



Program of the workshop

September 16th and 17th 2016

Stirin castle, Prague

Future Of Ultrashort Pulses II

Website: <http://www.future-of-ultrashort-pulses.de/>

Email: foup@mpq.mpg.de



15:00- 15:10

introductory remarks

Session 1

Chairman: Dr. Joachim Pupeza

15:10-15:45

Prof. Alfred Leitenstorfer

University of Konstanz, Germany

Title: Subcycle Quantum Electrodynamics

Abstract: A time-domain approach that gives access to the quantum properties of light is presented, covering the entire mid-infrared and terahertz frequency ranges. Ultrabroadband electro-optic sampling with few-femtosecond and highly stable laser pulses allows direct detection of the vacuum fluctuations of the electric field in free space [1,2]. Besides the Planck and electric field fundamental constants, the variance E^2 of the ground state is determined solely by the inverse of the four-dimensional space-time volume over which a measurement process or physical system integrates. Therefore, we can vary the contribution of multi-terahertz vacuum noise in the statistical readout of our technique and discriminate against the trivial shot noise due to the constant flux of near-infrared probe photons. Subcycle temporal resolution and nonlinear coupling off resonance provide signals even from purely virtual photons, enabling access to the ground-state wave function without amplification to finite intensity.

Recently, we have succeeded in generation and analysis of mid-infrared squeezed transients with quantum noise patterns that are time-locked to the intensity envelope of the probe pulses. We find subcycle temporal positions with a noise level distinctly below the bare vacuum input which serves as a direct reference for the relative variance of the electric field. Delay times with increased differential noise indicate generation of highly correlated photons by spontaneous parametric fluorescence. Our time-domain approach offers a generalized understanding of spontaneous emission processes as a consequence of local anomalies in the co-propagating reference frame modulating the quantum vacuum, in combination with the boundary conditions set by Heisenberg's uncertainty principle.

[1] C. Riek et al., Science **350**, 420 (2015)

[2] A. S. Moskalenko et al., Phys. Rev. Lett. **115**, 263601 (2015)

15:45-16:20

Dr. Christian Ott
**Max Planck Institute of nuclear
Physics, Heidelberg, Germany**

Title: Attosecond Transient Absorption Spectroscopy - Measuring Dynamics of Correlated Electrons

Abstract: The technique of attosecond transient absorption spectroscopy (ATAS) has gained lots of interest in recent years. It combines direct spectroscopic and state-resolved access to bound electron dynamics in atomic systems with the perspective of measuring and controlling their intrinsic correlated dynamics on their natural time scale. Using ultrashort pulses, a unique access is gained to the fundamental interaction of light with matter, where the emitted light is measured interferometrically, and phase information is retrieved by identifying changes in the recorded spectroscopic line shapes. Here, the continuous tunability of the laser intensity is an important control parameter that allows to connect different regimes, from natural quasi field-free environments up to the manipulation of electronic dynamics in strong fields. Finally, recent progress is presented on employing ATAS to measure ultrafast dynamics in strongly correlated solid state systems, where the ultrafast insulator-to-metal phase transition in vanadium dioxide is followed in real time. Enabled by the combined temporal resolution and spectroscopic access, this approach allows for the separation of excited hot carrier dynamics from the intrinsic change in the electronic structure that is associated to the phase transition.

16:20-16:45

coffee break

Session 2	Chairman: Dr. Hanieh Fattahi
16:45-17:20	Prof. Nader Engheta University of Pennsylvania, U.S.A

Title: Extreme Metamaterials and Near-Zero Photonics

Abstract: Recent development in nanotechnology, nanoscience and materials science and engineering has provided opportunities to engineer structures with unprecedented attributes and characteristics in manipulating waves and fields. We are exploring wave-matter interaction in platforms with extreme scenarios, such as near-zero permittivity and near-zero permeability, and with extreme features such as very high phase velocity, very low energy velocity, nonreciprocal vortices at the nanoscale, giant anisotropy and nonlinearity, “near-zero” photonics, nanoscale computation with optical nanocircuits, and more. Such “extreme metamaterials” will provide us with exciting features and functionalities for wave-based paradigms such as optics, acoustics, and thermodynamics. I will discuss some of our ongoing work in these fields, will present some of the opportunities and challenges, and will forecast some future directions and possibilities.

