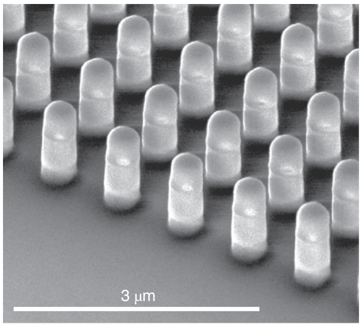
NONLINEAR OPTICS

Metasurface mixer

Nat. Commun. **9**, 2507 (2018)



Credit: Springer Nature Ltd

Optical frequency mixers generally rely on bulk nonlinear crystals and weak nonlinear optical processes. Sheng Liu and colleagues from Sandia National Laboratories, USA have now demonstrated an ultra-compact all-dielectric metamixer that enables many simultaneous nonlinear optical processes across a broad spectral range. The device is a gallium arsenide-based metasurface consisting of an 840-nm periodic square array of nanocylinders with a diameter of ~400 nm. Each nanocylinder is composed of an ~300-nm-thick SiO_x etch mask, an ~450-nm-thick GaAs nanodisk and an ~400-nm-thick $(Al_xGa_{1-x})O_3$ layer. On pumping the metamixer with two femtosecond pulses at ~1.24 µm and ~1.57 µm, near the magnetic and electric dipole resonances of the metasurface, the team observed the generation of 11 new frequencies spanning from ~380 nm to ~1,000 nm, generated by 7 different concurrent nonlinear processes (second-harmonic, third-harmonic and fourth-harmonic generations, sum-frequency generation, two-photon-absorption-induced photoluminescence, four-wave mixing and six-wave mixing). Applications in communications, quantum optics, sensing and biology are expected. *RW*

https://doi.org/10.1038/s41566-018-0230-4

POLARITONS

Spin orientation switching

Phys. Rev. B **97**, 235303 (2018)

For the realization of integrated spintronic devices, a spin-switching device is desired. Now, Alexis Askitopoulos and co-workers from the UK, Russia and Greece have experimentally observed that the two spin components of a polariton condensate can switch their orientation via illumination with light. A polariton condensate was generated in a high-quality ($Q = 16{,}000$) GaAs-based microcavity consisting of 10 nm GaAs quantum wells and a Rabi splitting of 9 meV. Light from a continuous-wave Ti:sapphire laser emitting at 754 nm was sent to the microcavity and the first excited state of the polariton condensate was optically trapped. The spin component of the condensate was investigated by means of polarization-resolved spectroscopy. When the excitation density of the light was increased from 12.48 mW to 14.56 mW, the dominant spinor state with a p-orbital symmetry was rotated by $\pi/2$. The phenomenon is explained by the spatially inhomogeneous depletion of the exciton reservoir and the repulsive exciton–polariton interaction. In principle, the approach could lead to a spin-demultiplexing device for polariton-based spin circuits. *NH*

https://doi.org/10.1038/s41566-018-0227-z

PHOTONIC CRYSTALS

Cherenkov detector

Nat. Phys. http://doi.org/crv7 (2018)

Cherenkov radiation — light emission that occurs when a charged particle propagates through a medium at a speed that is faster than the phase velocity of light in the medium — is of importance to applications such as particle detection. However, the relation between the angle of Cherenkov emission and the particle velocity is inherently limited by the refractive index of the material. Now, an international team led by Xiao Lin has removed this restriction by using a one-dimensional photonic crystal to control the Cherenkov angle at will. The photonic crystal was constructed by alternating two transparent dielectric materials, and the Cherenkov angle can be engineered to be suitable for particle identification of high momenta near 500 GeV/c, which is hard to achieve with a conventional Cherenkov detector. Another advantage of the one-dimensional photonic crystal approach is that the crystal only needs to be a few millimetres thick. *NH*

https://doi.org/10.1038/s41566-018-0228-y

MICROWAVE PHOTONICS

Single-mode operation

Sci. Adv. **4**, eaar6782 (2018)

The concept of optical parity–time (PT) symmetry, whereby optical gain and loss are carefully controlled within a photonic system, has enabled the generation of pure, low-noise single-mode microwave signals without the need for complex filtering. In an optoelectronic oscillator, an optical feedback loop is used to generate high-frequency microwave signals with low phase noise, but ensuring single-mode operation usually requires the use of an ultra-narrow-band optical filter. Now, Jiejun Zhang and Jianping Yao from the University of Ottawa, Canada have shown that employing PT symmetry can remove the need for such a filter. In their approach, a polarizing beam splitter and polarization controllers are used to create two feedback loops that have a variable splitting ratio, thus allowing the level of gain and loss to be controlled and PT symmetry to be broken for just one mode, enabling single-mode operation. The approach has been tested with optical fibre loops of 20.31 m, 433.1 m and 9.166 km in length and demonstrated to produce a microwave signal at a frequency of 9.867 GHz with a phase noise of –142.5 dBc Hz^{-1}. *OG*

https://doi.org/10.1038/s41566-018-0229-x

METAMATERIALS

Deep-learning boost

ACS Nano **12**, 6326–6334 (2018)

Wei Ma and colleagues from Northeastern University, USA have developed an accurate, efficient deep-learning-based model for designing three-dimensional chiral metamaterials. The model consists of two bidirectional neural networks, with a forward combiner and an inverse combiner. It is trained heuristically with multiple functions for fast prototyping, optimization and inverse design. The unit cell of the chiral metamaterial under study consists of two stacked gold split-ring resonators twisted at a certain angle and separated by two spacing dielectric layers with a continuous gold reflector at the bottom. The team demonstrated that the model can significantly shorten the prediction time for generating chiral dichroism and can solve the design-on-demand inverse problem accurately and efficiently, retrieving geometric parameters of the metamaterial from specific requirements of its optical response. *RW*

https://doi.org/10.1038/s41566-018-0231-3

Oliver Graydon, Noriaki Horiuchi and Rachel Won