“The CHEOPS Mission: Goals and Challenges”

Willy Benz, from the Physics Institute of the University of Bern

The CHaracterising ExOPlanet Satellite (CHEOPS) is a mission jointly led by Switzerland and ESA which was selected in October 2012 as the first small-class mission in the ESA Science Programme. CHEOPS will be the first space observatory dedicated to search for transits of exoplanets by means of ultrahigh precision photometry on bright stars already known to host planets. This will allow a first order characterisation of the planets’ internal structure (i.e. the determination of the mean density, which provides direct insights into its composition). CHEOPS will also provide precise radii for new planets discovered by the next generation of ground- and space-based transits surveys.
Modern clinical practice relies on multimodal imaging for diagnosis and patient-tailored therapy. Within this scope we develop novel ultrasound (US)-based techniques, to complement conventional pulse-echo sonography with spatially resolved images of diagnostically relevant physiological parameters. This presentation summarises the achievements that we accomplished during the past two years: In the field of optoacoustic (OA) imaging, we have demonstrated, in phantoms and in volunteers, the feasibility of quantitatively determining the blood oxygen saturation (SO2) inside blood vessels. In the field of speed-of-sound (SoS) imaging, we have obtained volunteer results that show the clinical applicability of computed ultrasound tomography in echo-mode (CUTE) and its promise for diagnosing liver disease. In addition we set up a through-transmission US tomography system and are developing algorithms for fast and robust breast SoS imaging. The highlights will be presented along with briefly discussing the most important challenges and solution strategies.
Microwave Remote Sensing from Space: IAP Contribution to the MetOP-SG Instruments MWS and ICI

Axel Murk, from the Microwave Physics Department

The talk will give an introduction to microwave remote sensing and the instruments which are developed at IAP. It will then focus on two instruments which are currently developed for the second generation of operational meteorological satellites MetOP-SG. For these instruments we are developing the on-board calibration targets and an on-ground calibration target, which will be briefly described. In addition we are characterizing the reflector losses of all MetOP-SG radiometers over a wide frequency range using a free space resonator and waveguide cavity techniques.
Posters

BIOMEDICAL PHOTONICS

A novel model for quantitative SoS imaging in handheld ultrasonography

M. Jaeger¹, M. Kuriakose¹, P. Stähli¹, A. Berzigotti², M. Frenz¹

¹Biomedical Photonics, Institute for Applied Physics, University of Bern, Switzerland
²Universitätsklinik für Viszerale Chirurgie, Bern University Hospital

Computed ultrasound tomography in echo mode (CUTE) is a novel technique for imaging the spatial distribution of speed of sound (SoS) inside tissue, which may improve the diagnostic value of clinical ultrasonography via monitoring tissue composition. Apart from providing tissue contrast, an absolute SoS value is highly desirable which would allow an operator-independent quantitative diagnosis of e.g. liver disease progression. We have developed a novel physical model of how the spatial distribution of SoS relates to the measured quantity – the local echo phase shift when changing the angle of ultrasound transmission and reception. The subsequent space-domain solution of the corresponding inverse problem results in improved quantitative reconstruction and delineation of SoS contrast in phantom studies.

Receive steering for speed-of-sound imaging inside flowing blood

M. Kuriakose¹, J. W. Muller¹,², M. Frenz¹, M. Jaeger¹

¹Biomedical Photonics, Institute for Applied Physics, University of Bern, Switzerland
²Department of Cardiovascular Biomechanics, Biomedical Engineering, Technical University of Eindhoven, Netherlands

Computed Ultrasound Tomography in Echo mode (CUTE) was developed to image the speed-of-sound (SoS) inside tissue using echo ultrasound, based on measuring the phase shift of reconstructed echoes when insonifying the tissue under varying transmit (tx) angles. One promising target of CUTE is the diagnosis of atherosclerotic plaque inside the carotid artery. However, substantial blood motion during the acquisition of a typically required number of tx angles leads to decorrelation of echoes, and has so far inhibited
successful results. To solve this problem, we propose receive (rx) steering as opposed to tx steering: Only few tx angles are used, but for each tx angle, echoes are reconstructed for a variety of different rx angles. The data corresponding to different rx angles can thus be obtained from a single acquisition, enabling robust echo phase tracking across different view angles without the influence of blood motion. In a phantom study, we have demonstrated that rx steering is equivalent to tx steering in terms of the resulting echo phase shift and reconstructed SoS images.

