occurs in the BIC theory[1]. In contrast to the scalar problem[7], the vectorial nature of the BIC states uncovered by Gomis-Bresco and co-authors[3] may help to simplify the shape of dielectric microcavities, as was suggested for waveguiding systems.

The possibility to engineer modes into the BIC regime allows one to realize a supercavity with extreme Q-factor values in compact resonators[2]. The main problem in miniaturization is fitting a pair of orthogonal modes with comparable frequencies into a small volume. The recent progress on all-dielectric resonant nanophotonics[8] may enable a way to realize BICs at the nanoscale, achieving very high Q-factors. For example, birefringence of many high-index dielectric materials involving the vectorial nature of electromagnetic waves could be employed to reduce the resonator dimensions and support the modes coupled externally in the avoided crossing regime. Thus, we anticipate development of electromagnetic theory of vectorial resonances in high-index dielectric nanoparticles described in terms of the formalism employed in quantum mechanics. By engineering Q-factors of high-index dielectric resonators in the BIC regime, one could substantially enhance multipolar nonlinear effects[9], and develop unidirectional low-threshold lasers and realize strong-coupling regimes of nanoscale supercavities. ❐

Yuri Kivshar is at the Nonlinear Physics Center, Australian National University, Canberra, Australian Capital Territory 2601, Australia. Mikhail Rybin is at the Ioffe Institute, St Petersburg 194021, Russia. Yuri Kivshar and Mikhail Rybin are also at ITMO University, St Petersburg 197101, Russia.
e-mail: ysk@internode.on.net; m.rybin@mail.ioffe.ru

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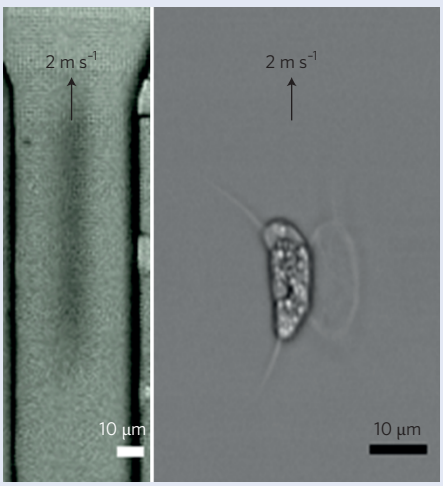
LASER IMAGING

Mapping cell dynamics at visible wavelengths

Ultrafast optical imaging is attractive and useful for applications involving fast dynamic monitoring and high-throughput screening. Optical time-stretch imaging stands out because of its MHz frame rate, defined by the repetition rate of the ultrafast, pulsed laser. However, owing to low temporal dispersion and high optical loss, it has been challenging to realize spatially resolved time-stretch imaging at the visible wavelengths demanded by many biological applications.

Tackling these pitfalls, Jiang-Lai Wu and co-workers now report an elegant solution they call free-space angular-chirp-enhanced delay (FACED) that offers a large dispersion-to-loss ratio and inherently provides an ultrafast all-optical laser-beam-stretching mechanism in the visible regime (*Light Sci. Appl.* **6,** e16196; 2017). Because the pulse-stretching concept used in FACED is based on wavelength-invariant geometrical optics, and hence does not necessarily entail chromatic dispersion, the time-stretch imaging can be implemented both with and without spectral encoding.

The FACED device consists of a pair of high-reflectivity angle-misaligned plane mirrors. Owing to the minute misalignment of <1 mrad, beam propagation can be viewed as a set of spatially chirped zigzag paths that eventually return to the input without escaping from the far end of the mirror pair. This substantially enhances the temporal delay of each path and thus significant temporal dispersion of >1 ns nm^{-1} (or pulse stretching of >10 ns) can be realized in a compact set-up (100–200 × 10–20 mm) without substantial optical loss (<6 dB) in free space, which is typically regarded as an ineffective medium for creating large temporal dispersion. In essence, FACED transforms an input pulsed beam into an all-optical scanned beam in space.



Wu and colleagues evaluated the basic imaging performance of their FACED-enabled visible-light bright-field time-stretch imaging scheme on stained biological tissue sections and live microphytoplankton at 710 nm at an effective line-scan rate of 10 MHz. They also demonstrated single-cell imaging in an ultrafast microfluidic flow of 2 m s^{-1} at 710 nm at a line-scan rate of 80 MHz. Compared with the image captured by a high-speed CMOS camera at 15,000 frames per second (left image), the time-stretch image of a single cell (right image) is blur-free with high image contrast and resolution, showing subcellular features. The team also demonstrated MHz fluorescence and colourized time-stretch microscopy in this unexploited visible spectrum. Further, they carried out the laser-scanning time-stretch imaging without the spectral encoding scheme. An image resolution comparable to that achieved with an ordinary bright-field transmission microscope was obtained.

The findings show the great potential of the technique, which will enable a wider application scope of high-speed and high-throughput biological microscopy. The researchers envisage that two-dimensional ultrafast dynamic imaging is also possible with an additional high-speed beam scanner in the orthogonal directions.

RACHEL WON