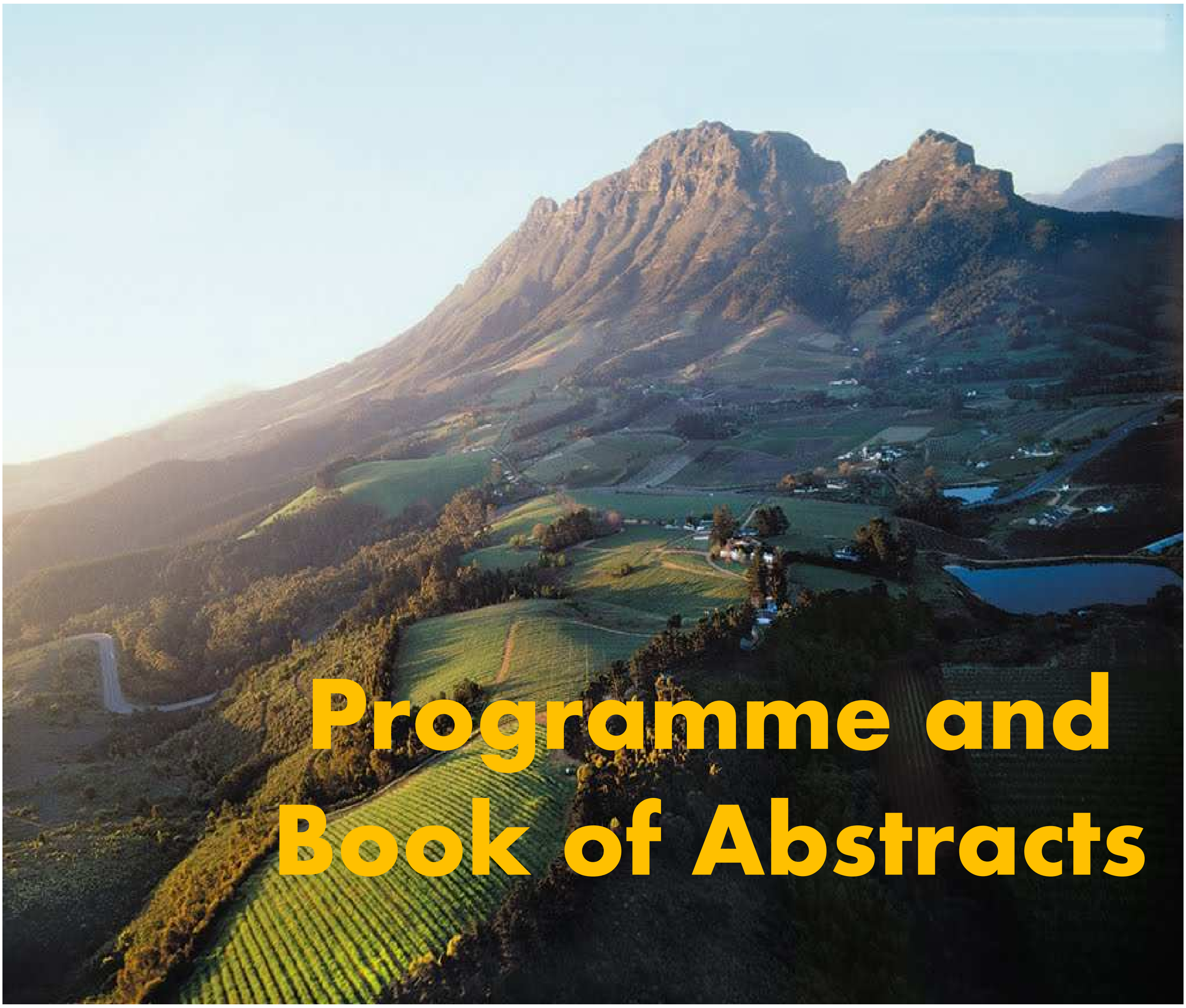
South Africa

AOIM 2013

9th International Workshop on Adaptive Optics for Industry and Medicine

2 – 6 September 2013
Stellenbosch, South Africa

One day **Spring School**: 2nd September 2013



Programme and Book of Abstracts

SOUTH AFRICAN INSTITUTE OF PHYSICS

african laser centre

PISA
PHOTONICS INITIATIVE OF SOUTH AFRICA

AOIM2013
Programme & Abstracts Book

Contents

Organizing Committee
Chairperson: Andrew Forbes (South Africa)

International Organising Committee:

- Alexis Kudryashov (Russia)
- Pablo Artal (Spain)
- Sergio Restaino (USA)
- John Gonglewski (UK)
- Ulrich Wittrock (Germany)

Conference Management - SAIP Office (www.saip.org.za)

- Brian Masara
- Linette White

Monday 02 September 2013

SPRING SCHOOL PROGRAMME

Spring School Chair – Andrew Forbes

WELCOME FOR SPRING SCHOOL

Time	SPRING SCHOOL WELCOME	Presenter
08:15 – 08:20	Welcome Remarks	Prof. FORBES, Andrew
08:20 – 08:30	Welcome Remarks – SA Biophysics Initiative	Dr SPARROW, Raymond

INTRODUCTORY LECTURES ON THE CORE TECHNOLOGY - (08:30-10:45)

Time	Lecture Title	Presenter
08:30 – 09:15	Basics of AOs and adaptive control	Prof. KUDRYASHOV,
09:15 – 10:00	Basics of deformable mirrors	Prof. WITTROCK, Ulrich
10:00 – 10:45	Basics of wavefront sensing	Dr. RESTAINO, Sergio
10:45 – 11:15	**TEA BREAK**	

INTRODUCTORY LECTURES ON APPLICATIONS IN MEDICINE AND HEALTH - (11:15-13:30)

Time	Lecture Title	Presenter
11:15 – 12:00	AOs in Vision	Prof. ARTAL, Pablo
12:00 – 12:45	Adaptive Lenses	Prof. LOVE, Gordon
12:45 – 13:30	AOs and microscopy	Dr. MARTIN, Booth
13:30 – 14:15	**LUNCH BREAK**	

INTRODUCTORY LECTURES ON CURRENT STATE-OF-THE ART AO SYSTEMS - (14:15-16:30)

Time	Lecture Title	Presenter
14:15 – 15:00	Turn key AO systems	Mr. BIERDEN, Paul
15:00 – 15:45	AOs in ultrafast and ultrahigh power lasers	Dr. LANCIS, JESUS
15:45 – 16:30	AOs in high precision materials	Dr. MARTIN, Booth

WORKSHOP WELCOME FUNCTION BRAAI & ENTERTAINMENT - (17:00-20:00)

AOIM2013 - WORKSHOP PROGRAMME

Tuesday 03 September 2013

Session I : AO in Lasers - (08:10-10:30) – Chair: Alexis Kudryashov		
Time	**Abstract 1D, Title**	**Presenter**
09:00 – 09:40 **(INVITED TALK)**	[24] Recent advances in high-power fundamental mode thin-disk lasers using intra-cavity deformable mirrors	Mr. PIEHLER, Stefan
09:40 – 10:30 **(INVITED TALK)**	[64] Achieving the highest intensity from the Orion Laser Facility	Dr. HOPPS, Nicholas
10:30 – 11:00	**TEA BREAK**	
Session II : Imaging and Microscopy - (11:00-13:00) – Chair: Patience Mthunzi		
11:00 – 11:40 **(INVITED TALK)**	[59] ADAPTIVE OPTICS FROM MICROSCOPY TO NANOSCOPY	Dr. MARTIN, Booth
11:40 – 12: 00	[10] Layer-oriented adaptive optics for extended objects	Dr. KELLERER, Aglae
12:00 – 12:20	[22] High resolution in-vivo imaging of the mouse retina using an adaptive optics system with MEMS	Dr. ZAWADZKI, Robert J.
12:20 – 12:40	[26] Modal deformable mirror optimization in sensorless Optical Coherence	Dr. BONORA, Stefano
12:40 – 13:00	[51] Superpenetration Multiphoton Microscopy Enabled Through MEMS DM Technology	Mr. BIERDEN, Paul
13:00 – 14:00	LUNCH BREAK	
Session III: Wavefront Sensing Techniques - (14:00-15:30) – Chair: Pablo Artal		
14:00 – 14:40 **(INVITED TALK)**	[17] Impact of wavefront aberrations in ultrafast nonlinear optics	Dr. BORREGO-VARILLAS, Rocío
14:40 – 15: 20 **(INVITED TALK)**	[9] Modal decomposition for wavefront reconstruction	Dr. Duparre, Michael
15:30 – 16:00	**TEA BREAK**	
Session IV: Adaptive Control - (16:00-18:20) – Chair: Claudia Reinlein		
16:00 – 16:40 **(INVITED TALK)**	[78] Wavefront correction in large-scale glass laser LFEX	Prof. JITSUNO, Takahisa
16:40 – 17:00	[19] Multi-conjugated adaptive optics for intense	Dr. CHERIAUX, Gilles
17:00 – 17:20	[25] Characterization and application of a deformable mirror for pulse shaping in the Mid-Infrared	Mr. BONORA, Stefano
17:20 – 17:40	[27] Ultrafast time compensated monochromator with deformable diffraction gratings	Dr. BONORA, Stefano
17:40 – 18:00	[28] High resolution wavefront control using a photocontrolled deformable mirror in closed loop	Dr. BONORA, Stefano
18:00 – 18:20	[48] Real-time high speed adaptive optical system for imaging and laser beam control	Prof. KUDRYASHOV, Alexis

Wednesday 04 September 2013

Session V: AO Techniques - (08:30-10:30) – Chair: David Williams

Time	Abstract 1D, Title	Presenter
08:30 – 09:10 (INVITED TALK)	[36] Adaptive Lenses for Displays & Vision	Prof. LOVE, Gordon
09:10 – 09:30	[37] Results on the high power testing of screen-printed deformable mirrors	Dr. REINLEIN, Claudia
09:30 – 09:50	[44] Design optimization of an actuator pattern for a unimorph deformable mirror	Mr. APPELFELDER, Michael
09:50 – 10:10	[45] Large Scale Deformable Mirror Based on Bimorph and Stack Actuators	Dr. SAMARKIN, Vadim
10:10 – 10:30	[50] Recent Advances in MEMS Deformable Mirror Technology	Mr. BIERDEN, Paul
10:30 - 11:00	**TEA BREAK**	