3.................................................................................................................................

Anthropomorphic oil/gel breast phantoms

P. Stähli, M. Jaeger, C. Etter, M. Frenz

Biomedical Photonics, Institute for Applied Physics, University of Bern, Switzerland

To examine new ultrasound-based imaging modalities, anthropomorphic phantoms that mimic acoustic properties (speed of sound, echogenicity, attenuation) and realistic tissue complexity are essential tools. Longevity, mechanically robustness, low manufacturing costs and non-toxicity are also important considerations. Among the available approaches, Oil-in-gel emulsions provide realistic speed of sound and echogenicity where the former is determined by the oil/water ratio and the latter can be independently adapted by adding further ingredients such as cellulose or glass microspheres. To verify the phantom production process, breast phantoms based on a 2D design were produced, providing an undulated fat layer around a glandular inner core containing cylindrical inclusions. To characterize these breast phantoms, a 2D ultrasound tomography setup was designed based on a linear single element transmitter and a commercial linear array probe as a receiver, both coupled to acoustic windows in the walls of a water tank. SoS reconstruction is non-iterative and is based on analyzing the time-of-arrival of detected US pulses after propagation through the phantom.

4.................................................................................................................................

Frequency-Domain Reconstruction in Optoacoustic Microscopy and the Ominous Coherence Factor

F. Spadin¹, M. Jaeger¹, R. Nuster², P. Subochev³, M. Frenz¹

¹Biomedical Photonics, Institute for Applied Physics, University of Bern, Switzerland
²Institute of Physics, University of Graz, Austria
³University of Nizhny-Novgorod, Russia

In Optoacoustic Microscopy, images are formed from measured acoustic transients which are collected in a time-resolved manner. Due to the geometry of the detection, the recorded signals exhibit strong distortions, necessitating the use of a reconstruction algorithm in order to obtain a meaningful image. While time-domain delay-and-sum algorithms are the most widely used, an alternative fourier-domain algorithm is shown
and compared. We show how a fourier-based approach can return the same result while being much faster to compute. We also investigate the concept of the coherence factor, a measure commonly used to improve the apparent image quality, and show why it should not be mistaken as a means to increase resolution or SNR of the image.

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Clutter reduction methods in epi-optoacoustic imaging: a comparative study

T. Petrosyan, M. Frenz, M. Jaeger

Biomedical Photonics, Institute for Applied Physics, University of Bern, Switzerland

In epi-optoacoustic (OA) imaging, optical components are attached or directly integrated into the ultrasound probe, providing single-handed probe guidance for flexible imaging of the human body. Such a setup, however, generates clutter signals originating from optical absorption at the tissue irradiation site near the probe, reducing contrast and imaging depth. To increase imaging depth towards the noise limit, various clutter reduction techniques have been proposed: (1) Displacement compensated averaging (DCA) employs the clutter decorrelation that results from quasi-static tissue deformation when palpating the tissue with freehand probe motion. (2) Photoacoustic-guided focused ultrasound (PAFUSion) uses ultrasound pulse-echo acquisitions to mimic reflection artefacts, which can then be subtracted from the OA image for clutter reduction. (3) In localized vibration tagging (LOVIT), a focused ultrasonic pushing beam transiently displaces optical absorbers at its focus and thus leads to a phase shift of OA signal originating from this focal region inside the tissue. Subtraction of OA acquisitions before and after the push highlights OA signals from the focus but eliminates clutter from outside the pushing beam. In this study, we compare DCA, PAFUSion and LOVIT in terms of clutter reduction efficiency for different imaging depths and laser irradiation geometries, where all the three techniques can be implemented in a single custom built setup.

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In-vivo SO\textsubscript{2} level imaging of arteries and veins in a human forearm using optoacoustic multiple-irradiation-sensing


Biomedical Photonics, Institute for Applied Physics, University of Bern, Switzerland

Spectral optoacoustic (OA) imaging enables spatially-resolved measurements of the blood oxygenation (SO\textsubscript{2}) level in distinct blood vessels, due to the difference in the optical absorption spectra of oxygenated and deoxygenated blood. The unknown extent of the wavelength-dependent optical attenuation inside the surrounding tissue, however,
renders deep quantitative SO$_2$ imaging extremely challenging. We show that a correction for this spectral distortion can be achieved on a broad spectral range, based solely on OA imaging using the OA multiple-irradiation sensing (OA-MIS). The tissue is modeled as a strongly scattering background, in which a discrete number of blood vessels are sparsely distributed with an excess absorption with respect to said background. OA signals generated by the vessels, which serve as “intrinsic fluence detectors”, are recorded as a function of irradiation position. We have developed an empirical light diffusion model that is fitted to the recorded signals so as to retrieve the background optical properties for arbitrarily shaped tissues.

