam energy. They say that this should result in a cleaner output and increased spectral brightness to beyond what is possible with current X-ray source schemes of comparable bandwidth, such as high-order harmonic generation and storage-ring-based synchrotrons. Numerical simulations predict that a spectral brightness of 30–180 μJ eV^{-1} should be possible at a central wavelength of 6.2 nm. The researchers also show that mode-locking might allow the output bandwidth to be controlled by varying the undulator section length. *DP*

QUANTUM COMPUTING

Optical nuclear coupling

Nature Commun. **2,** 378 (2011)

Although semiconductor-based quantum computers exploiting NMR have the potential to achieve all-optical operation, the internuclear coupling exhibited by semiconductors is too weak. Now, through cross-polarization experiments with GaAs under light illumination, Atsushi Goto and co-workers in Japan have shown that light can be used to control nuclear spin–spin coupling strength and even semiconductor on/off switching in GaAs. First, they measured the temporal magnetization behaviour of ^{71}Ga and ^{75}As at 10 K using an optical-pumping double-resonance NMR system. When illuminated by infrared light from a Ti:sapphire laser, the magnetization of GaAs sample rapidly increased and then oscillated on a millisecond timescale. When the intensity of the pumping light was increased from 100 mW to 166 mW, the contact time changed from 3.1 ms to 0.8 ms. Using a damping oscillation model that takes the indirect scalar coupling into account, the researchers showed that the coupling became strong and extended its spatial interaction length to farther nuclei as the pump intensity was increased. Their findings encourage the development of semiconductor-based NMR quantum computers and introduce a variety of options for arranging qubits. *NH*

ULTRAFAST PHOTONICS

Zeptosecond accuracy

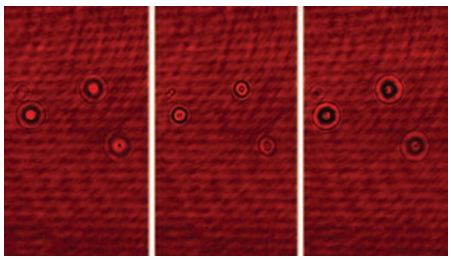
Opt. Express **19,** 11638–11653 (2011)

Ultrashort pulses with high temporal precision are needed for a variety of ultrafast optical applications. Jens Köhler and co-workers from the University of Kassel in Germany have developed an all-optical technique for realizing an extremely stable high-precision interferometer. The scheme combines a femtosecond polarization pulse shaper with a polarizer, and uses two linear spectral phase masks to mimic an ultrastable common-path interferometer. The pulse shaper comprises a double-layer liquid-crystal spatial light modulator whose polarization directions can be oriented at ±45° with respect to the polarization of the input pulse. By applying appropriate linear spectral phase functions, the researchers split the input pulse into two identical temporally delayed replicas of crossed linear polarization. A subsequent polarizer projected the polarization directions of the two pulses onto the same plane. The researchers used pulses with durations of <12 fs from an 800 nm Ti:sapphire laser to investigate the temporal precision limit of the set-up. They determined the minimum limit in achievable delay step size to be 280 zs, which means the precision of the optical path length is less than the Bohr radius of 0.529 Å, and applied the precisely generated pulse pairs to a strong-field quantum control experiment. The researchers say that this scheme might pave the way to the development of attosecond pump–probe experiments. *NH*

DIGITAL HOLOGRAPHY

Counting cells

Appl. Opt. **50,** 3589–3597 (2011)



In the field of pathology, chromatographic agents are used in the analysis of blood samples to obtain useful information about cell morphology for diagnosing a wide range of diseases. Unfortunately, the sample preparation and analysis stages of this process may take several hours if the red blood cells being imaged are particularly young. Mona Mihailescu and co-workers in Romania have now combined holography with image processing to simultaneously image, identify and count more than 1,000 red blood cells from several three-dimensional images of the same sample. Based on the interference patterns obtained by digital holographic microscopy, they noted that mature and immature cells exhibit very different diffractive patterns when illuminated with a central intensity distribution in a given plane along the propagation axis. They then developed a computer programme capable of automatically and simultaneously identifying, separating and counting individual cells, even when they partially overlap, using at least six images obtained in the reconstruction phase of digital holographic microscopy. The technique accurately measures the morphological features of cells and can separate mature from immature red blood cells through a decision based on their gradient and radius values. *JB*

Written by James Baxter, David Pile, Noriaki Horiuchi and Rachel Won.