European XFEL

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"A brave new world of ultrafast optics in the mid-infrared"

by

Aleksei Zheltikov

Physics Dept., Intl. Laser Center, M.V. Lomonosov Moscow State University; Kurchatov Inst. Natl. Research Center, Moscow, Russia; Dept. of Physics & Astronomy, Texas A&M University; Russian Quantum Center, Skolkovo, Russia

Recent progress in the generation of high-power ultrashort pulses in the mid-infrared opens new horizons in ultrafast optical science and technologies, revealing unusual phenomena and unexpected properties of materials in the mid-infrared range and promising new, unprecedented opportunities for laser-filamentation-assisted long-range transmission of high-power laser radiation and standoff detection. With the critical power of self-focusing scaling as the laser wavelength squared, a longer-wavelength driver would radically increase the peak power and, hence, the laser energy in a single laser filament in the atmospheric air. The search for such drivers has been ongoing over two decades, during which time the available laser sources limited filamentation experiments in the atmosphere to the near-infrared and visible ranges. In our experiments, filamentation of ultrashort mid-infrared pulses in the atmosphere has been demonstrated for the first time. With the spectrum of a femtosecond laser driver centered at 3.9 μm, right at the edge of the atmospheric transmission window, radiation energies above 20 mJ and peak powers in excess of 200 GW can be transmitted, as our experiments show, through the atmosphere in a single filament. Our studies reveal unique properties of mid-infrared filaments, where the generation of powerful mid-infrared supercontinuum is accompanied by unusual scenarios of optical harmonic generation, giving rise to remarkably broad radiation spectra, stretching from the visible to the mid-infrared. Generation of few- and even single-cycle mid-infrared field waveforms with peak powers ranging from a few megawatts to hundreds of gigawatts has been demonstrated within a broad range of central wavelengths.

Host: Thomas Tschentscher