With the purpose of investigating the performance of OA-MIS for in-vivo SO$_2$ level imaging of blood-carrying vessels in a human forearm, we present the outcome of OA-MIS measurements on a non-trivial forearm mimicking tissue phantom (i.e. presence of optically absorbing heterogeneities (e.g. network of blood vessels), in addition to lateral and arbitrarily shaped sample confining boundaries). We conclude by showing initial results of an in-vivo case study performed on the forearm of a human volunteer. The calculated two-dimensional SO$_2$ maps highlight the relevance to account for the spectral attenuation when aiming at deep in-vivo SO$_2$ level imaging, allowing after spectral correction for the spatially-resolved estimation of physiologically realistic SO$_2$ levels of arterial and venous blood.

### Spectral correction for handheld optoacoustic (OA) imaging by means of near-infrared optical tomography (NIROT) in reflection mode: a feasibility study

L. Ulrich$^1$, L. Ahnen$^2$, H. G. Akarçay$^1$, K. G. Held$^1$, M. Jaeger$^1$, S. Sánchez Majos$^2$, M. Wolf$^2$, M. Frenz$^1$

$^1$Biomedical Photonics, Institute for Applied Physics, University of Bern, Switzerland  
$^2$University Hospital Zurich, Division of Neonatology, Frauenklinikstrasse 10, CH-8091 Zürich

In vivo imaging of tissue/vasculature oxygen saturation levels is of prime interest in many clinical applications, e.g., for the early detection of cerebral ischemia in preterm infants. To this end, we investigated the feasibility of combining two complementary imaging modalities, optoacoustics (OA) and near-infrared optical tomography (NIROT), both operating non-invasively in reflection mode. Experiments were conducted on optically heterogeneous phantoms, aimed at modeling tissue at two different points in time, before and after the occurrence of a perturbation, caused, e.g., by hemorrhages. OA imaging was used to resolve submillimetric vessel-like optical absorbers at different depths (up to 25 mm), yet with a spectral distortion in the OA signals caused by the wavelength-dependent attenuation of light in tissue. NIROT measurements were utilized to image the perturbation in the background and to estimate the light fluence inside the phantoms at the wavelength pair (760 nm, 830 nm). This enabled the spectral correction of the vessel-like absorbers’ OA signals: the slopes of their absorption spectra between the two wavelengths were retrieved with 10-20% inaccuracy, which suggests that absolute oxygen saturation levels can be determined with <10% inaccuracy. These results rely on
the proper identification/quantification of the OA signals emanating from vessels, necessitating adequate segmentation methods and a statistical signal evaluation.

Fig. 1 Hybrid optoacoustic (OA) imaging and near-infrared optical tomography (NIROT) on phantoms: oxygen saturation level (SO₂) maps within submillimetric vessels are completed in the background by the relative change in the absorption ($\mu_a$) between two points in time, before and after the occurrence of a simulated perturbation.

8..........................................................................................................

Er-YAG laser fiber transmission and bone ablation

A. Jain, M. Frenz

Biomedical Photonics, Institute for Applied Physics, University of Bern, Switzerland

Er-YAG (2.94μm wavelength) lasers are promising tools for cutting or drilling of soft and hard tissues. While various applications require the use of robotic articulated arms, a compact and flexible system can only be achieved via incorporating optical fibers. Our goal was to transmit the high power diode pumped Er-YAG laser radiation (Pantec Medical laser) through an optical fiber and use it to perform ablation of cortical bone tissue without causing damage to the fiber system. Fiber selected for this study was a GeO₂ fiber (450μm core diameter & approx. 0.12 N.A. from Infrared fiber systems), which showed a 60-70% transmission. To protect the output end of the fiber during ablation from the ejected debris and water droplets, and to facilitate the ablation process, we studied two assemblies; one using a sapphire window (6.35mm in diameter with 0.5mm thickness) and the other using a half ball lens (diameter 4.8mm). We created grooves in the sample keeping pulse energy and duration constant at 145mJ and 400μs respectively but varied the pulse frequency from 50 and 100Hz. The groove depth at 100Hz was found to be deeper than at 50Hz. We also observed that the fiber assembly using a half ball lens turned out to be a better choice for ablation because of multiple reasons. The half ball lens focused the beam at a distance of 6mm to a spot of 510μm diameter. This distance allowed us to incorporate water and air spray. The maximum
groove depth measured using 100Hz pulse frequency, a radiant exposure of 70.98J/cm² (at 6mm distance) with 4 cycles was 2.55±0.017mm, in comparison to 1.94±0.023mm depth at 50Hz. In conclusion we proved that it is possible to use a high power laser system running at high pulse frequency together with an optical fiber to perform precise ablation in cortical bone without causing damage to the optical fiber system.

