A round-up of recent papers in the field of photonics published by the physical sciences division of the Nature Publishing Group.


## A compact synchrotron radiation source driven by a laser-plasma wakefield accelerator

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Ultrashort light pulses are powerful tools for time-resolved studies of molecular and atomic dynamics. They arise in the visible and infrared range from femtosecond lasers, and at shorter wavelengths, in the ultraviolet and X-ray range, from synchrotron sources and free-electron lasers. Recent progress in laser wakefield accelerators has resulted in electron beams with energies from tens of mega-electron volts to more than 1 GeV within a few centimetres, with pulse durations predicted to be several femtoseconds. The enormous progress in improving beam quality and stability makes them serious candidates for driving the next generation of ultracompact light sources. Here, we demonstrate the first successful combination of a laser-plasma wakefield accelerator, producing 55–75 MeV electron bunches, with an undulator to generate visible synchrotron radiation. By demonstrating the wavelength scaling with energy, and narrow-bandwidth spectra, we show the potential for ultracompact and versatile laser-based radiation sources from the infrared to X-ray energies.

## Noise autocorrelation spectroscopy with coherent Raman scattering

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Coherent anti-Stokes Raman scattering (CARS) with femtosecond laser pulses has become a widespread method in nonlinear optical spectroscopy and microscopy. As a third-order nonlinear process, femtosecond CARS exhibits high efficiency at low average laser power. High sensitivity to molecular structure enables detection of small quantities of complex molecules and non-invasive biological imaging. Temporal and spectral resolution of CARS is typically limited by the duration of the excitation pulses and their frequency bandwidth, respectively. Broadband femtosecond pulses are advantageous for time-resolved CARS spectroscopy, but offer poor spectral resolution. The latter can be improved by invoking optical or quantum interference at the expense of increasing complexity of instrumentation and susceptibility to noise. Here, we present a new approach to coherent Raman spectroscopy in which high resolution is achieved by means of deliberately introduced noise. The proposed method combines the efficiency of a coherent process with the robustness of incoherent light. It does require averaging over different noise realizations, but no temporal scanning or spectral pulse shaping as commonly used by frequency-resolved spectroscopic methods with ultrashort pulses.

## Memory-built-in quantum teleportation with photonic and atomic qubits

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The combination of quantum teleportation and quantum memory of photonic qubits is essential for future implementations of large-scale quantum communication and measurement-based quantum computation. Both steps have been achieved separately in many proof-of-principle experiments, but the demonstration of memory-built-in teleportation of photonic qubits remains an experimental challenge. Here, we demonstrate teleportation between photonic (flying) and atomic (stationary) qubits. In our experiment, an unknown polarization state of a single photon is teleported over 7 m onto a remote atomic qubit that also serves as a quantum memory. The teleported state can be stored and successfully read out for up to 8 μs. Besides being of fundamental interest, teleportation between photonic and atomic qubits with the direct inclusion of a readable quantum memory represents a step towards an efficient and scalable quantum network.


## Hard-X-ray dark-field imaging using a grating interferometer

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Imaging with visible light today uses numerous contrast mechanisms, including bright- and dark-field contrast, phase-contrast schemes and confocal and fluorescence-based methods. X-ray imaging, on the other hand, has only recently seen the development of an analogous variety of contrast modalities. Although X-ray phase-contrast imaging could successfully be implemented at a relatively early stage with several techniques, dark-field imaging, or more generally scattering-based imaging, with hard X-rays and good signal-to-noise ratio, in practice still remains a challenging task even at highly brilliant synchrotron sources. In this letter, we report a new approach on the basis of a grating interferometer that can efficiently yield dark-field scatter images of high quality, even with conventional X-ray tube sources. Because the image contrast is formed through the mechanism of small-angle scattering, it provides complementary and otherwise inaccessible structural information about the specimen at the micrometre and submicrometre length scale. Our approach is fully compatible with conventional transmission radiography and a recently developed hard-X-ray phase-contrast imaging scheme. Applications to X-ray medical imaging, industrial non-destructive testing and security screening are discussed.

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