European Optical Society — Coherence for Europe ®

EOS Annual Meeting (EOSAM) 2021

13-17 September 2021, Sapienza University of Roma- Engineering Faculty, Via Eudossiana, 18, 00184, Roma RM, Italy

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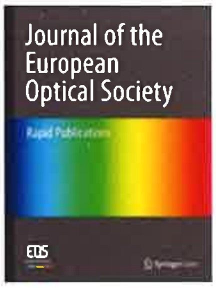

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Session Overview

Session

TOM13 S01: Ultrafast: New trends in ultrafast photonics

Time: **Monday, 13/Sept/2021: 8:15 - 10:30**
Session Chair: **Lucile Rutkowski**, Institute of Physics of Rennes, France

Location: **Aula 1**
1st floor

Presentations

8:15 - 8:45
Invited
ID: 391 / TOM13 S01: 1
TOM 13 Ultrafast Optical Technologies and Applications

Machine learning: a new tool for ultrafast photonics applications

Goery Genty
Tampere University, Finland

In this talk, we review the recent developments in machine learning applications to ultrafast photonics with emphasis on the study of complex dynamics and transient instabilities.

8:45 - 9:00
ID: 430 / TOM13 S01: 2
TOM 13 Ultrafast Optical Technologies and Applications

Neural network prediction of supercontinuum generation dynamics

Lauri Salmela[1], Mathilde Hary[1,2], John M. Dudley[2], Goëry Genty[1]
[1]Tampere University, Finland; [2]Institut FEMTO-ST, Université Bourgogne Franche-Comté CNRS UMR 6174, France

We introduce a new approach based on two neural network architectures for mimicking the nonlinear propagation dynamics of ultrashort pulses in optical fibers for supercontinuum generation, allowing for significant memory and speed improvements compared to the conventional approach of numerically integrating the generalized nonlinear Schrödinger equation.

9:00 - 9:15
ID: 168 / TOM13 S01: 3
TOM 13 Ultrafast Optical Technologies and Applications

Robust self-referenced Generator of programmable multi-millijoule terahertz-rate Bursts

Vinzenz Stummer[1], Tobias Flöry[1], Edgar Kaksis[1], Audrius Pugzlys[1,2], Andrius Baltuska[1,2]
[1]TU Wien, Austria; [2]Center for Physical Sciences & Technology, Lithuania

We demonstrate a technique for the programmable generation and multi-millijoule amplification of ultrashort pulse bursts, which can be applied to any master-oscillator regenerative-amplifier system with very low implementation complexity and high stability in burst-mode operation.

9:15 - 9:30
ID: 329 / TOM13 S01: 4
TOM 13 Ultrafast Optical Technologies and Applications

Mid-infrared laser filaments for local modification of atmospheric aerosol densities

Valentina Shumakova[1,2], Elise Schubert[3], Skirmantas Alisauskas[1], Denis Mongin[3], Mary Mattews[3], Tadas Balciunas[3], Audrius Pugzlys[1,4], Jerome Kasparian[3], Andrius Baltuska[1,4], Jean-Pierre Wolf[3]
[1]Photonics Institute, TU Wien, Austria; [2]University of Vienna, Faculty of Physics, Faculty Center for Nano Structure Research, Christian Doppler Laboratory for Mid-IR Spectroscopy and Semiconductor Optics, Austria; [3]GAP, Université de Genève, Switzerland; [4]Center for Physical Sciences & Technology, Lithuania

Laser-Induced Aerosol Formation (LIAF), driven by UV and near-IR filaments, relies on the nitrogen photo-oxidative chemistry, triggered by photoionization and leading to the production of HNO3, stabilizing the growth of aerosol. Mid-IR filaments were expected to be less efficient due to their lower photoionization rates. However, we observed surprisingly high yields of aerosols, generated by mid-IR laser pulses, which cannot be fully explained by the HNO3-pathway. Therefore, we suggest a new mechanism of LIAF, based on the resonant excitation of volatile organic compounds, enabled by the spectral broadening during filamentation.