Revisiting backscattering Perrin-Mueller matrices: a case study on colloidal suspensions

M. Hornung¹, A. Jain², M. Frenz², H. G. Akarçay²

¹Institute for Theoretical Physics, University of Bern, Switzerland
²Biomedical Photonics, Institute for Applied Physics, University of Bern, Switzerland

There has been a growing interest in probing tissue with polarized light for diagnostics, as polarized light believed to reveal microscopic features of the tissue that are invisible with unpolarized light. Polarimetric imaging experiments consist in illuminating the tissue with different input states and recording with a CCD camera the backscattered light passing through different analyzer states. The cross- and auto-correlations between these input/output states is commonly encoded in a 4x4 Perrin-Mueller (PM) matrix, that contains all the polarization altering properties of the probed tissue. However, this popular encoding is very dense and hence, rather difficult to interpret. Over the past decades, many groups have been developing mathematical “decomposition” techniques to facilitate the reading of the PM matrix by distinguishing retardance, diattenuation, and depolarization induced by the tissue. Here, we argue that when studying scattering systems such as tissue, these decompositions are not necessarily helpful. We present a case study, where we performed polarimetric measurements on colloidal suspensions and quantitatively validated our results with Monte Carlo simulations. We discuss to what extend an alternative encoding (based on the spatially distributed polarization ellipse properties) can potentially facilitate the interpretation of the measurements and the diagnostics of tissue. Further, (i) we demonstrate that an ad hoc calculation of retardance, diattenuation, and depolarization is preferable to a generic decomposition and (ii) propose a simple analytical model that can, in the case of these colloidal suspensions, relate macroscopic observations to microscopic features of the matter.
MICROWAVE PHYSICS

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Long-term trends in middle-atmospheric ozone over Central Europe

L. Bernet1,2, K. Hocke1,2, N. Kämpfer1,2

1Microwave Physics, Institute of Applied Physics, University of Bern, Switzerland
2Oeschger Centre for Climate Change Research, University of Bern, Switzerland

Stratospheric ozone depletion has been a focus of attention for the last few decades. After a continuous ozone decline, first signs of an ozone recovery in the stratosphere were observed starting in 1997. Recent studies have confirmed that ozone is increasing in the upper stratosphere at mid- and low-latitudes, but different trend profiles are not always consistent. To improve trend estimations of stratospheric ozone profiles, continuous and stable time series are crucial and trend uncertainties need to be addressed.

We present an updated and improved 22-years time series of stratospheric ozone from the GROMOS (GROund-based Millimeter-wave Ozone Spectrometer) microwave radiometer located at Bern, Switzerland. Stratospheric ozone trends based on GROMOS and lidar data were estimated with a multilinear trend model, which can handle uncertainties in a flexible way. To better understand trend uncertainties, we investigate how the trend profiles react to biases in the time series. We identify possible biases in the GROMOS time series by comparing the data to ground-based lidar data at Hohenpeissenberg (Germany). We found a good agreement in the middle and upper stratosphere with relative differences of 5 to 7%. Furthermore, we show how the period lengths influences the resulting trends.

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Long-term observation of mid-latitude quasi 2-day waves by a water vapor radiometer

M. Lainer1, K. Hocke1,2, N. Kämpfer1,2

1Microwave Physics, Institute of Applied Physics, University of Bern, Switzerland
2Oeschger Center for Climate Change Research, University of Bern Switzerland

A mesospheric water vapor data set obtained by the middle atmospheric water vapor radiometer (MIAWARA) close to Bern, Switzerland (46.88° N, 7.46° E) during October 2010 to September 2017 is investigated to study the long-term evolution and variability of quasi 2-day waves (Q2DWs). We present a climatological overview and an insight on the dynamical behavior of these waves with the occurring spectrum of periods as seen from a mid-latitude observation site. Such a large and nearly continuous measurement data set as ours is rare and of high scientific value. The core results of our investigation
include that the activity of the Q2DW manifests in burst-like events and is higher during winter months (November-February) than during summer months (May-August) for the altitude region of the mesosphere (up to 0.02 hPa in winter and up to 0.05 hPa in summer) that is accessible for the instrument. Single Q2DW events reach at most about 0.8 ppm in the H$_2$O amplitudes. Further, monthly mean Q2DW amplitude spectra are presented and reveal a high frequency variability between different months. A large fraction of identified Q2DW events (20 %) develop periods between 38 – 40 h.

