402ND WILHELM UND ELSE HERAEUS-SEMINAR

Novel Light Sources and Applications

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Book of Abstracts

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Monday, February 4

Chair: F. *Ehlotzky*

9.15–9.35 E. **Dreisigacker**,"Welcome by the Heraeus Foundation"

9.35–10.10 **A.** Bandrauk, S. Chelkowski, S. Kawai, and H. Z. Lu, "Effect of nuclear motion on ATI and HHG spectra in H2 and 02: the recoliision model revisited;

10.10–10.45 D. B. Milosevic, E. Hasovic, M. Busuiadzic, A. Gazibegovic-Busuladzic, and W. Becker, "High-order above-threshold ionization of atoms and molecules"

10.45–11.20 **A.** Saenz, "Molecules in intense laser pulses: frorn models to ab-initio treatments"

Chair: J. *Burgdörfer*

16.30–17.05 M. Vrakking," Attosecond time-resolved electron dynamics in the hydrogen rnolecular ion"

17.05–17.40 K. Taylor. J. S. Parker, L. R. Moore, K. J. Meharg, and G. S. J. Armstrong, "The HELIUM code from Ti:sapphire to xray laser waveiengths"

17.40–18.15 P. Coiosimo, G. Dourny, C. I. Blaga, J. Wheeier, J. Tate, F. Catoire, P. Agostini, L. F. DiMauro, and G. G. Pauius, "Above-threshold ionization spectra at mid-infrared wavelengths"

18.15–18.50 ***O.*** D. Mücke, "Advanced infrared sources for high-field science"

Tuesday, February 5

Chaic *S. Goreslavski*

8.45–9.20 **C.** Figueira de Morisson Faria, "Quantum interference in high-order harmonic generation and above-threshold ionization: frorn attosecond pulse trains to diatomic rnolecules"

9.20–9.55 K. Schiessl, K. L. Ishikawa, E. Persson, and J. Burgdörier, "Quantum path interference in high-harrnonic generation"

9.55–10.30 S. V. Popruzhenko and D. Bauer, " Strong-field ionization at arbitrary frequencies"

10.30–11.05 S. Pieper and M. Lein, "Channel closings in the strong-field ionization of molecules"

Advanced Infrared Sources for High-Field Science

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Intense phase-stable few-cycle laser pulses have numerous intriguing applications in attosecond science and high-field science including attosecond XUV/soft-X-ray pulse generation by high-harmonic generation (HHG), tomographic imaging of molecular orbitals, and laser-induced electron diffraction. A major challenge for using HHG in time-resolved studies of ultrafast molecular dynamics in excited electronic states, such as the dynamics in the vicinity of conical intersections of potential energy curves in polyatomic molecules, is that excited molecular states have low ionization potential I_p preventing generation of broad HHG spectra, which is a prerequisite for good tomographic reconstruction. The solution are laser sources with high ponderomotive energy $U_p \propto \lambda^2 I$ at moderate intensity level, i.e., infrared (1.5-2.5 μm), phase-stable, few-cycle, high-power laser systems. High-U_p-sources also open the door to experimental investigations of the λ-scaling laws of strong-field physics (Keldysh parameter $\propto\lambda^{-1}$, electron energies $\propto\lambda^2$, HHG cutoff $\propto\lambda^2$, HHG efficiency $\propto\lambda^{-5}$, minimum attosecond pulse duration $\propto\lambda^{-1/2}$ [1]), and they would benefit laser-induced electron diffraction because of the shorter de Broglie electron wavelength and consequently higher spatial resolution [2]. The main objective of our work is to generate IR pulses with ~40-fs duration that fully satisfy the requirements for external spectral broadening in gas [3]. In addition, with an IR pulse we expect to surpass the energy limitation (4-5 mJ at 0.8 μm) for gas broadening schemes because the critical power of self-focusing also scales as λ^2.