9:30 - 9:45
ID: 392 / TOM13 S01: 5
TOM 13 Ultrafast Optical Technologies and Applications

Ultrafast pulse-shaping modulates perceived visual brightness in living animals

Geoffrey Gaulier[1], Quentin Dietschi[2], Swarnendu Bhattacharyya[3], Cedric Schmidt[1], Matteo Montagnese[1], Adrien Chauvet[1], Sylvain Hermelin[1], Florence Chiodini[4], Luigi Bonacina[1], Pedro L. Herrera[5], Ursula Rothlisberger[3], Ivan Rodriguez[2], Jean-Pierre Wolf[1]

Robust Self-Referenced Generator of Programmable Multi-Millijoule THz-Rate Bursts

Vinzenz Stummer[1*], *Tobias* Flöry[1], *Edgar* Kaksis[1], *Audrius* Pugžlys[1,2] and *Andrius* Baltuška[1,2]

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[2]Center for Physical Sciences & Technology, LT-02300 Vilnius, Lithuania

Abstract. We demonstrate a technique for the programmable generation and multi-millijoule amplification of ultrashort pulse bursts, which can be applied to any master-oscillator regenerative-amplifier system with very low implementation complexity and high stability in burst-mode operation.

The generation of ultrashort laser pulse bursts has already contributed to many applications such as materials processing [1], pulsed laser deposition [2], laser induced breakdown spectroscopy (LIBS) [3] and seeding of free electron lasers [4]. Currently, there is a rising demand on burst sources providing terahertz (THz) intraburst repetition rates or higher corresponding to pulse spacings in the order of a few picoseconds, given by applications such as resonant driving of optical nonlinearities [5], time-resolved nonlinear spectroscopies [6], coherent control of quantum systems [7] or as driver for secondary radiation sources, e.g. generation of THz bursts [8].

However, the amplification of bursts to multi-millijoule energies at THz intraburst repetition rates is highly problematic. This is given by the appearance of spectral modes, that are formed by interpulse spectral interference of closely spaced pulses, and their mapping from the frequency- into the time-domain when applying chirped pulse amplification (CPA). The latter results from the fact that pulses are temporally strongly chirped and thus overlapping, because of spacings much lower than the stretched pulse duration. These spectral modes lead to insufficient energy extraction in an amplifier and, if not stabilized over time in their frequency positions, to temporally unstable burst generation. Recently, we have successfully demonstrated energy-safe, stabilized chirped-pulse amplification of ultrashort pulse bursts with THz intraburst frequencies up to multi-millijoules by applying Vernier-enabled phase-modulation techniques, breaking the mentioned energy-limiting barrier [8]. In this contribution, we demonstrate a new version of our burst-generation technique, which drastically lowers system complexity compared to our previous approach, allowing its application to any master-oscillator (MO) regenerative-amplifier (RA) combination setup with only minor modifications.

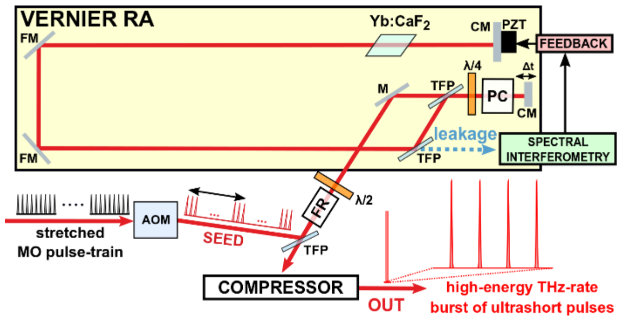

Fig. 1. Schematics of the MO-RA burst generation setup. The temporal intraburst pulse spacing can be set by moving an end mirror, thus changing the RA roundtrip time. By applying spectral interferometric techniques, the roundtrip detuning information is extracted and fed back to a piezoelectric transducer, which controls roundtrip time.

Our setup can be seen in Fig. 1, which is based on a MO-RA combination with a round-trip time difference Δt, giving the temporal spacing of burst pulses and hence the intraburst repetition rate (Vernier effect). The MO pulse train with MHz repetition rate is stretched to several hundreds of picoseconds and burst seed pulses are picked by an acousto-optical modulator (AOM), which allows modulation of amplitudes and phases of individual pulses. Direct Δt-stabilization is achieved via spectral interferometry by investigating the buildup signal from the RA. Fig. 2 shows the spectrum of the buildup signal, of its Fourier-transform and of the amplified burst. Phases are modulated for every individual pulse in such a way, that spectral modes are reduced to improve energy extractability from the amplifier (phase-scrambling). However, independent on mode suppression, the Fourier-transform always shows a clear signal at a position which corresponds to the pulse spacing Δt (dashed line in Fig. 2b). Thus, one is able to stabilize burst performance without the need of any separate reference. There are only two requirements that need to be fulfilled by an MO-RA setup to operate in this type of burst-mode: 1. The difference in roundtrip time needs to be matched to the

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desired pulse spacing Δt. 2. The RA Pockels Cell needs to be able to run at zero, intermediate and full-voltage levels, which refer to an open, burst-accumulating and closed cavity, respectively.