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Overview of middle atmospheric water vapour and ozone measurements at Ny-Alesund in winter 2015/16

F. Schranz$^1$, S. Fernandez$^2$, B. Tschanz$^1$, K. Hocke$^1$, N. Kämpfer$^1$, N. Ryan$^3$, M. Palm$^3$

$^1$Microwave Physics, Institute of Applied Physics, University of Bern, Switzerland
$^2$Department of Physics, University of Santiago de Chile, Santiago, Chile
$^3$Institute of Environmental Physics, University of Bremen, Germany

The ground based microwave radiometers MIAWARA-C (middle atmospheric water vapour radiometer) and GROMOS-C (ground based ozone monitoring system) measure water vapour and ozone in the middle atmosphere respectively. The instruments are located at the AWIPEV research base at Ny-Alesund/Svalbard (78 ◦ N/12 ◦ E) in the Arctic since September 2015. Both microwave radiometers have been developed by the University of Bern, Switzerland. The advantage of the ground based microwave radiometry is a continuous observation of the vertical water vapour and ozone profiles with a high time resolution, depending on tropospheric opacity. In case of ozone hourly profiles are possible whereas in the case of water vapour two to four hours are realistic. As the ozone radiometer is able to observe in the four cardinal directions it is possible to have observations inside and outside of the vortex in case the vortex edge is close to Svalbard. The time series of water vapour profiles clearly shows the decent of air within the polar vortex with a velocity of approximately 300 m/day. In the ozone time series a strong diurnal variation is observed during the transition from polar day to polar night. The observation of water vapour and ozone in parallel allows us to investigate the link between these two quantities in the middle atmosphere. Additionally the effect of the sudden stratospheric warming of February 2016 on water vapour and ozone is analyzed. Inter-comparisons are performed with the microwave radiometer of the University of Bremen (OZORAM) which is also located at Ny-Alesund and with satellite data. We further use the specified dynamics version of the whole atmosphere community climate model (WACCM) to compare model output and data from the different instruments in order to better characterize processes in the Arctic winter.
Simulation of passive radar measurements of manned and unmanned aircraft

P. J. Speirs\textsuperscript{1}, A. Schröder\textsuperscript{1}, P. Wellig\textsuperscript{2}, A. Murk\textsuperscript{1}

\textsuperscript{1}Microwave Physics, Institute for Applied Physics, University of Bern, Switzerland
\textsuperscript{2}armasuisse, Science and Technology, Thun, Switzerland

Passive radar has the potential to be a useful tool for airspace surveillance, taking advantage of existing transmitters, reducing cost and spectrum requirements and also allowing detections to be covert. However, the interpretation of passive radar data to determine the location of the target is more complex than for conventional radars, partially due to the bistatic nature of the measurements. At the Institute for Applied Physics we perform calculations, on behalf of armasuisse, to show what the expected bistatic radar cross section (RCS) of test targets would be for a given transmitter and receiver geometry, as well as a given flight path and target orientation.

This poster explains the basic principles behind passive radar, the methods used to determine the particular bistatic radar cross section required for each step in the measurement would be, the method used to perform a Method of Moments (MoM) calculation of the radar cross section of the aircraft, and the conversion of this into an RCS. Examples are given both for a Pilatus PC-12 aircraft and for a DJI Phantom II quadcopter.