Session VI: Vision - (11:00-13:00) – Chair: Gordon Love

Time	Abstract 1D, Title	Presenter
11:00 – 11:40 (INVITED TALK)	[66] Functional Imaging of Single Cells in the Living Eye	Prof. WILLIAMS, David
11:40 – 12:00	[4] Dynamic plenoptic perception with adaptive mirror	Mr. MOURA, Thiago D. O.
12:00 – 12:20	[6] The use of Zernike and Q-Polynomials combined for the Representation of Intraocular-Lens Topologies	Mr. COSTA, Rodolfo
12:20 – 12:40	[7] Aberration correction with adaptive optics for lowering the threshold energy for femtosecond laser induced optical	Mrs. HANSEN, Anja
12:40 – 13:00	[41] Dynamic generation of scattering for high resolution adaptive optics in the eye	Dr. FERNANDEZ, Enrique-Josua
13:00 – 14:00	**LUNCH BREAK**	

POSTER SESSION (14:00 – 17:00)

14:00 – 17:00

Abstract	Title	Primary Presenter
2	Imaging the expression of Channelrhodopsin-2 as a directly light-gated cation-selective membrane channel in HEK 293 cells	Dr. EL-HUSSEIN M.KAMEL, Ahmed
5	Imaging of solid aerosols produced by optical catapulting	Mr. MOHAMED, Mahmoud
14	Propagating aberrated laser beams	Dr. MAFUSIRE, Cosmas
16	Biomedical applications of optics	Dr. MTHUNZI, Patience
18	Free-motion measurement of the beam propagation factor by means of a spatial light modulator.	Mr.PéREZVIZCAíNO, Jorge
20	Computational Testbench and Flow Chart for Wavefront Sensors	Mrs. ABECASSIS, Úrsula;
30	Utilizing speckle decorrelation for tomographic wavefront sensing (with one wavefront sensor)	Dr. BHARMAL, Nazim
32	Optical Design and Optimization of Adaptive Automobile Headlight with Liquid Optical Element and Freeform	Prof. FANG, Yichin
34	Compensation of the two-stage phase-shifting algorithms with respect to detuning and harmonics	Dr. MALACARA-DOBLADO, Daniel
43	A parametric study of the contributing factors influencing femtosecond pulse shape transfer via difference frequency mixing.	Ms. BOTHA, Nicolene
46	Wide field wavefront sensing on extended scenes and possible applications	Dr. RAGAZZONI, Roberto
47	Localization and image reconstruction of inclusions embedded in biological tissue (turbid media) by means of adaptive optical system	Mr. GALAKTIONOV, Ilya
49	Artificial model of human eye aberrations proceeded in real-time	Ms. LYLOVA, Anna
81	81 - Producing Kaleidoscope Modes using the Digital Laser	Ms. Burger, Liesl

Wine Tasting & Cocktail Function - (17:00-20:00)

Thursday 05 September 2013

Time	Abstract 1D, Title	Presenter
Session VII : Imaging and Microscopy - (08:30-10:30) – Chair: Ulrich Wittrock		
08:30 – 09:10 **(INVITED TALK)**	[38] Advances in adaptive optics nonlinear microscopy for applications in medical and life sciences	Dr. BUENO, Juan M.
09:10 – 09:30	[11] Adaptive optics for multi-photon microscopy using direct and sensorless measurement	Mr. VAN WERKHOVEN, Tim
09:30 – 09:50	[13] Constrained optimisation for fast wavefront sensorless adaptive optics in microscopy	Mr. ANTONELLO, Jacopo
09:50 – 10:10	[15] Active spatial polarization control for microscope objectives	Mr. SCHAAL, Frederik
10:10 – 10:30	[35] Correction for distortions in holographic nanointerferometers	Prof. VENEDIKTOV, Vladimir
10:30 – 11:00	**TEA BREAK**	
Session VIII : Spatial Light Modulators - (11:00-13:00) – Chair: Sergio Restaino		
11:00 – 11:40 **(INVITED TALK)**	[63] Shaping ultrafast pulsed beams in space and time with programmable spatial light modulators	Dr. LANCIS, JESUS
11:40 – 12:00	[29] All-digital holographic tool for real-time mode excitation and analysis in optical waveguides	Mr. SCHULZE, Christian
12:00 – 12:20	[42] Phase generation in white light with a 6-Pi Liquid Crystal on Silicon (LCoS) device	Dr. PRIETO, Pedro
12:20 – 12:40	[52] A novel technique to generate and temporally shape multiple pulsed laser beams using 2D-SLMs	Mr. SPANGENBERG, Dirk-Mathys
12:40 – 13:00	[79] Real-time dynamic control of laser modes	Mr. NGCOBO, Sandile
13:00 – 14:00	**LUNCH BREAK**	
Session IX: Space - (14:00-15:20) – Chair: Paolo Villoresi		
14:00 – 14:20	[3] Strehl ratio, divergence, M2 factor –What is good for describing the propagation of a diffracted laser beam?	Prof. AIT-AMEUR, Kamel
14:20 – 14:40	[8] Adaptive Optics in Astronomy: deblurring the atmosphere	Dr. BUCKLEY, David
14:40 – 15:00	[12] Overview and perspectives of Active and Adaptive Optics for Space	Mr. HALLIBERT, Pascal
15:00 – 15:20	[31] Manufacturing and Testing of Unimorph Deformable Mirrors for Space	Prof. WITTROCK, Ulrich
15:20 – 15:50	**TEA BREAK**	
Session X: Propagation and Turbulance - (15:50-17:30)- Chair: Andrew Forbes		
15:50 – 16:30 **(INVITED TALK)**	[65] Quantum Communications along Optical Links with Strong Turbulence	Prof. PAOLO, Villoresi
16:30 – 16:50	[39] Adaptive Optics for Horizontal Propagation Applications	Dr. RESTAINO, Sergio
16:50 – 17:10	[61] Free space propagation without the free space	Mr. SCHULZE, Christian
17:10 – 17:30	[80] Quantum communication with OAM entangled photons	Mr. IBRAHIM, Alpha
17:30 – 18:00	**WORKSHOP DISCUSSION, CLOSING REMARKS AND VOTE OF THANKS**	

Friday 06 September 2013

Group Tour - Table Mountains - (08:30-16:00)

	GROUP TOUR TABLE MOUNTAINS	
08:30 – 16:30	**BUSES DEPART 08:30 from STIAS** **BUSES RETURN 16:30 to STIAS**	
17:30	**BUSES DEPART FOR MOYO RESTAURANT FROM STIAS**	
18:00 – 22:00	**BANQUET AT MOYO**	
22:30	**BUSES RETURN TO STIAS**	

INVITED SPEAKERS BIOS

David R. Williams, Ph.D.
Dean for Research of Arts, Science, & Engineering
William G. Allyn Professor of Medical Optics
Director, Center for Visual Science
University of Rochester

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Williams received his Ph.D. from the University of California, San Diego in 1979. He was a postdoctoral fellow at Bell Laboratories, Murray Hill in 1980 and joined the University of Rochester in 1981, where he has an appointment in the Institute of Optics as well as in the departments of Brain and Cognitive Sciences, Biomedical Engineering, and Ophthalmology. He is currently William G. Allyn Professor of Medical Optics. Since 1991, Williams has served as Director of Rochester's Center for Visual Science, an interdisciplinary research program of 32 faculty interested in the mechanisms of human vision. In 2011, he was appointed Dean for Research of Arts, Science and Engineering where he is responsible for maximizing opportunities for faculty research and scholarship. Williams' research marshals optical technology to address questions about the fundamental limits of human vision. His research team demonstrated the first adaptive optics system for the eye, showing that vision can be improved beyond that provided by conventional spectacles. This work lead to wavefront-guided refractive surgery used throughout the world today. More recently, his group has been deploying adaptive optics to obtain microscopic images with unprecedented resolution in the living eye, which is providing a new way to study blinding diseases of the retina and accelerate the development of therapies for them. Williams is a Fellow of the Optical Society of America, the American Association for the Advancement of Science, and the Association for Research in Vision and Ophthalmology. Awards he has received include the OSA Edgar G. Tillyer Award in 1998, the Association for Research in Vision and Ophthalmology's Friedenwald Award in 2006, the Bressler Prize from the Jewish Guild for the Blind in 2007, and the Champalimaud Vision Award in 2012.

Dr Nick Hopps
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AWE, Aldermaston, Reading, RG7 4PR

Dr Nick Hopps obtained his BSc in Physics in 1992 and PhD in Laser Physics in 1996, both from the University of Manchester in the UK. He has worked on the high power laser programme at the UK's Atomic Weapons Establishment (AWE) since 1995. He has undertaken two upgrades to the HELEN 1kJ laser, culminating in a 100J, 100TW short pulse beam. During a secondment to Lawrence Livermore National Laboratory in California, Nick helped to develop the pre-amplifier subsystems for the National Ignition Facility (NIF). Since 2004, he has been involved in the project to build the 6kJ, petawatt Orion Laser Facility at AWE, initially overseeing the design and procurement of certain laser subsystems, and later leading the commissioning the main laser beamlines. Nick now leads the laser development activities at AWE's Plasma Physics Centre.

Dr Martin Booth

University of Oxford UNITED KINGDOM

Email: martin.booth@eng.ox.ac.uk

Martin Booth is a Senior Research Fellow based jointly in the Department of Engineering Science and the Centre for Neural Circuits and Behaviour, at the University of Oxford, UK. His research interests cover methods and applications of dynamic optics to a range of interdisciplinary applications. In particular, his work involves the development of adaptive optics for biomedical microscopy and laser-based nano-fabrication of photonic devices.

Dr. JesúsLancis

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Dr. JesúsLancis is a full professor of Photonics at UniversitatJaume I in Castelló Spain since 2009 where now he leads the Photonics research group. His research activity has been devoted to diffractive engineering of light fields and the main research lines can be grouped in two main research areas:

- Advanced techniques in optical imaging
- Science and applications of ultrashort light pulses.

