



PhD Thesis Defense MATTHIAS BAUDISCH 'High Power, High Intensity Few-Cycle Pulses in the Mid-IR for Strong-Field Experiments'

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Wednesday July 12, 11:00. ICFO Auditorium

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Attoscience and Ultrafast Optics

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High energy, few-cycle, mid-IR radiation sources featuring high pulse repetition rates are of tremendous interest for a variety of strong-field physics and attoscience applications. Such systems could be used in combination with the high harmonic generation process as novel,

tabletop, high flux X-ray radiation sources providing photon energies up to the keV level. Additionally, strong-field ionization experiments of atom and molecules could help unravel the underlying physics of photo-chemical reactions and molecular transformations. Nevertheless, implementing such sources remains challenging due to the absence of suitable mid-IR laser gain materials. One approach to overcome current limitations is optical parametric chirped pulse amplification (OPCPA). While this method is already commonly used in the visible and near-IR spectral range, just few demonstrations emitting mid-IR, high energy, few-cycle pulses meeting the stringent requirements set by strongfield physics experiments have been demonstrated. In this thesis is present our effort to push the performance of current high power, mid-IR OPCPA systems to overcome existing limitations and to match and even exceed the performance of similar visible and near-IR radiation sources.

We report on the design and implementation of a high efficiency, frequency up-conversion extension of the one-of-a-kind, high power, few-cycle, mid-IR OPCPA system located in the AUO group at the Institute of Photonic Sciences in Barcelona. The unique multi-color source provides optically synchronized, high energy, femtosecond outputs at wavelength ranging from the deep-UV up to the mid-IR regime and a high pulse repetition rate beyond 100 kHz. The short output pulse durations in combination with the all-optical synchronization scheme makes the source a unique tool to drive highly nonlinear and strong-field pump-probe experiments in the tunnel or multi-photon ionization regime.

In the second part, is reported the fundamental redesign and rebuild of the original high power, mid-IR source yielding the first implementation of a GW-level peak-power, mid-IR OPCPA system featuring simultaneously pulse repetition rates beyond 100 kHz. The upscaling of the pulse energy by a factor of 6 while maintaining the pulse repetition rate yields a mid-IR output average power of 19 W. In order to enable such high mid-IR average power, we performed an in-depth study of common, nonlinear mid-IR crystals in respect to their thermal, via residual absorption induced parametric amplification limitations.

In the third part, is presented one of the first realizations of few-cycle, mid- IR pulse self-compression via filamentary propagation in the anomalous dispersion regime in a bulk medium. The spectro-temporal behavior of the self-compressed pulses is studied as a function of the driving mid-IR pulse parameters resulting in temporal pulse shortening down to sub-3 optical cycles. We prove the suitability of this technique as compact and stable

post-compression method featuring CEP-stable, few-cycle pulse generation in the mid-IR spectral range.

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Thesis Director: Prof . Dr. Jens Biegert