\textbf{Fig. 1} The mesh for the Pilatus PC-12 aircraft used in the calculations
The WIRA-C microwave wind radiometer: Results and comparisons from the Maïdo campaign

J. Hagen¹, N. Kämpfer¹, S. Khaykin², A. Hauchecorne²

¹Microwave Physics, Institute of Applied Physics, University of Bern, Switzerland
²LATMOS-IPSL, Université Versailles St.-Quenin, CNRS/INSU, Guyancourt, France

Measurements of atmospheric wind speeds in altitudes between 30 and 70 km are surprisingly rare. Passive microwave radiometry and Doppler lidar techniques provide two methods for covering this gap region. With the Rayleigh-Mie Doppler wind lidar of CNRS/INSU (Guyancourt, France) and OSUR (La Réunion, France) and the passive microwave radiometer WIRA-C of the IAP (Bern, Switzerland) two such instruments are collocated in the Maïdo observatory on La Réunion. We present the WIRA-C instrument and its measurement results from the campaign on the Maïdo observatory on La Réunion island (21°S). We compare our measurements to coincident measurements of the Rayleigh-Mie Doppler wind lidar acquired in the frame of the LIDEOLE-III campaign that took place in June 2017.
Quantum State Tomography with Regularized Finite Statistics

S. Schwarz\textsuperscript{1}, B. Eckmann\textsuperscript{1,2}, D. Rosset\textsuperscript{3,4}, A. Stefanov\textsuperscript{1}

\textsuperscript{1}Laser Physics, Institute of Applied Physics, University of Bern, Switzerland
\textsuperscript{2}Institute for Theoretical Physics, ETH Zurich, Switzerland
\textsuperscript{3}Departement of Physics, National Cheng Kung University, Tainan 701, Taiwan
\textsuperscript{4}Perimeter Institute for Theoretical Physics, Waterloo, Ontario Canada N2L 2Y2

In many different experimental studies of quantum mechanical systems, a detailed knowledge of the prepared quantum state is advantageous for further processing tasks. Therefore, a technique called Quantum State Tomography (QST) is usually employed in order to fully reconstruct the corresponding density matrix. For this, a finite tomographic complete set of projective measurement operators is applied onto the experimentally prepared quantum system such that the density matrix estimate is derived through linear inversion (LIN) of the measurement results. But since in this way the density matrix estimate is typically not physical, due to the limitation to finite statistics, reconstruction schemes like Maximum-Likelihood (ML) estimations are exploited instead, reconstructing the density matrix by maximizing some target function within the set of physical density operators. But in this case, however, it is known that in such parameter estimations for finite statistics, systematic deviations occur, leading to biased estimators. Hence, we end up in QST with the trade-off between non-physical but unbiased reconstructed density matrices by linearly inverting the measurement results, and physical but biased density matrices when we apply reconstruction schemes like ML.

In our work based on entangled bipartite quantum states, we present first evidences of an alternative approach inspired by device-independent quantum information. We embed a tomographic complete set of measurement operators within the framework of a Bell scenario such that statistical fluctuations are tamed by regularizing the corresponding input-output probability distributions.
Super-Resolution Quantum Imaging at the Heisenberg Limit

M. Unternährer\textsuperscript{1}, B. Bessire\textsuperscript{1}, L. Gasparini\textsuperscript{2}, M. Perenzoni\textsuperscript{2}, A. Stefanov\textsuperscript{1}

\textsuperscript{1}Laser Physics, Institute of Applied Physics, University of Bern, Switzerland
\textsuperscript{2}Fondazione Bruno Kessler, via Sommarive 18, Povo, 38123 Trento, Italy

In imaging, the wavelength of the used illumination and the numerical aperture of the imaging system determine the image resolution through the Rayleigh limit. Changing the illumination to a correlated or even spatially entangled light source can improve the resolution but is still limited by the standard quantum limit (SQL). The method of optical centroid measurement (OCM) was proposed in \cite{1} in order to improve the resolution beyond the SQL, ideally up to the so-called Heisenberg limit. While the OCM method was already demonstrated in interferometry experiments, we apply it here, for the first time, to imaging of a 2-d object without relying on a scanning operation mode \cite{2}.

The scheme is implemented using a dedicated spatially entangled two-photon state. This OCM-type quantum state is produced by illuminating the object with the pump laser before down-converting the light into a pair of photons (Fig. 1). The expected resolution enhancement at the Heisenberg limit, i.e. close to a factor of two, is demonstrated for 2-d imaging by comparison with classical imaging schemes (Fig. 2). The coincidence photon detection is efficiently performed by means of a new type of integrated time-resolving 2-d array detector.

