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Ultrafast nonlinear optics in the mid-infrared: from laser filaments to electron wave-packet dynamics in solids

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The mid-infrared spectral range is unique in many ways. Within this region, electromagnetic radiation can resonate with the most intense signature molecular bands, thus drastically enhancing the coupling between the field and molecular motions. Electrons driven by intense ultrashort mid-IR field waveforms acquire unusually high pondermotive energies within a fraction of the field cycle, giving rise to new regimes of high-field nonlinear optics. The λ^2 scaling of phase-space mode volume with radiation wavelength λ translates into the λ^2 dependence of the self-focusing threshold, allowing much higher peak powers to be transmitted in a single laser filament in the mid-IR range without losing beam continuity and spatial coherence. Recent breakthroughs in ultrafast photonics in mid-IR help understand complex interactions of high-intensity ultrashort mid-IR pulses with matter, offer new approaches for x-ray generation, enable mid-IR laser filamentation in the atmosphere, facilitate lasing in filaments, give rise to unique regimes of laser-matter interactions, and reveal unexpected properties of materials in the mid-IR range. Motivated and driven by numerous applications and long-standing challenges in strong-field physics, molecular spectroscopy, semiconductor electronics, and standoff detection, ultrafast optical science is rapidly expanding toward longer wavelengths. Experiments reveal unique properties of filaments induced by ultrashort laser pulses in the mid-infrared, where the generation of powerful supercontinuum radiation 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 has been demonstrated within a broad range of peak powers and central wavelengths. Below-the-bandgap high-order harmonics generated by ultrashort mid-infrared laser pulses are shown to be ideally suited to probe the nonlinearities of electron bands, enabling an all-optical mapping of the electron band structure in bulk solids. As a part of a bigger picture, laser-induced filamentation in the mid-infrared and intraband high-harmonic generation using ultrashort mid-infrared pulses offer important physical insights into the general properties of the nonlinear-optical response of matter as a function of the wavelength. Unlike their near-infrared counterparts, which can be accurately described within the framework of perturbative nonlinear optics, mid-infrared filaments often entangle perturbative and nonperturbative nonlinear-optical effects, showing clear signatures of strong-field optical physics. With the role of nonperturbative nonlinear-optical phenomena growing, as a general tendency, with the field intensity and the driver wavelength, extension of laser filamentation to even longer driver wavelengths, toward the long-wavelength infrared, promises *a hic sunt dracones* land.

Für diese Zeit steht eine Kinderbetreuung nach vorheriger Anmeldung zur Verfügung.

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