In the past, e.g., to push the HHG cutoff to ever higher photon energies, terawatt Ti:sapphire amplifier systems at 0.8 μm have been developed culminating in keV soft-X-rays generated by HHG in helium [4]. A technological problem hindering further progress is gas ionization in the gas-filled hollow-fiber compressors required to achieve few-cycle pulse duration at pulse energies >1 mJ. More fundamentally, helium already saturates for intensities $\gtrsim$1 PW/cm^2 and few-cycle pulses at 0.8 μm, thus the HHG cutoff and photon flux is limited by ground-state depletion in helium in these experiments.

Recently, Optical Parametric Chirped Pulse Amplification (OPCPA) [5] has attracted enormous attention as promising alternative to the traditional Ti:sapphire-based amplifier systems. The main advantages of OPCPA are large single-pass parametric gain, large 'engineerable' gain bandwidth supporting few-cycle pulses, and absence of thermal loading problems. Most importantly, OPCPA allows the generation of multi-mJ pulses in the IR region that is so far unreachable to stimulated-emission-based laser amplifiers.

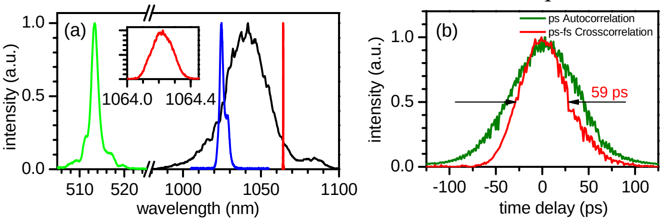

Fig. 1. Optical synchronization of the Yb:KGW and Nd:YAG amplifiers. (a) Laser spectra: Kerr-lens mode-locked Yb:KGW oscillator (black), Yb:KGW regenerative amplifier (blue), Nd:YAG with an intracavity 2-mm-thick etalon (red), and SHG of Yb:KGW (green). (b) Pulse measurement of the ps amplifier, showing an autocorrelation and a cross-correlation between the Yb:KGW (~200-fs) and Nd:YAG pulses (60 ps).

In this talk, we present our ongoing prototype development of a multi-mJ all-optically synchronized (Fig. 1) and phase-stable OPCPA at 1.5 μm: (1) with the advent of a mature 200-fs Yb:KGW DPSS MOPA system (Pharos, Light Conversion, Ltd.) it became possible to abandon the Ti:sapphire front-end; (2) we avoid working close to the signal-idler wavelength degeneracy and reduce the quantum defect for the signal wave; (3) as in Refs. [7], we employ (nearly) collinear Type II phase matching that, as opposed to Type I, supports a much narrower bandwidth but is free of parasitic self-diffraction.

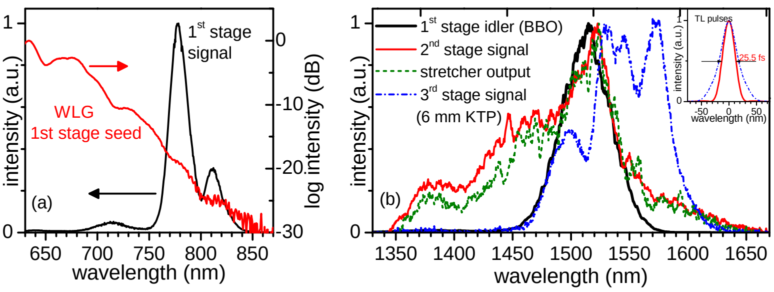

Fig. 2. Spectral properties of the 3-stage parametric amplifier. (a) NIR seed and signal spectra of the 1st stage. (b) IR phase-stable seed and amplified spectra of stages 2 and 3. The 3rd stage is pumped by flash-lamp pumped Nd:YAG amplifier (Ekspla Ltd.) operating at 20 Hz. As a prospective higher-repetition-rate pump system for the future, diode-pumped cryogenically-cooled fs Yb sources are developed in parallel.

At present, the energy of the amplified 1.5-μm signal wave after the 3rd stage (see Fig. 2) is 3.9 mJ using an ~30-mJ 1064-nm pump and is limited by an AR coating damage on the output crystal surface by the IR waves. Current work aims to increase the output energy and recompress the pulse.

References:

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