\textbf{Fig. 1:} OCM experiment setup. A 2-d object is imaged by a CW laser at 405 nm from $\Sigma_o$ to $\Sigma_i$ by the lenses $L_1$ and $L_2$. A non-liner crystal (NLC) generates entangled photon pairs at 810 nm which image $\Sigma_o$ to $\Sigma_i$ via lens $L_3$. The later is equipped with a circular aperture to reduce its numerical aperture and thus the resolution of the imaging system. A bandpass filter (BP) transmits 810 nm. The 2-d pixelated detector array $D$ measures spatial photon correlations.
Fig. 2: Imaging results. Left: A 2-d object is imaged by an entangled OCM quantum state at 810 nm. Right: For comparison, a CW coherent laser at 810 nm images the same object. The increase in resolution due to the OCM method is clearly visible.

References

Energy-Entangled photon pairs for probing general relativity with quantum states
B. Bessire1, A. Stefanov1, M. Unternährer1, A. Hickey2, J. Grover2

1Laser Physics, Institute of Applied Physics, University of Bern, Switzerland
2Advanced Concepts Team, ESA, ESTEC, Netherlands

Distributing entangled photon pairs through a gravitational potential, from ground to space, is essential for plans to use satellites for global quantum key distribution. Such schemes face several challenges. Fundamentally, our knowledge of the effect of spacetime curvature on quantum systems is limited. We present a framework for testing the propagation of entanglement in the presence of gravity, using interferometry with broadband energy-entangled photon pairs. Practically, losses over these distances are high, due to diffraction in the atmosphere and limited detector size. Hence we explore the emission rate limits of spontaneous parametric down conversion (SPDC) sources of energy entangled photon pairs, as well as methods for detecting such high fluxes.
Ultrafast lasers with wavelength in the 2 micron region has been attracted a considerable attention in recent years due to their various applications specially in medical treatment, chemical processing and Lidar. Also Tm-doped fiber has broad spectral width which make it suitable for ultrashort pulse generation. Among the methods for producing ultrashort pulses, nonlinear polarization rotation (NPR) mode-locking is one of the most noticeable methods since it is based on the kerr effect and the process is quiet fast so basically it does not insert a limit for the shortest pulse obtainable by this method. We have constructed a Tm-doped fiber laser based on the NPR technique. Mode-locking is obtained by proper adjustment of the waveplates. Since this process is time consuming, we implemented motorized waveplates in the setup that are able to sweep 180° using a Matlab software. In this case we are able to have a map of all the mode-locked positions regarding the waveplates positions. Since we have an oscillator with all anomalous dispersion, the output pulse forms in the shape of a soliton which is the result of the balance between the anomalous dispersion and the nonlinearity and they can preserve their shape during propagation. Based on the scan results the largest spectral bandwidth that has been obtained, was 11.7 nm with the pulse duration of 393 fs and the center wavelength was located at 1930 nm. Moreover by adjusting the wavelength we are able to tune the center wavelength.
Fig. 1 Setup

Fig. 2. Histogram of center wavelength

Fig. 3 Spectrum

Fig. 4. Mode-locking map
Single cycle THz pulse-induced Stark effect observed in ground state spectrum of liquid-phase solvated molecules

E. Rohwer\textsuperscript{1}, Z. Ollmann\textsuperscript{1}, S.X. Liu\textsuperscript{2}, J. Moser\textsuperscript{3}, T. Feurer\textsuperscript{1}

\textsuperscript{1}Laser Physics, Institute of Applied Physics, University of Bern, CH-3012, Bern
\textsuperscript{2}Department of Chemistry and Biochemistry, University of Bern, CH-3012, Bern
\textsuperscript{3}Institute of Chemical Sciences & Engineering, Ecole Polytechnique Federale de Lausanne, CH-1015, Lausanne

We report on the implementation of a THz-generation stage using a LiNbO\textsubscript{3} prism pumped in a non-colinear and pulse-tilted scheme. The resulting THz pulse by optical rectification is characterized. The new setup increases the achievable maximum electric-field strength of the pulse to 1 MV/cm. The improvement results in observing for the first time a ground state Stark effect in liquid-phase solvated molecules.

\begin{figure}
\centering
\includegraphics[width=\textwidth]{Fig1.png}
\caption{Transient spectral response of Perovskite crystal to single cycle THz pulse in new setup.}
\end{figure}
Femtosecond seeding of a Tm-Ho fiber amplifier by a broadband coherent supercontinuum pulse from an all-solid all-normal photonic crystal fiber

J. M. Hodasi, A. Heidt, M. Klimczak, B. Siwicki, T. Feurer

1Laser Physics, Institute of Applied Physics, University of Bern, Sidlerstrasse 5, 3012 Bern, Switzerland
2Department of Physics, University of Ghana, Legon, Accra, Ghana
3Glass Department, Institute of Electronic Materials Technology, Wolczynska 133, 01-919 Warsaw, Poland

Thulium-Holmium co-doped silica fiber amplifiers have a promising potential for femtosecond pulse amplification due to their broad gain bandwidth spanning from 1.7 to 2.2 μm, which could further support the growing application-driven demand for high peak power sub-100 fs pulse sources in this wavelength region. However, exploiting the full amplification bandwidth is limited mainly by a shortage of sufficiently broadband and coherent seed sources [1].