Overall, Dr. JesúsLancis is active in fine control over and comprehensive characterization of optical beams, both continuous wave and pulsed in the femtosecond range by use of diffractive optical elements.Further, Dr. JesúsLancis has extensively characterized and employed programmable spatial light modulators, both liquid crystal based or digital micromirror devices, to codify diffractive optical components, which, in this way, were readily integrated in dynamical devices. Dr. Lancis has a large experience in the design and development of all- optical devices to manipulate femtosecond pulses in a controlled fashion by means of diffractive optical elements as well as their application to optical imaging and material processing. In the field of imaging science, current research interest is devoted to digital holography, optical imaging through turbid media, multiphoton microscopy and applications of compressive sensing technique to optical imaging.

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Rocío Borrego-Varillas received a BSc in Physics (2006) and a MSc in Physics and Technology of Lasers (2007) from Salamanca University in Spain. She joined Prof. Luis Roso's group on Extreme Optics (GIOE) as a predoctoral fellow in 2008 and obtained the PhD degree in 2013. Her doctoral research was focused on the improvement of nonlinear processes (filamentation, second harmonic and supercontinuum generation) by means of wavefront control. She also worked on the development of novel methods for wavefront sensing of intense femtosecond lasers. During her PhD, she did internships at Prof. Krausz's division in the Max Planck Institute of Quantum Optics (Germany), where she collaborated on the development of the Petawatt Field Synthesizer. She is currently a postdoctoral researcher at the Photonics Group of Prof. Lancis at the Universitat Jaume I in Castellón (Spain), where she works on beam shaping of femtosecond pulses by means of spatial light modulators for applications in nonlinear optics. She has been recently awarded a Marie Curie Fellowship, which will allow her to conduct experiments on spectroscopy of biomolecules in Prof. Cerullo's group at the Politecnico di Milano (Italy).

Prof. Paolo Villoresi
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Born in Treviso, Italy, in 1962, he studied Physics and Applied Mathematics at the University of Padova.

He is a Professor (II f., 02/B1) at theUniversity of Padova since 2005, where he currently teaches Quantum Electronics and Quantum Optics.

Current research activities:

- Experimental Quantum Communication - Q-Space Experiment 2003-2006: First Demonstration of single-photon link between a satellite and the Earth - Principal Investigator of ASI SpaceQ project (2007-2008), to study a dedicate satellite for quantum communication in Space. Principal Investigator of University of PadovaQuantumFuture project (2009-2012), on the frontier of free-space communications.He is presently coordinator of two projects on the development of Quantum Communications in free-space. - Applications of femtosecond lasers to material processing and - Development of novel applications of Adaptive Optics.

He has served as coordinator of several national and international research projects, including space quantum communication.

He is member of the Board of the Institute for Photonics and Nanotechnology, National Research Council, Italy.

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Paul Bierden is the President and CEO of Boston Micromachines Corporation. Mr. Bierden received his B.S. and M.S. in Mechanical Engineering from Boston University in 1992 and 1994. He has spent over 15 years working with high technology small business. Since co-founding Boston Micromachines in 1999, he has led research efforts in optical MEMS fabrication, system integration, and compact Adaptive Optics. He has been the PI on over a dozen federally funded research programs and has over 50 publications to his name. He has also led the commercialization efforts of the company's optical MEMS systems which have resulted in global sales of their award winning product. A current focus of Boston Micromachines is providing adaptive optics solutions for life science imaging, which Mr. Bierden is leading. Prior to joining Boston Micromachines, Mr. Bierden worked with Prism Corporation as Chief Engineer. While at Prism, he was responsible for the development of new equipment for optical disk manufacturing. Mr. Bierden is a member of the Optical Society of America, SPIE and the Association for Research in Vision and Ophthalmology

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Dr. Juan M. Bueno

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Juan M. Buenoreceived his M.Sc. degree in Physics (1993) from theUniversity of Salamanca (Spain), and his Ph.D. degree in Physics (Optics, 1999) from the University of Murcia (Spain). During 2000 and 2001 he was a Post-doctoral Research Fellow at the University of Waterloo (Canada) and Maisonneuve-Rosemont Hospital (Montreal, Canada). Since 1994,Dr. Bueno has held different faculty positions at the University of Murcia and heis currently an Associate Professor in Optics.Dr. Buenohas also been President of the Visual Sciences Committee of the Spanish Optical Society (SEDOPTICA) and Director of the Physics Department at the University of Murcia. His research interests are centered on the biophotonic properties of ocular tissues, the development of innovative methods to improve multiphoton biomedical imaging and the investigation of new techniques to explore polarization and scattering properties of eye.

Christian Schulze
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Christian Schulze received his diploma in physics from the University of Jena, Germany, in 2010. He is currently working towards his PhD at the Institute of Applied Optics in Jenawithin the group for laser beam characterization. His research concentrates on the modal characterization of laser and fiber systems using computer-generated holograms, including the development of novel techniques to measure the beam quality, wavefront, and momentum of laser beams, as well as the investigation of light propagation in multimode fibers. During his PhD he did several internships at the mathematical optics group of Prof. A. Forbes at the National Laser Centre of the Council for Scientific and Industrial Research in Pretoria, South Africa, where he worked on the characterization of laser resonators and vortex beams with spatial light modulators.

Sergio R. Restaino
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Education

Ph.D. Physics (summa cum laude), major optics, (1990),
University of Florence Italy
MS Physics, major astrophysics (1986), University of Naples Italy

Professional Affiliations S.P.I.E. (Fellow)

Research Interests

- High Angular Resolution imaging.
- Active and Adaptive Optics with special emphasis on Wavefront Sensing especially through Phase Diversity techniques. Use of novel techniques like Liquid Crystals and/or MEMS mirrors.
- Interferometry and image restoration.
- Helioseismology and Astroseismology
- Non-LTE spectral line formation

Dr. Restaino is author or co-author of over 220 technical publications, and editor in chief of several international proceedings, co-author of two books.

Post-graduate Appointments

2012-present Branch Head, Radio-IR-Optical Sensor Branch, Remote Sensing Division Code 7210 Naval Research Laboratory
2005-2012 Section Head, Wavefront Sensing and Control Section, Remote Sensing Division, Naval Research Laboratory
2002- 2005 Senior Optical Physicist, US Naval Research Laboratory (NRL) Remote Sensing Division. Adjunct Full Professor, Physics Dept., University of Puerto Rico. National Research Council Advisor.
1996-2002 Senior Optical Physicist, USAF Research Laboratory, Directed Energy Directorate, Advanced Optical Division.
1992-1996 Senior Research Associate at U.N.M. and I.P.A. At Phillips Laboratory/LIMI KAFB, NM
1989-1992 Post-Doctoral position with Physics Dept. of New Jersey Inst. of Tech., Visiting Astronomer National Solar Observatory/SP NM.

Research Achievements

1) First use of Phase Diversity on extended source for wavefront sensing
2) First experimental demonstration of a liquid crystal AO system on the sky
3) First experimental demonstration of a MEMS based AO system on the sky
4) First phasing of a long baseline optical interferometer on a man-made obj

AOIM2013 LIST OF ABSTRACTS

2 - Imaging the expression of Channelrhodopsin-2 as a directly light-gated cation-selective membrane channel in HEK 293 cells

Wednesday 04 September 2013 14:00

Authors: *EL-HUSSEIN M.KAMEL, Ahmed (The National Institute of Laser Enhanced Science, Cairo University)*

Channelrhodopsins (ChRs) originated from algae of Chlamydomonas genus have been considered as directly light-gated ion channels. In microalgae, their primary function is to direct the organism towards or away from the light stimulus as well to optimize the light conditions needed for photosynthesis. ChR2 originated from Chlamydomonas reinhardtii was shown to be involved in generation of photocurrents in this green alga has been found to be 10 times better than ChR1 for the expression in most host cells like Xenopus oocytes. Despite of this fact and ChR2 can be easily targeted genetically; many of selective promoters cannot achieve sufficient expression levels of ChR2 for photostimulation. In the present work, HEK 293 cells has been expressed by ChR2 tagged with the fluorescent protein mCherry (ChR2mCherry) in one series of experiments and by ChR2 and mCherry individually in another set of experiments. The results have shown that ChR2 is a directly light-switched cation-selective ion channel upon stimulating the cells with 475 nm blue light. This channel opens rapidly after absorption of a photon to generate a large permeability for monovalent and divalent cations. Furthermore the degree of expression of ChR2mCherry in HEK 293 cells was better than that of ChR2 alone despite the initial thought of being mCherry genes could compete with the ChR2 genes.

3 - -Strehl ratio, divergence, M2 factor –What is good for describing the propagation of a diffracted laser beam?

Session IX: Space - Thursday 05 September 2013 14:00

Primary authors: *AIT-AMEUR, Kamel (CIMAP-ENSICAEN,Caen, France)*
Co-authors: *BOUBAHA, Boualem (Faculté de Physique-USTHB, Algiers); NAIDOO, Darryl (NLC-CSIR, Pretoria); GODIN, Thomas (CIMAP-ENSICAEN,Caen, France); BENCHEIKH, Abdelhalim (LOA, Sétif, Algeria); FROMAGER, Michael (CIMAP-ENSICAEN,Caen, France); FORBES, Andrew (NLC-CSIR, Pretoria)*

We consider the transverse characteristics of a laser beam suffering amplitude or phase diffraction. In particular, we consider the correlation or the absence of correlation between the parameters divergence angle, Strehl ratio and M2 factor usually used for describing the focusability of a laser beam. We will also introduce the concept of transverse correlation of a laser beam. We will give concrete examples for which the information holds by the above parameters is contradictory, and can disturb for instance the monitoring of a distributed lensing effect or the determination of the focal volume.