17th of September	
Session 3	Chairman: Olga Razskazovskaya
9:00-9:35	Dr. Guenter Steinmeyer Max Born Institute, Berlin, Germany

Title: Characterization and measurement of few-cycle pulses

Abstract: In the past 20 years, several techniques emerged that enable the full characterization of the shape of an ultrashort pulse in amplitude and phase. The pioneering technique is frequency-resolved optical gating (FROG), which can also be seen as the prototypical tomographic pulse measurement technique. A few years later, spectral-phase interferometry for direct electric-field reconstruction (SPIDER) appeared as an alternative technique with similar capabilities. Further complementary techniques like d-scan, 2DSI, and MIIPS followed up. For all demonstrated techniques, numerous variants have been demonstrated, with varying suitability for few-cycle pulses. Ultimately, limiting problems are imposed by phase-matching issues, by overlapping fundamental and nonlinearly generated spectra, and, in non-collinear geometries, due to beam smearing. Another plaguing problem is the possible appearance of coherent artifacts, which may give rise to erroneous interpretations of measurement results. This talk will give some advice on what to try and what to absolutely avoid when pulse durations approach the single-cycle barrier that seems to magically limit all available measurement techniques.

9:35-10:10	Dr. Lukas Gallmann, ETH, Zurich, Switzerland
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Title: Advanced quasi-phase-matching structures for ultrabroadband parametric amplification

Abstract: High-average-power sources of few-cycle pulses based on optical parametric amplification are presently a hot topic in ultrafast amplifier development. Most systems presented to date are based on conventional birefringent phase-matching. We discuss several advanced schemes based on quasi-phase matching that provide highly customizable ultrabroadband gain and address some of the design challenges of conventional systems. We successfully demonstrated these technologies on a high-repetition-rate mid-infrared optical parametric chirped-pulse amplifier (OPCPA) system. We also provide an overview of our recent results on non-dipole strong-field interactions. These studies were enabled by our OPCPA source

and demonstrate how the emerging ultrafast pulse technologies yield access to new regimes of strong-field and attosecond physics.

10:10-10:30

coffee break

Session 4

Chairman: Dr. Vladislav Yakovlev

10:30-11:05

Dr. Georg Korn

ELI Beamlines, Czech Republic

Title: Extreme Light Infrastructure: Exceeding the ultra-relativistic interaction regime using super - short optical pulses at the Kilojoule level

Abstract: We will be giving an overview on ELI-Beamlines high power lasers and experimental areas which are dealing with ultra-intense laser plasma and laser vacuum interaction. A way of bringing the 10 PW (150fs, 1.5 kJ) laser to over 250 PW will be discussed.

This paves the way to intensities well over 10^{24} W/cm² allowing experiments beyond the ultra-relativistic regime in which protons become relativistic do to the interaction with the high laser field on the length of one wavelength of the laser driver. In principle this laser technology can be extended to the Exawatt regime which could be reached with 10 kJ, 10fs pulses. In this case the field in the focus could reach 10^{-3} - 10^{-2} of the Schwinger field and besides pair creation which would be the manifestation of the most promising nonlinear vacuum effect a new strong field phenomenon will occur, the generation of electromagnetic cascades.

11:05-11:40

Prof. Laszlo Veisz

Umeå University, Sweden

Title: Next generation light source for relativistic attosecond physics

Abstract: The development of attosecond as well as ultra-relativistic laser-plasma physics calls for more and more sophisticated drivers lasers in the single-cycle pulse duration regime with ever increasing energy. A fundamental step has been made in this direction by developing Light Wave Synthesizer 20 (LWS-20), an optical parametric synthesizer based an optical parametric chirped pulse amplification combining two complementary spectral regions to approach a full octave. LWS-20 routinely generates pulses with 80 mJ energy and sub-2-optical-cycle length focusable to ultra-relativistic intensity (10^{20} W/cm²) with excellent contrast for

demanding laser-solid interactions. The system allows novel investigations of field-dependent plasma physics phenomena and nonlinear interaction of energetic attosecond pulses, which experiments are conducted in our laboratory.

11:40

Prof. Ferenc Krausz
MPQ, Munich, Germany