Here we present, for the first time, the seeding of a Tm-Ho: fiber amplifier by a broadband coherent supercontinuum (SC) pulse generated in all-normal dispersion (ANDi) fiber. This approach has two significant advantages: (i) excellent coherence is maintained for a wide range of pump pulse and fiber parameters [2], and (ii) the SC consists of a single ultrashort pulse in the time domain, i.e. it does not break up into individual solitons [3]. Hence, it is ideally suited for seeding fiber amplifiers whose gain bandwidth overlaps with any part of the SC bandwidth.

We demonstrate amplification of ultrashort pulses with 120 nm FWHM spectral width at 1.9 μm to Watt-level average power, compressible to below 40 fs in an all-fiber system.

References
The Ultrafast Investigation of the Photocycle of Carbon Nanodots

A. Sciortino$^{1,2,3}$, M. Gazzetto$^1$, E. J. Rohwer$^1$, L. Sciortino$^2$, T. Feurer$^1$, F. Messina$^2$, A. Cannizzo$^1$

$^1$Laser Physics, Institute of Applied Physics, University of Bern, Switzerland
$^2$Department of Physics and Chemistry, University of Palermo, Italy
$^3$Department of Physics and Astronomy, University of Catania, Italy

Carbon nanodots (CDs) are a new class of optically-active carbon-nanomaterials discovered 10 years ago consisting in ≤10 nm nanoparticles composed by carbon, oxygen, nitrogen and hydrogen. Both their structure (core and surface) and the specific optical characteristics depend on the synthesis procedure, but, in the literature, the great part of the samples gather the same properties: bright tuneable fluorescence in all the UV-VIS spectral range, high water solubility, high sensitivity to local environment and non-toxicity. All of these characteristics allow the use of CDs in many applications as bio-imaging, optoelectronics and nano-sensing.

Despite the existence of many works in literature, there are still many open questions which regard, for example, the origin of the tunability of the fluorescence and the interactions with the external environment. To answer some of the open questions, we studied the optical characteristics of a sample of CDs which shows the very new core structure of $\beta$-C$_3$N$_4$. This sample shows a clear absorption feature in the visible range (around 400 nm) and an unstructured absorption at longer wavelengths. Our studies are various and include, for example, a solvatochromic investigation through which we understood the excitonic nature of the electronic transition, the study of the interaction with metal ions in solution which allowed us to go deeply inside the photocycle of CDs and of CD-Cu$^{2+}$ complexes, where the emission is typically quenched, and an ultrafast hole burning experiment at variable wavelength which addresses the origin of the tunability of the fluorescence and disentangles the inhomogeneous and homogeneous broadening of their electronic transitions.

Investigating long range electron transfers and intramolecular electrostatic fields with multidimensional transient Stark shift spectroscopy

A. Riede, A. Cannizzo

Laser Physics, Institute of Applied Physics, University of Bern, Switzerland

An impelling need of our society is to develop efficient, cheap and environment-friendly photo-catalysts for conversion of solar energy into chemical fuels as H$_2$ by water splitting. Among the strategies under investigation, the one based on the synthesis of artificial supramolecular catalysts is particularly promising. In such systems as well as in
natural electron transfer proteins the charge generated at the photo-active moiety, needs to be transferred over long distances (>1nm) through an intramolecular electron relay to the catalytically active center. We propose to combine ultrafast coherent two-dimensional spectroscopies and intense single-cycle THz pulses, to investigate the role of local intramolecular electrostatics and of the polar properties of the intermediate states on the charge transfer and localization, triggered by a Vis or UV fs pump pulse. This original approach will open the way to a deeper comprehension of the mechanisms underlying charge transfer and localization with the long term prospect to manipulate such a kind of phenomena. This project is in tight collaboration with the Feurer’s group @ IAP. approach will open the way to a deeper comprehension of the mechanisms underlying