4 - Dynamic plenoptic perception with adaptive mirror

Session VI: Vision - Wednesday 04 September 2013 11:40

Authors: *MOURA, Thiago D. O. (Graduate Program in Electrical Engineering - Federal University of Minas Gerais - Av. Antônio Carlos 6627, 31270-901, Belo Horizonte, MG, Brazil); AMARAL, Felipe T. (Graduate Program in Electrical Engineering - Federal University of Minas Gerais - Av. Antônio Carlos 6627, 31270-901, Belo Horizonte, MG, Brazil); DE LIMA MONTEIRO, Davies W. (Associate Professor - OptMA_lab - DEE/UFMG Electrical Engineering Department, Av. Antonio Carlos, 6627 - Pampulha, 31270-010 - Belo Horizonte - MG)*

Plenoptic cameras enable one to take a single shot of a scene and have the focal plane decided upon later, by rendering the custom registered image in a post-processing step[1][2]. This approach takes a fuller advantage of the optics, as the name implies, capturing multiple light fields of a single scene. A given plane can be selected for optimal focus, and naturally all planes within its depth of field; but, by tweaking the rendering algorithm, also multiple distant planes can be presented simultaneously in focus. It works for static images and demands some post computation either on-board or in a PC. We, therefore, wondered whether videos, i.e. a sequence of static frames, could also exhibit such a feature.We aim to present the plenoptic concept applied to dynamic imaging by means of an adaptive mirror coupled to an ordinary camera system. The outcome of our first tests seems to be quite promising when the mirror is driven at an appropriate duty cycle and amplitude, adjusted to the transfer function of the human retina.There is a myriad of applications that can deploy this concept, ranging from displays to microscopy. In this paper we intend to exploit the experimental setup, the obtained results and the constraints that must be observed for a successful dynamic plenoptic effect. [1] NG, R. 2005. Fourier slice photography, ACM Trans. Graph., 735-744.[2] GEORGIEV, T., LUMSDAINE, A.

2010. Focused Plenoptic Camera and Rendering, Journal of Electronic Imaging, Volume 19, Issue 2.

5 - Imaging of solid aerosols produced by optical catapulting

Wednesday 04 September 2013 14:00

Primary authors: *MOHAMED, Mahmoud (The National Institute of Laser Enhanced Science)*
Co-authors: *FERNANDEZ-BRAVO, Angel (Department of Analytical Chemistry, Faculty of Sciences, University of Malaga, Spain); FORTES, Francisco Javier (Department of Analytical Chemistry, Faculty of Sciences, University of Malaga, Spain); ABDEL HARITH, Mohamed (The National Institute of Laser Enhanced Science); LASERNA, Javier (Department of Analytical Chemistry, Faculty of Sciences, University of Malaga, Spain)*

The analysis of solid aerosols has a great importance in many fields of applications including atmospheric sciences, process monitoring and control. Optical catapulting OC is a good sampling method and has been used in combination with Laser induced breakdown spectroscopy LIBS for analysis of solid aerosols. In the present study Imaging experiments were performed in order to probe the behavior and dynamics of OC- produced solid aerosols. Two synchronized Nd: YAG lasers have been used, one for optical catapulting at wavelength = 1064 nm and the other for imaging purpose at wavelength = 532 nm. Standard aluminium silicate particles of size ranging from 0.2 to
8 μm have been used as catapulting target. Several parameters relevant to aerosols dynamics have been studied, such as the effect of interpulse delay time Δt, the effect of laser fluence as well as the effect of working distance. Experimental velocity values of the solid aerosols have been also obtained.

6 - The use of Zernike and Q-Polynomials combined for the Representation of Intraocular-Lens Topologies

Session VI: Vision - Wednesday 04 September 2013 12:00

Authors: *CARVALHO, Luiz (Graduate Program in Electrical Engineering - Federal University of Minas Gerais); DAVIES W. DE LIMA, Monteiro (Graduate Program in Electrical Engineering - Federal University of Minas Gerais); COSTA, Rodolfo (Graduate Program in Electrical Engineering - Federal University of Minas Gerais)*

Intraocular lenses (IOLs) have gained a momentum in their development in the last few years as new technologies and materials became available. They are alternative to the natural crystalline lens of the eye in several clinical conditions, especially cataract, which is the most important cause of blindness in the world. IOLs can be divided into three main groups: monofocals, torics and multifocals. This paper focuses on the refractive monofocal IOLs that differ from each other according to the shape of the surface (i.e. spherical or aspheric) and dioptric power. Spherical lenses present peripheral distortion reducing contrast sensitivity. This is minimized with aspheric lenses, based on a conic, usually hyperbolic, topology. There are numerous possibilities to mathematically represent IOL surfaces. In Ophthalmology, Zernike polynomials have been historically employed as the orthogonal basis for the precise description of recurrent eye-lens topologies as defocus, astigmatism, spherical aberration and coma. However, Zernike polynomials present limitations when describing aspheric surfaces, often requiring a large number of terms for their representation. Recently, Forbes proposed a group of orthogonal polynomials, also known as Q polynomials, that ease the representation and manufacturability of aspheric surfaces [1]. This paper compares the reconstruction of aspheric monofocal IOL surfaces sequentially using the first couple of Zernike and Forbes polynomial terms. We, therefore, propose the investigation of the reconstruction of both rotationally symmetric and asymmetric IOL surfaces in two steps that can be performed in the reverse order as well: 1) reconstruction with the first Zernike terms and 2) reconstruction of the residual surface with Forbes polynomials. This analysis verifies whether the combination of both polynomials renders the reconstruction of relevant ophthalmic surfaces with a prescribed precision and using fewer terms than required by each basis individually.We believe that successful results will also have a direct impact on adaptive optical systems.**References**[1] G. W. Forbes, “Characterizing the shape of freeform optics,” OPTICS EXPRESS, vol. 20, pp. 2483-2499, 30 January 2012

7 - Aberration correction with adaptive optics for lowering the threshold energy for femtosecond laser induced optical breakdown in a water based eye model

Session VI: Vision - Wednesday 04 September 2013 12:20

Primary authors: *HANSEN, Anja (Laser Zentrum Hannover e.V.)*
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In vision science, individual eye aberrations often compromise the quality of images of or stimuli to the retina. Here, adaptive optics is an established method for aberration correction. In femtosecond laser ophthalmic microsurgery, optical aberrations of the eye distort the irradiance profile at the laser focus which reduces the precision. Furthermore, the distorted focus increases the required laser pulse energy for the surgery process of laser-induced optical breakdown which increases the risk of collateral damage. For this reason, vitreo-retinal surgery in the posterior part of the eye has so far been considered impossible. The combination of adaptive optics for vision science with a femtosecond laser for ophthalmic surgery could overcome the obstacle of eye aberrations and therefore enable vitreo-retinal laser microsurgery. In this study we used water for modeling eye tissue during optical breakdown. Optical breakdown threshold was determined in single pulse plasma transmission loss measurements. We show that the threshold energy can be considerably reduced when using adaptive optics for aberration correction. For initial aberrations with a root-mean-square wave front error of only one third of the wavelength an adaptive optics aberration correction to the diffraction limit enables a reduction in threshold energy by a factor of three. At twice the threshold the transmitted pulse energy is reduced by seventeen percent. The reduction in both applied and transmitted pulse energy when correcting for aberrations could be transferred from the model eye to ophthalmic applications. With the present work we are confident that ophthalmic surgery could benefit from an aberration correction with adaptive optics, especially with regard to retinal safety. A lowered threshold energy for laser induced optical breakdown poses an important step towards femtosecond laser vitreo-retinal surgery.

8 - Adaptive Optics in Astronomy: deblurring the atmosphere

Session IX: Space - Thursday 05 September 2013 14:20

Primary authors: *BUCKLEY, David (Southern African Large Telescope)*
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The application of Adaptive Optics in astronomy has been revolutionary for ground based telescopes, particularly those working in the near infrared region of the electromagnetic spectrum. Techniques are rapidly evolving and current systems can already rival space-based telescopes (e.g. the Hubble Space Telescope) in some areas. This talk will briefly review how astronomical AO works and the results that can be achieved. The effects of the atmosphere in causing image degradation will be presented, as will the manner in which we can monitor its effect in real time. Finally the potential future use of Ground Layer AO for the Southern African Large Telescope will be discussed.

9 - Modal decomposition for wavefront reconstruction

Session III: Wavefront Sensing Techniques - Tuesday 03 September 2013 14:40

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We present a novel method for measuring the wavefront of laser beams based on modal decomposition using correlation filters. Accordingly, the beam under test is correlated with the modes encoded into the filter, which enables the reconstruction of the optical field in amplitude and phase and consequently the determination of Poynting vector and wavefront. The method is applied to aberrated free space Gaussian beams and beams emanating from optical fibers, for both, scalar and vector beams. Results are compared to those of a Shack-Hartmann wavefront sensor revealing excellent agreement, hence proving the high fidelity of wavefront reconstruction.

10 - Layer-oriented adaptive optics for extended objects

Session II : Imaging and Microscopy - Tuesday 03 September 2013 11:40

Primary authors: *KELLERER, Aglae (Durham University)*
Co-authors: *MYERS, Richard (Durham University)*

A key feature of future adaptive-optical systems will be multi-conjugate (MCAO) correction. There are fundamentally two different approaches to MCAO – star-oriented and layer-oriented.Up to now, MCAO for extended objects uses exclusively a star-oriented approach, which is a natural extension of a conventional AO system. The field-size of a star-oriented MCAO system is however limited due to the difficulty involved in the tomographic reconstruction.We argue that extended objects – e.g. the retina and biological tissues – are ideal targets for layer-oriented MCAO systems because the wavefront distortions can be sensed continuously over the entire field-of-view. Interestingly, in a layer-oriented approach, the correction is improved with increasing field-sizes. A practical implementation, however, meets current technological limits in terms of detector sizes and read-out frequencies.

