waves. A true coherent regenerator must operate independently and remotely from the data transmitter, with its only input being the freely transmitted signal.

In contrast, the regenerator developed by Slavík *et al.* is a true standalone 'black box'. Not only can the device operate remotely and in the absence of transmitter-supplied pump waves, but it also does not use any electronic processing to establish the reference signal required for phase-sensitive discrimination. The solution of Slavík *et al.* is simple, yet remarkably elegant. The signal is used as a pump in an auxiliary parametric mixer to create a weak but phase-locked copy of the strong wave. This copy is then injected into a free-running laser to generate the second strong wave, which is locked to the original signal phase. Subsequently, the two strong waves are used in a phase-sensitive mixer to perform true coherent regeneration. In practical terms, the device locks two free-running lasers (pumps) to the noisy signal using an ultrafast fibre nonlinearity, the response of which does not depend on the incoming signal speed.

Although this new device certainly deserves attention for its remarkable simplicity, the demonstrated results are of particular interest as they imply considerable technology potential. The team constructed a physical test-bed capable of rigorous performance characterization, with a sequence of two billion bits being used to measure noise removal in 10 Gbit s^{-1} and 40 Gbit s^{-1} channels. They were able to show that the regenerator can clean phase fluctuations of 50° and amplitude fluctuations of 50% (Fig. 1), as well as considerably improving receiver sensitivity.

This coherent regenerator would not have been possible without recent advances in parametric mixers and narrow-linewidth lasers. Low-noise, high-efficiency and speed-invariant parametric mixers — a key part of this work — were not viable until recently. The best mixer devices continue to be based on high-confinement silica fibres, which, after a decade of development, are still being qualitatively improved. This fact offers both an opportunity and a challenge: although the deployment of silica-based fibre devices poses no risk, will the perceived physical footprint of such devices hinder their widespread use? Recent promises of chip-based optical mixers comparable in performance to silica mixers[3,4] have not yet materialized but could be a preferable solution in terms of size and integration potential. However, as network demands grow, there is a little doubt that the first deployments of terabit channels based on coherent encoding schemes are just around the corner. ❐

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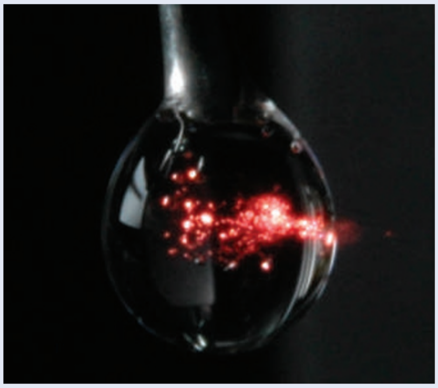
NONLINEAR OPTICS

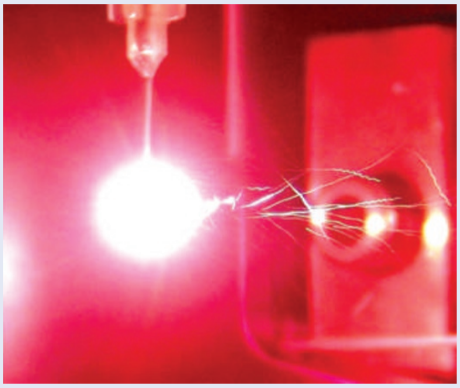
Water droplet emission

What happens when gigawatt peak-power femtosecond laser pulses interact with millimetre-scale water droplets? The answer, according to scientists in Russia, is the intense emission of visible light from a laser-induced plasma that forms within the droplets, with a strong spectral broadening as the laser power rises.

The self-focusing properties of transparent spherical water particles can create very intense optical fields, making them a potentially interesting tool for studying a variety of nonlinear optical effects. Yuri Geints and co-workers from the Zuev Institute of Atmospheric Optics in Tomsk and the Institute of Automation and Control Processes in Vladivostok have now investigated the dynamics of the interaction between laser pulses and water droplets as a function of laser power (*Opt. Lett.* **35,** 2717–2719; 2010). The researchers prepared large millimetre-size droplets, which have sufficient curvature and volume for realizing the required focusing effect.

They then focused femtosecond pulses from a Ti:Sapphire chirped-pulse amplification laser (with a central wavelength of 800 nm, repetition rate





of 1 kHz, pulse energy of 1 mJ and beam diameter of 7 mm) onto a droplet of distilled water. The peak power of the laser pulses was varied over the range of 1–25 GW. The droplet emission was measured by a spectrometer in the wavelength range of 195–1,150 nm.

The emission was sparkling white to the naked eye but orange–red when viewed through a neutral density filter. The areas of light emission within the droplet have a distributed and granulated structure, which is indicative of boiling. The researchers measured emission lines of N_2 in the droplet (near 430 and 575 nm), and estimated that the laser-induced optical breakdown caused a rise in temperature of approximately 1,000 °C.

For higher peak-power laser pulses with durations of less than 285 fs, the emission spectra widened dramatically and an extended pedestal formed around the incident wavelength of 800 nm. The authors believe that this is attributable to self-phase modulation effects of the laser pulses as they propagate within the droplet.

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