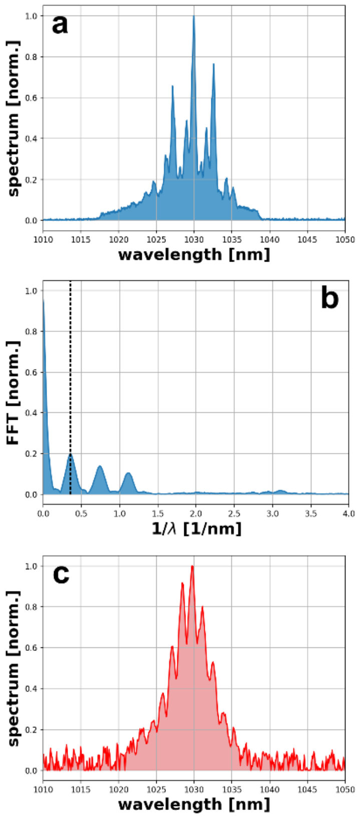

Fig. 2 Spectrum of a) reference buildup signal from the RA cavity. b) Fast Fourier Transform (FFT) of the buildup spectrum. c) amplified burst. The dashed line marks the position, which corresponds to the fundamental intraburst pulse spacing.

Fig. 3 shows the temporal evolution of the spectrum of an unscrambled burst, showing an instability of the interference fringes caused by the pulse spacing drift, introduced by relative cavity length drifts. By evaluation of the cavity detuning signal in Fig. 2b, and by application of a PID control loop, drifts are compensated leading to stable burst spectra. One can see, that the pulse spacing Δt is directly stabilized by stabilizing the buildup signal, which was measured with a higher resolution to optimize stabilization performance and in which even the less pronounced side modes survive during stabilization when integrating over 30 seconds. Finally, this leads to a pulse-to-pulse phase stabilization within a mean deviation of 0.0137π from its target values.

References

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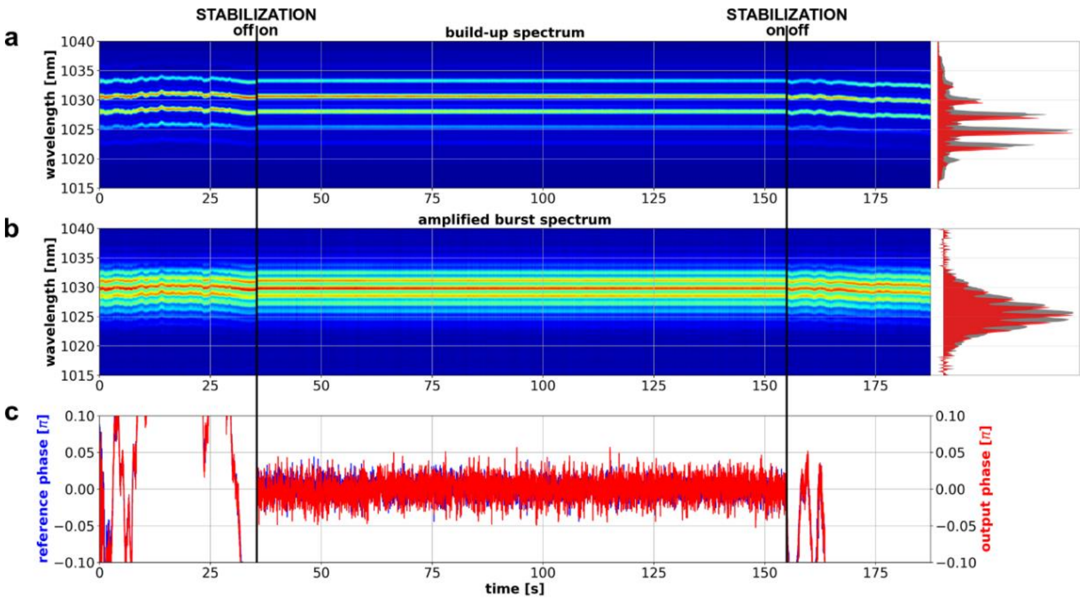

Fig.3: Amplified spectrum over time of a) reference buildup b) amplified burst. The on-set/off-set of stabilization is depicted by black lines. The inlay shows a spectrum integrated over 30 seconds, both non-stabilized (grey) and stabilized (red). A high-resolution spectrometer (OceanOptics HR4000) was used for the reference, while for the amplified signal the SHG spectrum was measured with less resolution (OceanOptics USB2000). c) The phase extracted from the reference point, corresponding to the fundamental intraburst pulse spacing, over time.