11 - Adaptive optics for multi-photon microscopy using direct and sensorless measurement

Session VII : Imaging and Microscopy - Thursday 05 September 2013 09:10

Primary authors: *VAN WERKHOVEN, Tim (Leiden Observatory, Leiden University)*
Co-authors: *GERRITSEN, Hans (Molecular Biophysics, Utrecht University); KELLER, Christoph (Leiden Observatory, Leiden University); ANTONELLO, Jacopo (Delft University of Technology, Delft Center for Systems and Control); TRUONG, Hoa (Molecular Biophysics, Utrecht University); VERHAEGEN, Michel (Delft University of Technology, Delft Center for Systems and Control)*

Adaptive optics is widely used in astronomy to obtain diffraction-limited images through the turbulent atmosphere of the Earth. Over the last years, adaptive optics has gained the attention of a wider audience including microscopy. In this field, deep imaging in turbid media such as tissue is challenging due to scattering and optical aberrations. Adaptive optics can compensate the tissue aberrations. We use a coherence-gated wavefront sensing (CGWFS) scheme for multi-photon scanning microscopes using the pulsed, near-infrared light reflected back from the sample. Coherence gating isolates the light from a layer of interest and rejects ghost reflections in the optical system, solving an intrinsic problem for direct wavefront sensing methods.By interfering the back-reflected light with a tilted reference beam, we create a fringe pattern with a known spatial carrier frequency in an image of the back-aperture plane of the microscope objective. The sample-induced wavefront aberrations distort this fringe pattern and thereby imprint themselves at the carrier frequency, which allows us to separate the aberrations in the Fourier domain from low-frequency noise. A Fourier analysis of the modulated fringe pattern retrieves the wavefront aberrations, and the pulsed laser rejects spurious signals through coherence gating. This wavefront sensing method can directly measure the wavefront which is subsequently corrected using a deformable mirror.Our method has a reproducibility of $\lambda/86$ peak-to-valley for defocus. We verified our method with a deformable mirror (DM) to measure the wavefront sensing accuracy. We present wavefront measurements of biological samples, and compare our method to sensorless methods, where the feedback loop uses an image quality metric instead. Finally, we will present first results of AO corrected measurements.

12 - Overview and perspectives of Active and Adaptive Optics for Space Optical Applications

Session IX: Space - Thursday 05 September 2013 14:40

Authors: *HALLIBERT, Pascal (ESA-ESTEC)*

The increasing need for higher resolution for space optical applications has prompted the study of technologies aimed at improving imaging performance beyond what is currently achievable by classical optical systems. Active Optics and Adaptive Optics are very promising examples of such technologies, potentially allowing to counter in-flight effects (such as thermo-elastic deformations, radiation effects on optical materials, micro-vibrations…) which impact the optical quality of space instruments. They can also potentially decrease the manufacturing complexity of optical component and reduce the outage rate of missions (due e.g. to Sun baffle intrusions or eclipses altering the thermal conditions within the instrument). This paper gives an overview of the current state-of-the-art of Active/Adaptive Optics developments for Space Applications. It details as well the constraints that such systems would encounter during a Space mission and lists effects affecting image quality that Active/Adaptive Optics could help reduce.

13 - Constrained optimisation for fast wavefront sensorless adaptive optics in microscopy

Session VII : Imaging and Microscopy - Thursday 05 September 2013 09:30

Primary authors: *ANTONELLO, Jacopo (DCSC, Delft University of Technology)*
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Specimen-induced aberrations severely affect the image quality in fluorescence scanning microscopy. Therefore, adaptive optics is used to restore diffraction-limited imaging [1]. Since direct wavefront sensing has been shown to be challenging in fluorescence microscopy, wavefront sensorless adaptive optics techniques have been developed. Instead of attempting to measure the wavefront, a suitable image quality metric is used as a feedback signal for the aberration correction procedure. This is a sequential process that consists of probing different settings of a wavefront correction element (e.g. a deformable mirror) until the corresponding value of the image quality metric is optimised.Sensorless adaptive optics has been theoretically studied and experimentally demonstrated for different microscopy approaches [2]. In particular it was shown that a model of the image quality metric allows to reduce the time necessary for the aberration correction procedure. This minimises both the overall image acquisition time and undesirable side effects such as photobleaching and phototoxicity.Here we consider the case when a quadratic polynomial is used to model the image quality metric [3]. This class of models has been widely employed in different microscopy approaches. We show that a robust aberration correction is achieved by solving a suitable constrained optimisation problem. We also show that, exploiting an a priori assumption about the unknown wavefront aberration, an incremental correction can be applied before the minimum number of measurements necessary to uniquely determine the aberration is reached. Our proposed algorithms are compared with other solutions present in the literature and validated in a laboratory environment. [1] M. J. Booth, ``Adaptive optics in microscopy.'' Philosophical transactions. Series A, Mathematical, physical, and engineering sciences 365, 2829-2843 (2007). [2] A. Facomprez, E. Beaurepaire, and D. Débarre, ``Accuracy of correction in modal sensorless adaptive optics,'' Opt. Express 20, 2598-2612 (2012). [3] J. Antonello, M. Verhaegen, R. Fraanje, T. van Werkhoven, H. C. Gerritsen, and C. U. Keller, ``Semidefinite programming for model-based sensorless adaptive optics,'' J. Opt. Soc. Am. A 29, 2428-2438 (2012).

14 - Propagating aberrated laser beams

Wednesday 04 September 2013 14:00

Primary authors: *MAFUSIRE, Cosmas (CSIR National Laser Centre)*
Co-authors: *FORBES, Andrew (CSIR National Laser Centre)*

We outline a theory for the calculation of the laser beam quality factor of an aberrated laser beam. We provide closed form equations which show that the beam quality factor of an aberrated TEM00 Gaussian beam depends on all primary aberrations except tilt, defocus and x-astigmatism. We extend this concept to defining the mean focal length of an aberrated lens and show that this quantity depends on all Zernike aberrations of ordinal number 0 or 2 except piston. The models are verified experimentally by implementing aberrations as digital holograms in the laboratory. Lastly, we show how the definition of the two concepts may be of use in controlling thermal aberrations in laser resonators using adaptive optics, thereby improving the quality of the beam generated and also reducing the effects of thermal lensing.

15 - Active spatial polarization control for microscope objectives

Session VII : Imaging and Microscopy - Thursday 05 September 2013 09:50

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We show a micro optical device for non-pixelated active spatial polarization control. The device is based on a photoaddressable material (PAM). The birefringence of the PAM is locally modulated due to the intensity of the addressing light. This enables the creation of non pixelated spatial polarization patterns with fewer artefacts compared to devices like spatial light modulators.The optical addressing is done by an integrated micro-optical illumination unit. VCSELs are used as a light source. The addressing patterns are generated by diffractive optical beam shapers. Due to the small size of the components it is possible to realize several addressing channels in one device. By controlling the current of the VCSELs, different illumination patterns can be switched or combined.The complete system can be integrated into a microscope objective e.g. for switchable phase contrast methods.

16 - Biomedical applications of optics

Wednesday 04 September 2013 14:00

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Mammalian cells can be optically micro-manipulated in-vitro to promote embryonic stem cell research, neurodegenerative disorder studies, human immunodeficiency virus (HIV-1) investigations and cancer research science. In this work, lasers of different regimes are employed as they possess special properties that allow classical biomedical applications. Studies toward the interaction of laser light, nanomaterials and biological materials can lead to an understanding of a wealth of disease conditions and result in photonics-based therapies and diagnostic tools. In this talk; firstly, optical transfection and differentiation of embryonic stem cells is presented. Secondly, somatic and dendritic phototransfection of neuroblastoma cells on graphene substrates is shown. Thirdly, using different beam shapes photo-translocation of HIV-1 drugs into TZM-bl cells is given. Finally, optical trapping and sorting of cancerous from healthy ones is demonstrated.

17 - Impact of wavefront aberrations in ultrafast nonlinear optics

Session III: Wavefront Sensing Techniques - Tuesday 03 September 2013 14:00

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Ultraintense femtosecond lasers have become workhorses in disciplines as materials microprocessing, particle acceleration or spectroscopy. Due to the optics inside the cavity and the high-peak-power, wavefront aberrations (WA) are present, degrading the beam quality. The accurate WA measurement and control is therefore essential to get diffraction limit conditions and achieve high peak intensities. In this contribution we present the phase characterization along the chain of a femtosecond laser.On the other hand, many of their applications originate from the nonlinearities they induce. However, nonlinear processes usually yield significant phase distortions. The effects of WA for experiments in the field of nonlinear optics are also analyzed:**Second-harmonic generation (SHG)**SHG of aberrated pulses is studied in terms of focusability, spatial chirp, beam quality and WA. At high intensities, a phase shift, proportional to the pump beam profile, is induced by the SHG. It is found that in general WAs lead to spatio-spectral coupling and degrade the SH focusability, although under particular conditions they can compensate for the induced phase shift. **Supercontinuum generation (SCG)**We show that diffractive lenses exhibiting strong chromatic aberration can be used for spectral shaping of SCG with femtosecond pulses, obtaining tunable SC pulses and extending the cut-off frequency. **Filamentation** Nowadays, filamentation is commonly used for obtaining shorter pulses. The main constraint of this scheme originates from the existence of an upper energy limit for single filamentation. We demonstrate that astigmatic focusing allows for an increase in the multi-filamentation threshold, consequently improving post-compression. **Electron generation**WA analysis is applied to optimize the experimental setup for electron acceleration in gases and solids. In the first case, it allows for an accurate control of the density of the gas and its dynamics under different experimental conditions, and in the latter it is used as input for a propagation simulation code.

18 - Free-motion measurement of the beam propagation factor by means of a spatial light modulator.

Wednesday 04 September 2013 14:00

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The standard ISO/DIS 11146 describes a procedure to measure the beam propagation factor (M^2) by mechanical scanning of the beam waist region. In contrast to this method, we propose a novel experimental implementation where no moving elements are needed. Our proposal takes advantage of the features of low-cost programmable liquid crystal spatial light modulators (SLMs). A set of lenses with different focal lengths are sequentially encoded in the SLM. Then, by using a digital sensor at a fixed position, the beam width according to the second order moment of the irradiance is measured for each focal length of the encoded lenses. After fitting the measured data to the theoretical focusing behavior of a real laser beam, the beam propagation factor is obtained. The use of this kind of modulators introduces some benefits, such as the possibility for high numerical aperture or local beam control of the phase of the lenses which allows for minimizing systematic errors originated by lens aberrations.The proposed method was successfully validated in the laboratory where a full digital control of the measurement procedure was implemented. The M^2 calculation by this method is very low time-consuming and allows very simple setup. Its application to compact Optics systems is straightforward.

