ATTOSECOND OPTICS

Space–time characterization

Nature Phys. **9,** 159–163 (2013)

So far, no method exists that can observe the complex space–time structure of attosecond extreme-ultraviolet pulses. Now, Kyung Taec Kim and colleagues from the University of Ottawa and the National Research Council in Canada have demonstrated an all-optical method for measuring the space–time characteristics of an isolated attosecond pulse, without temporal and spatial averaging. The success of their approach relies on the fact that adding a single photon to an already highly nonlinear process only weakly perturbs the process, but can modify the spatial and spectral patterns of a beam. The team uses a fundamental laser pulse with a time-dependent polarization to produce an isolated attosecond pulse. They then use the second harmonic of the fundamental laser pulse to perturb the attosecond pulse generation process in both space and time. The perturbation modulates the spatial dependence of the phase, and hence the near- and far-field patterns. The researchers then measure the far-field pattern as a function of time delay, and reconstruct the amplitude and phase of the attosecond pulse in space and time by using a parametric fitting procedure. The approach will provide further insight into ultrashort pulse generation, and could potentially be used to finely control pulse characteristics. *RW*

GEOMETRIC OPTICS

Fractional spiral zone plates

J. Opt. Soc. Am. A **30,** 233–237 (2013)

Diffractive optic elements using spiral zone plates (SZPs) have been widely employed in imaging and microscopy as they permit flexible design, are easy to arrange, and are small. However, they are limited to isotropic imaging applications. Lai Wei and co-workers from the China Academy of Engineering Physics in Sichuan have now proposed a general concept of SZPs, which is also valid for anisotropic imaging. The azimuthal phase profile of an SZP is described by $\exp(ip\varphi)$, where p is a non-zero integer and φ represents the azimuthal coordinate. To make fractional SZPs (FSZPs) the team changed p from an integer into a fraction. The diffraction patterns of FSZPs simulated using the Fresnel diffraction formula showed that the vortex-shaped field distribution fades and a sub-lobe emerges. The researchers also investigated the field distribution as a function of p and s (a parameter denoting the order of focal length of the FSZP) and demonstrated that the orientations and the intensity distribution of the diffraction beam through FSZPs can be flexibly controlled by the variables p, s and the starting orientation of the azimuth. *NH*

X-RAY SOURCES

Plasmonic photocathode

Phys. Rev. Lett. **110,** 076802 (2013)

Scientists in the USA have designed a plasmon-enhanced photocathode for bright, high-repetition-rate X-ray sources. The idea of Aleksandr Polyakov and co-workers from Lawrence Berkeley National Laboratory and Pacific Northwest National Laboratory was to use nanostructured plasmonic surfaces to trap light and greatly enhance the photoemission of electrons. Their chosen structure was aluminium with grooves 15 nm in width, 60 nm in depth and 100 nm in period and a plasmonic resonance at a wavelength of about 720 nm. By experimentally measuring the photoemission current from the sample using a 20-fs laser with a central wavelength of 800 nm, the researchers confirmed that the process was caused by four-photon photoemission. The generated photocurrent was 2.45 pA for a beam intensity of 0.065 GW cm^{-2}. The fourth-order photoemission was enhanced by over six orders of magnitude relative to that from a flat gold surface. *NH*

OPTICAL CIRCUIT

Spin–photon interface

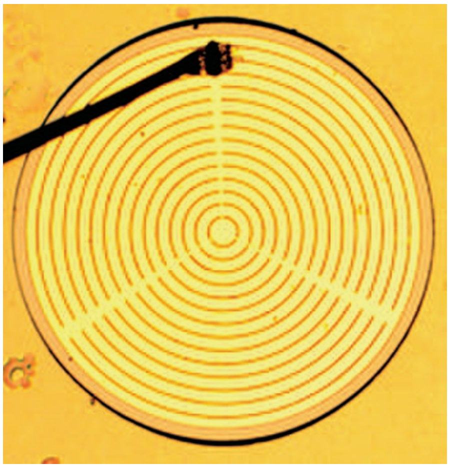
Phys. Rev. Lett. **110,** 037402 (2013)

An in-plane spin–photon interface is essential for integrating quantum dot spins with optical circuits. This is difficult to achieve because the circularly polarized light emitted from a quantum dot is reduced to a linear-polarization component in a planar optical circuit, which inhibits the in-plane transfer of spin information. Isaac Luxmoore and co-workers in the UK and India have now demonstrated a spin–photon interface based on two orthogonal waveguides, where the polarization emitted by a quantum dot is mapped to a path-encoded photon. The device consists of two orthogonal freestanding waveguides (about 200 nm wide) connected to four out-couplers. The waveguides were fabricated from a 140-nm-thick GaAs layer containing a single layer of InGaAs quantum dots. The photoluminescence observed vertically from the intersection of the waveguides showed two peaks corresponding to right and left circularly polarized transitions. Both peaks were also observed from the edges of the orthogonal waveguides. The interference of the photoluminescence from both peaks was simultaneously measured from the orthogonal waveguides, and it showed that the relative phase between the two peaks was close to π, confirming that the spin-up or -down state of the quantum dot is encoded in the relative phase between the waveguides. *NH*

QUANTUM CASCADE LASERS

Concentric circular gratings

Appl. Phys. Lett. **102,** 031119 (2013)



Terahertz (THz) quantum cascade lasers (QCLs) are promising light sources for THz applications such as spectroscopy, heterodyne detection and imaging. However, conventional edge-emitting ridge-waveguide THz QCLs suffer from multimode operation, extremely wide beam divergence and low output power. To overcome these drawbacks, Guozhen Liang and co-workers in Singapore, the UK and China have now demonstrated single-mode surface-emitting THz QCLs that use second-order concentric circular gratings (CCGs). The gold CCGs were fabricated on top of a conventional THz QCL mounted on a copper substrate. The CCGs were designed for single-mode emission at around 3.8 THz and surface emission for efficient and directional optical power out-coupling. The light–current–voltage characteristics of the device were compared with those of a similar device without CCGs. Although the threshold current density did not change greatly, the output power of the device with CCGs was about three times larger for the same level of electrical pumping. Another advantage of the CCG-based device was that its emission frequency was stable at all drive currents. *NH*

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