19 - Multi-conjugated adaptive optics for intense femtosecond lasers

Session IV: Adaptive Control - Tuesday 03 September 2013 16:40

Primary authors: *CHERIAUX, Gilles (Laboratoire d'Optique Appliquée)*
Co-authors: *VEDRENNE, Nicolas (ONERA-DOTA); MICHAU, vincent (ONERA-DOTA)*

Many developments since the early 90's have been done on intense laser sources, in order to increase the peak power. Significant progresses were also made to obtain higher and higher average powers. Developments are still on progress especially for systems such as the ILE-Apollon program in France. The various pillars of European ELI programs in the Czech Republic, Romania and Hungary are under construction and target peak power of 10 PW with pulse durations of 15 fs and energy of 150 joules. These lasers are at the state of the art, but many other less powerful systems are now under construction by the institutions themselves or purchased from companies that are Amplitude Technologies and Thales for example. A common requirement to all these systems is to reach highest intensity in the plane of interaction, with applications both on civilian and military side.To meet these requirements, these intense laser sources require optical components of high quality (reflectivity, flatness and damage threshold) and also of large dimension. Nevertheless despite of these efforts, the intensity on target is degraded by wavefront distortions and energy distribution modifications. This leads to a decreased intensity which is detrimental for the experiment.Since 2000; efforts have been done by use of one adaptive optic (deformable mirror or DM) and thus correction of the wavefront. This has lead to improve the focused intensity by 30 to 40 %. For achieving this result, the DM shape is derived from the wavefront measurement obtained in the mid-field. This measurement does not take into account the propagation of the beam after the DM and especially the aberrations of the focusing system.A collaborative French program, ILOOP, between LOA, ONERA and REOSC is aiming to measure the wavefront in the experimental plane and to improve the intensity at focus by the use of more than one adaptive optic in order to shape the energy distribution and the wavefront.The talk will present the design of the wavefront sensor and first measurement obtained with it. An analysis as a function of the wavelength will also be presented. This point is very important for the femtosecond lasers as the spectrum is lying over 200 nm of spectral bandwidth.The design of the multi-conjugate loop will be detailed as well as its implementation in a femtosecond laser chain.

20 - Computational Testbench and Flow Chart for Wavefront Sensors

Wednesday 04 September 2013 14:00

Authors: *ABECASSIS, Úrsula (Department of Electronics and Telecommunications, Instituto Federal do Amazonas – IFAM); DE LIMA MONTEIRO, Davies W. (Department of Electrical Engineering Universidade Federal de Minas Gerais – UFMG, Brazil); P. SALLES, Luciana (Department of Electrical Engineering Universidade Federal de Minas Gerais – UFMG, Brazil); BORGES, Euller (Department of Electrical Engineering Universidade Federal de Minas Gerais – UFMG, Brazil); STANIGHER, Rafaela (Department of Electrical Engineering Universidade Federal de Minas Gerais – UFMG, Brazil)*

Adaptive Optics is a multidisciplinary topic with a growing number of applications, from ophthalmology to astronomy, each with their respective requirements. There are, to date, many methods, algorithms, components and devices that can be combined in a vast variety of ways for a wavefront-sensor design in Adaptive Optics. There is also an increasing number of didactic books, scientific papers and websites that assist one through the meanders of wavefront sensing, control and actuation. Nevertheless, they often tackle a specific subject or are organized in a sequential structure of general topics, short of displaying in a straightforward fashion how elements can be chosen to work together. Most groups indeed have the knowledge to make suitable decisions, but for a newcomer, the realm of available options is often fuzzy, from device to system level. In this context, we have envisioned a chart that will be useful to aid the visualization of possible choices and how they relate to each other. We will focus on wavefront sensing and propose a method to display the available options, from wavefront generation to error analysis, aiming to assist in decision making and in organizing a testbench for simulation and optimization of a device or sensing system. This is based on a flow chart branching downwards and laterally, linking together only structurally feasible options. This detector sub-block of an Adaptive Optics system alone features such numerous pathways that we limit ourselves to detail just a few of the possible tracks to illustrate how one can couple simulation codes and tools to design a system and preview its performance. The chart is flexible enough to accommodate new developments on devices and codes. As the chart is communally extended to actuation and control, and its branches are cooperatively populated with simulation models, a more complete mapping of possible systems will result. We will present simulation results that include the effect of several components, including the sampling plane, photodetectors and electronic circuitry on wavefront reconstruction.

22 - High resolution in-vivo imaging of the mouse retina using an adaptive optics system with MEMS segmented piston/tip/tilt deformable mirror.

Session II : Imaging and Microscopy - Tuesday 03 September 2013 12:00

Primary authors: *ZAWADZKI, Robert J. (UC Davis)*
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High resolution in-vivo retinal imaging of small animals is becoming an increasingly important tool in developmental biology and vision science. It is especially attractive for studying temporal changes in animal models of retinal diseases and for monitoring disease progression in response to different risk factors or treatments. To achieve the best possible resolution of retinal structures for precise monitoring and quantification of changes at cellular resolution, one has to measure and compensate for ocular aberrations of the mouse eye over a large pupil. The mouse eye with dilated pupil has a numerical aperture (NA) 2.5X that of the human eye, enabling the possibility of imaging with optical coherence tomography (OCT) or scanning laser ophthalmoscopy (SLO) at resolutions much higher than available in human eyes. In our prototype instrument, we used Iris AO adaptive optics (AO) system that includes the PTT111 deformable mirror (with inscribed aperture of 3.5 mm consisting of 37 hexagonal segments and 5 um stroke (tip/tilt/piston)) and Hartmann-Shack wavefront sensor (WFS) with 37 lenslets, working in a 1:1 optical mapping of DM segments to WFS lenslets. We evaluated performance of this system by measuring and correcting aberrations of the mouse eye. Additionally, images of the microscopic morphology of the retina in-vivo have been acquired with both AO-OCT and AO-SLO modalities. During imaging, mice were anesthetized by inhalation of 2-3% isoflurane delivered in oxygen. Measurements of the wavefront error from a typical mouse eye with fundus contact lens and the best focus (AO off) was on the order of 200nm RMS error. By activating the AO system, the measured wavefront was reduced to < 50nm RMS error. This corresponds to diffraction-limited imaging as defined by RMS error < $\lambda/14$. Representative images of the mouse retina will be presented. Application of general anesthesia allowed for relatively long imaging sessions of up to 60 minutes without producing adverse effects. Additionally, several measurements of the same animals were performed every other day with no negative effects on the mouse.

24 - Recent advances in high-power fundamental mode thin-disk lasers using intra-cavity deformable mirrors

Seesion I : AO in Lasers - Tuesday 03 September 2013 09:00

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Thermally induced aberrations are limiting power scaling of solid-state lasers. The concept of the thin-disk laser was developed in order to mitigate this so-called “thermal lensing”. By scaling the gain medium down to a thin disk, a highly efficient back-side cooling scheme can be applied, minimizing the amount of thermally induced aberrations in the pumped laser crystal. This enables the design of high-brightness lasers with a broad dynamic stability range. In fundamental-mode operation, however, the aspherical components of the remaining wavefront distortions arising from the strong temperature gradient at the edge of the pump spot lead to diffraction losses which limit power scalability. These aspherical wavefront distortions can be compensated for by intra-cavity deformable mirrors. For this purpose, we have developed pneumatically deformable mirrors consisting of fused silica substrates with an annular groove applied from the back side. If pressure is applied from the back side of the mirrors, the HR-coated front surface of the mirrors is deformed in a way that closely matches the super-gaussian shape of the aspherical components of the wavefront deformations induced in the thin-disk laser crystal. The magnitude of the deformation is linearly dependent on the applied pressure, which can be controlled very precisely. Hence, the mirror can be accurately tuned in order to effectively compensate for the wavefront deformations generated in the laser crystal at a large range of different pump powers. In recent experiments, we have successfully demonstrated the use of these mirrors in a thin-disk laser resonator. With output powers of up to 815 W from a single disk at close to fundamental-mode operation (M^2 < 1.4) reported so far, power scaling beyond the 1 kW is within reach. The results of further experiments currently in progress will be reported during the workshop along with a full characterization of the mirrors

25 - Characterization and application of a deformable mirror for pulse shaping in the Mid-Infrared

Session IV: Adaptive Control - Tuesday 03 September 2013 17:00

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Deformable mirrors (DMs) can be realized with many technologies. Each of them matches different requirements and have found applications in different specific research fields. The most of the DMs have been designed for the UV or visible or near infrared spectral range which present the wider range of available sources and applications. Parametric amplifiers have reported successful results in pulse compression in different spectral region from visible to the mid-infrared [Optics Letters 35, 757-759 (2010)]. The mid-infrared (MIR) region is of particular interest because offers unique possibilities to steer the phase state of condensed matter. Selective excitation of low-energy modes, such as lattice vibrations, by intense few-cycle pulses in this spectral range has been shown to control insulator-metal transitions or magnetism in manganites and to induce superconductivity in cuprates. The availability of precisely tailored light pulses may open up new path ways for the control of phase transitions.Changing the temporal shape of short laser pulses with a given bandwidth requires control of the spectral phase of their electric field. Widely used devices in the near-infrared or visible range, such as acousto-optic or liquid crystals modulators, are not suitable for operation at wavelengths longer than 12 µm: as they require propagation in bulk materials, absorption in this spectral range prevents their use. For this reason, reflective schemes based on deformable mirrors are promising candidates for pulse shaping at these wavelengths. Their spectral coverage is indeed only limited by the reflectivity of their metallic coating. The DM was designed to operate at the OPA spectral range of about 17um. Since the DM stroke has to be comparable with the wavelength this DM gives a maximum stroke of about +/-110um. We will present the characterization of the DM, carried out with a Moire interferometer and the experimental results of the pulse shaping.

26 - Modal deformable mirror optimization in sensorless Optical Coherence Tomography

Session II : Imaging and Microscopy - Tuesday 03 September 2013 12:20

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We demonstrated that the modal sensorless correction can be used in Optical Coherence Tomography (OCT) with the use of a modal deformable mirror [Optics Communications, 284(13), 3467-3473 (2011)] exploiting a recent optimization method based on the cancellation of one aberration at a time. This strategy presents many advantages such as the use of few iterations and the absence of local maximum [Opt. Letters, 32(1) (2007)]. Sensorless optimization plays an important role in adaptive optics development thanks to the reduced hardware complexity. The use of sensorless optimization has been demonstrated in some fields such as laser focalization and in the improvement of image quality. In the most of the cases the optimization was carried out by the use of an optimization strategy, such as for example the genetic algorithm or others, which maximizes the value of a merit function which can be either the intensity in the focal spot for the laser optimization case or an image sharpening function in the case of the optimization of an image quality. The Modal Deformable Mirror (MDM) is an electrostatic membrane DM where the actuators are composed by a resistive layer which continuously distributes the electrostatic pressure on the membrane designed in order to directly generate low order aberrations such as defocus, astigmatism, coma and spherical aberration. To test the performance of our Sensorless Adaptive Optics - Optical Coherence Tomography system we tried to improve image quality of the Air Force Test target aberrated by some trial lenses.

27 - Ultrafast time compensated monochromator with deformable diffraction gratings

Session IV: Adaptive Control - Tuesday 03 September 2013 17:20

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Active deformable diffraction grating can be used for the realization of a time compensated pulses in the XUV. We present the preliminary tests of time compensation operated in the visible at 800nm.The compensated monochromator consists in a couple of deformable diffraction gratings. The devices consist of a laminar diffractive layer realized by UV lithography that is deposited on the top of a bimorph deformable mirror. The deformable diffraction gratings have been designed to have high optical quality, robustness and compatible with any coating deposition and have only vacuum-compatible materials. We present the characterization of the prototypes in the vacuum ultraviolet and in the visible, showing that the active grating can optimize the beam focusing through its rotation and deformation. Two active gratings have been mounted in a compensated configuration to realize a grazing-incidence time-delay compensated monochromator for high-order laser harmonics. The wavelength selection is performed through the grating rotation, the intermediate slit carries out the spectral selection of a single harmonic and the spectral focusing is maintained by adjusting the grating radii. The instrument has been initially tested in air with a Ti:Sa laser operated at 800 nm. We have been able to demonstrate that the double-grating configuration with active gratings compensates for the pulse front-tilt. The front-tilt given by the first grating is ■1 ps and is reduced to ■100 fs after the second stage. The final value is limited by the group delay dispersion of the monochromator within the 10-nm bandwidth of the laser centered around 800 nm. Active gratings may be considered as a cheaper and more flexible alternative to standard gratings for the realization of extreme-ultraviolet ultrafast monochromators.

28 - High resolution wavefront control using a photocontrolled deformable mirror in closed loop

Session IV: Adaptive Control - Tuesday 03 September 2013 17:40

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Using a photocontrolled membrane deformable mirror it is possible to control and correct the wavefront with unprecedented resolution. Our novel design of deformable mirror is an electrostatic membrane mirror actuated through the change of resistivity of a photoconductor substrate rather than using a conventional matrix of electrodes The Optically addressable Deformable Mirror (ODM) is composed by a Bismuth Silicon Oxide (BSO) photoconductive crystal, and a nitrocellulose metallized membrane. The light pattern which controls the mirror shape is emitted by a commercial DLP projector with 800 x 600 pixels. The main advantages of this device are the extreme reduction of hardware complexity, since just one high voltage line is used and the high resolution addressing of the DM instead of the array of high voltage lines used for standard electrode matrix geometries. We demonstrated those advantages through its use in a closed loop system, by the Zernike characterization exploiting a flexible light addressing up to an equivalent of 15x15 actuators. As a demonstration of the flexibility of use and high spatial resolution of this deformable mirror the mirror has been used as a simulator of atmospheric turbulence and to simulate the design of the ideal deformable mirror for the correction of thermal lensing in high power lasers.

29 - All-digital holographic tool for real-time mode excitation and ~analysis in optical waveguides

Session VIII : Spatial Light Modulators - Thursday 05 September 2013 11:40

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A real-time procedure for multiplexing and demultiplexing of transversal modes in optical waveguides is presented, based on dynamic and static digital holograms. By using a spatial light modulator (SLM) to encode a digital hologram, the desired complex field is shaped and injected into the waveguide. The SLM's ability to rapidly refresh the encoded transmission function enables one to excite pure single modes, as well as arbitrary coherent mode superpositions, in real-time. The modes leaving the output of the waveguide are subsequently demultipexed by applying a holographic correlation filter for modal decomposition, thus allowing for an all-digital-hologram approach to modal analysis of wave guiding structures. The working principle is tested using conventional step-index large mode area (LMA) fibers being excited with higher-order single modes as well as superpositions thereof. Extending this approach to a closed-loop-system, enables one to control amplitude- and phase distribution of the emerging optical field.

30 - Utilizing speckle decorrelation for tomographic wavefront sensing (with one wavefront sensor)

Wednesday 04 September 2013 14:00

Primary authors: *BHARMAL, Nazim (University of Durham)*
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Generation of speckle using scattering that is spatially incoherent is acommon, and often annoying, phenomenon but has not been as yet utilized inadaptive optics for wavefront sensing. This paper describes a method wherebylight is scattered from a surface (which may be a plane within a samplebeing imaged) and then an image is obtained of the speckle created at twodefocused planes at some equal but opposite distance from that pupil. Due tothe correlation of speckle with propagation, a cross correlation of detectedintensity (or amplitude, via interferometric detection) can be used tomeasure the wavefront gradient. The key advantages of this technique includethe ability to alter the sensitivity of the wavefront gradient signal vs.the spatial sampling of the wavefront gradient. A further extensiondemonstrates how multiple but distinct regions of scattering can be utilizedto produce overlapping but mutually uncorrelated speckle. The individualspeckle cross-correlation can then be extracted to result in a set ofwavefront gradients that, in astronomy, would be described as star-oriented.Astronomical data-reduction approaches can then be used to produce atomographic or 3D wavefront solution. In this case, the wavefront sensorhardware is no different to the single-scattering source case and theangular source selection is done by computation rather than multipledevices; thus costs and complexity are minimized at the expense of detectionand computational time.

31 - Manufacturing and Testing of Unimorph Deformable Mirrors for Space Telescopes

Session IX: Space - Thursday 05 September 2013 15:00

Primary authors: *RAUSCH, Peter (University of Applied Sciences Muenster)*
Co-authors: *VERPOORT, Sven (University of Applied Sciences Muenster); WITTROCK, Ulrich (University of Applied Sciences Muenster)*

Future concepts of large space telescopes are based on lightweight primary mirrors. These primaries cannot meet the required optical surface figure due to their floppy structure, misalignment of the mirror segments, and gravity release and are likely to generate several microns of wave-front error. One potential solution to correct for these errors could be the integration of a space-compatible deformable mirror. Such a mirror is a prerequisite for a diffraction-limited space telescope with an aperture that is significantly larger than that of the James Webb Space Telescope. A temperature insensitive mirror with suitable diameter, stroke and surface fidelity embodied in the optical train would relax the specifications and improve the optical performance of a space telescope.The harsh environmental conditions in space impose special challenges on the instruments. A deformable mirror would be exposed to a broad vibration spectrum, as well as to accelerations of several tens of g. Cosmic irradiation may degrade the optical coating, exposure to vacuum could lead to contamination and further degradation of the mirror's surface. Cryogenic temperatures down to 100 K demand a thermally insensitive design of the mechanical support and careful selection of the used materials. We have scaled our small-sized laser mirror which was originally developed for high power laser applications towards an aperture diameter of 50 mm to take into account the Lagrange invariant of large aperture telescopes. To cope with the cryogenic temperatures, an athermal design was achieved via both CTE matching and stress relieve by implementing an isostatic mounting. The optomechanical layout of the mirror has been investigated by extensive finite element calculations, which allowed for an optimization of the design. The use of low outgassing materials ensures vacuum compatibility. A tailored test-bed has been designed to experimentally characterize the mirror's performance. To confirm space compatibility, performance tests in a cryogenic environment have been conducted. Further tests were carried out to validate the mirrors ability to withstand vibration, acceleration and irradiation levels typically occurring during space missions.

32 - Optical Design and Optimization of Adaptive Automobile Headlight with Liquid Optical Element and Freeform

Wednesday 04 September 2013 14:00

Authors: *FANG, YiChin (Head of Department)*

This research proposed a new optical design concept of advanced Mechanical Adaptive Steering Automobile Headlight System in order to tune up light efficiency, reduce volumetric size and the most important, get rid of complicated mechanical system. All research are mainly focus on (1) Optical Design of Freefrom Surface technology.(2) Image technology of DMD . (3) Human Vision characteristic .(4) Digital Signal Processing and its application with GPSTraditionally Automotive headlight employ a plate to create the light shape, which meet the rule of road safety, According to our new design, no more plate is required. Therefore, great improvement of light efficiency will be expected up to 30%, Besides, volumetric size will be further reduced. More details, please refer to “Optical design of automotive headlight system incorporating digital micromirror device, ” APPLIED OPTICS, Vol. 49
No. 22(SCI), 2010,pp.4182~4187” .First year, we mainly study optical design of advanced LED automotive headlight design and optimization with assistance of freefrom surface. New concept of optical design with DMD might greatly reduce volumetric size of headlight system,In second year, individual human vision characteristic will be considered as a part of automotive headlight system in my research in order to improve safety of road drive. Many experimental work and simulation analysis will be studied and compared in order to achieve best performance of automotive headlight system according to human vision.In third year, GPS will be optimized with DMD and infrared image from cameras in the car in order to achieve best performance during extremely driving situation. All are based on research of first and second year, optical design and human vision characteristic. With assistance of GPS and night vision camera, all road data will be fast optimized according to human characteristic of individual driver. Then DMD will deliver the best-projected illumination for driver during extremely situation.Keyword: light efficiency■DMD■Human Vision■GPS■Digital Signal Processing Freefrom surface

34 - Compensation of the two-stage phase-shifting algorithms with respect to detuning and harmonics

Wednesday 04 September 2013 14:00

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The study of two-stage phase-shifting algorithms is a topic of recent research, speci cally the Fourier analysis of these algorithms with respect to insensitivity properties to various error sources. The main motivation of this paper is to propose two-stage phase-shifting algorithms with insensitivity properties to detuning and harmonics for the two sets of interferograms with di erent or equal reference frequencies. In this work the design of two-stage phase-shifting algorithms is based on the development of generalized equations that consider non-constant phase shifts. The analysis of the frequency sampling functions representing these algorithms is also considered.

35 - Correction for distortions in holographic nanointerferometers

Session VII : Imaging and Microscopy - Thursday 05 September 2013 10:10

Primary authors: *VENEDIKTOV, Vladimir (St.-Petersburg State University)*
Co-authors: *PASECHNIK, Irina (St.-Petersburg State University); PUL'KIN, Sergey (St.-Petersburg State University)*

Fast progress in matrix liquid-crystal phase modulators, in particular those of Holoeye production, made it possible to realize some interesting schemes in holography, and, in particular, in holographic interferometery for investigation of nano-sized objects. Combination of analogous and digital processing made it possible, in particular, to provide the real-time magnification of holograms and real-time digital variation of spatial frequency of interferogram. However, when considering the nano-size objects, even in a high optical quality interferometer one has to keep in mind the residual distortions of the interfering wavefronts, imposed by residual defects and deformations of the interferometer elements. One can eliminate these distortions by combining in one and the same scheme of the real-time holographic magnification of interferogram and of the dynamic holographic correction for distortions. We discuss the results of theoretical evaluation of such a combined interferometer performance and of its experimental simulation.

36 - Adaptive Lenses for Displays & Vision

Session V: AO Techniques - Wednesday 04 September 2013 08:30

Authors: *LOVE, Gordon (Durham University)*

There are a whole host of technologies for producing lenses with controllable focal lengths, ranging from electro-wetting to liquid crystal technology. In this paper we will discuss some of our recent work on applying liquid crystal lenses to applications in 3D displays and vision science. For these applications we typically need very fast lenses and we shall also discuss the background technology of switchable birefringent ferroelectric liquid crystal lenses.

37 - Results on the high power testing of screen-printed deformable mirrors

Session V: AO Techniques - Wednesday 04 September 2013 09:10

Primary authors: *REINLEIN, Claudia (Fraunhofer IOF, Jena)*
Co-authors: *APPELFELDER, Michael (Fraunhofer IOF, Jena); GOY, Matthias (Fraunhofer IOF, Jena)*

The performance of high power laser systems is affected thermal lensing. Deformable mirrors have been applied for the compensation of these thermal lensing effects. Difficulties can arise as not only the optical properties of lenses and mirrors in the beam path are affected by thermal lensing, but also deformable mirrors itself. The radiation of a high power laser beam is partly absorbed by the deformable mirror surface and transferred into heat. Mirrors temperature is increased leading to laser-induced mirror deformations. These deformations need to be analyzed to evaluate the applicability of a deformable mirror in high power systems. This paper gives results on the high power testing of our MOEMS screen-printed deformable mirrors.We introduce the measurement set-up based on a 1 kW laser beam that is incident on the deformable mirror. The deformable mirror is equipped with a dielectric coating that offers a reflectivity of 99.4 % at 1070 nm in order to allow for the application in high power systems. The high power laser beam is expanded to a diameter of 20 mm to match the mirror's aperture. Subsequently, the beam is compressed to the wavefront sensor's aperture to measure the laser-induced aberrations. We measure the overall laser-induced mirror deformation and also give results on their temporal behavior. The laser-induced mirror deformation is only few micrometers in case of 1 kW laser load.The design of the deformable mirror allows for a compensation of the laser-induced deformations by mirror heating. The temperature-induced deformation rate is
-1µm/K. In the next step, we demonstrate the further minimization of the laser-induced deformations by mirror heating und demonstrate the applicability of the screen-printed deformable mirror for high power applications.

38 - Advances in adaptive optics nonlinear microscopy for applications in medical and life sciences

Session VII : Imaging and Microscopy - Thursday 05 September 2013 08:30

Authors: *BUENO, Juan M. (Universidad de Murcia)*

In the last years, the combination of imaging microscopy and ultrafast laser sources to produce nonlinear signals has opened new research opportunities in Biology and Biomedicine. In nonlinear (multiphoton) microscopy two infrared photons are simultaneously absorbed by the tissue and one visible is emitted. Two-Photon Excitation Fluorescence (TPEF) and Second-Harmonic Generation (SHG) are well-established non-invasive methods used for imaging and mapping sub-cellular biological structures. This technique is autoconfocal, provides intrinsic optical sectioning and allows 3D analysis and volume rendering. However, multiphoton imaging is also affected by aberrations (laser beam, microscope optics and specimen itself). These reduce the quality of images, in particular those corresponding to deeper planes within the sample. In our lab, a custom-made multiphoton microscope combined with adaptive optics (AO) devices has been developed to improve multiphoton imaging of biological tissues, in particular those of the eye. A deformable mirror with a Hartmann-Shack sensor (working in closed-loop), and a liquid-crystal spatial light modulator (in sensor-less mode) have been used to investigate the effects of aberrations when visualizing corneal and retinal structures. Along this presentation the last advances in AO multiphoton imaging, both TPEF and SHG, will be shown. AO techniques revealed ocular features never seen before without using fixation or staining procedures. Multiphoton image quality was improved independently of the depth location of the imaged plane. It will be also shown how that deeper the imaged structure the more influence of higher order aberration terms. The influence of the field-of-view and the order of the Zernike modes in a modal correction will be also explored. Finally, different algorithms and image quality metrics used to optimize the final image will be also compared.

39 - Adaptive Optics for Horizontal Propagation Applications

Session X: Propagation and Turbulance - Thursday 05 September 2013 16:30

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Adaptive Optics (AO) is a well proven technology for imaging systems used for astronomical and Space Surveillance applications. However, the application of these proven techniques to horizontal path imagery is not straightforward, and so far has not been investigated for imaging systems. There are two major problems with extending AO systems for vertical imaging systems to horizontal imaging regime. First, the optical effects of atmospheric turbulence are far more severe for horizontal than for vertical paths. Furthermore, there is now growing experimental evidence that in the horizontal regime the usual wavelength scaling of the strength of turbulence does not hold. This is readily apparent from observing the slight effect of twinkling of stars compared to the pronounced shimmering of objects when viewed across a hot pavement. . Second, horizontal imaging systems generally involve viewing extended sources over relatively large fields of view. Currently no wavefront sensing schemes exist for this application. Primarily for these reasons, the development of an AO system for horizontal imaging systems remains an important unsolved DoD problem. In this paper we will present results and analysis related to our horizontal path imaging and correction effort.

41 - Dynamic generation of scattering for high resolution adaptive optics in the eye

Session VI: Vision - Wednesday 04 September 2013 12:40

Primary authors: *FERNANDEZ, Enrique-Josua (Universidad de Murcia)*
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Adaptive optics (AO) is benefiting a number of different fields. In the particular case of ophthalmic applications, the correction of the aberrations of the eye permits to image the retina with unprecedented level of detail, unveiling the subtle structures of individual cells. On the other hand, the controlled manipulation of the wavefront accomplished by AO visual analyzers allows a better understanding of the impact of eye’s aberrations in vision. However, aberrations are not the only limiting factor for both vision and retinal imaging. Normal young eyes also exhibit moderate amounts of scattering which can degrade the optical quality of retinal images. Scattering is known to dramatically increase with age. Adaptive optics may have the potential of eventually removing some scattering, through high spatial frequency correctors. Liquid crystal devices can incorporate resolutions of up to 2 million of independent pixels for scattering compensation, being ideal candidates for such applications. Time reversal experiments demonstrating the practical compensation of scattering have been already reported under controlled situations in microscopy. In this direction, a reliable experimental eye model would be advantageous for the progress of the technique, before its real time demonstration in the living eye. The eye model is necessary for demonstrating the double-pass implementation of scattering compensation, and the subsequent refining of algorithms for real time operation. We have developed a relative simple eye model to mimics the optics of the eye, and includes a transmissive liquid crystal spatial light modulator for scattering control (LC 2002, Holoeye Photonics AG, Germany). The latter can be programmed to different configurations in real time producing different levels of scattering. The scattering can be generated by mostly phase modulation, or with different combinations of amplitude and phase. Double pass images obtained from the model resemble those obtained in real eyes with high levels of scattering. The experimental eye model is an important tool for the development of the next generation ophthalmic adaptive optics systems capable for both wavefront and scattering manipulation in the living eye.

42 - Phase generation in white light with a 6-Pi Liquid Crystal on Silicon (LCoS) device

Session VIII : Spatial Light Modulators - Thursday 05 September 2013 12:00

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Phase modulators based on liquid crystal are currently applied in many fields. The development of Liquid Crystal on Silicon (LCoS) technology has notably improved the performance of these devices. Analyzing vision with Adaptive Optics is one of the new applications taking advantage from these gadgets. In Vision Analysis procedures, subjects undergo visual testing through modified aberration patterns, controlled and manipulated by the operator. Some of the typical drawbacks of liquid crystals, such as slow response or diffraction losses, have been significantly reduced in LCoS devices but they are still present to some extent and can be relevant, especially when large aberrations are involved. This is typically the case for the eye, even in normal subjects, when low order terms are included. Therefore, there is a continued interest to produce enhanced devices. In this context, we present results for a new LCoS device capable for 6Pi modulation (Holoeye Photonics AG, Germany), comparing performance to that of a regular 2Pi LCoS. An experimental setup was built incorporating the two modulators, so that simultaneous operation and comparison could be performed, a Hartmann-Shack wavefront sensor and a camera for experimental point spread function (PSF) recording. Measurements were taken using a laser source and a tuned spectrum provided by a thermal source coupled to a liquid crystal tunable filter. The 6Pi modulator showed slightly slower temporal response than the standard 2Pi device, but still in the useful range for visual applications. Comparison between monochromatic PSFs showed similar fidelity for both devices, but diffraction effects were less marked in the 6Pi device. Wavefront measurements for different wavelengths showed less than 10% variation across the visible spectrum for the 2Pi modulator and less than 7% for the 6Pi device. In either case, this means a small chromatic degradation, especially when compared to the eye's natural chromatic aberration. In conclusion, the new 6Pi device has the potential for reducing the diffraction ghost produced by phase wrapping, in addition presenting lower chromatic dispersion than the 2Pi device. These features are particularly interesting for Vision Analysis applications, where subjects perform visual testing, typically in white light, through modified phase masks generated by an LCoS spatial light modulator.

43 - A parametric study of the contributing factors influencing femtosecond pulse shape transfer via difference frequency mixing.

Wednesday 04 September 2013 14:00

Primary authors: *BOTHA, Nicolene (NLC)*
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Shaped femtosecond pulses in the far infrared (IR) regime are required for various processes. However, current shaping techniques are limited to the visible and the near infrared. Difference frequency conversion is one method that can be used to transfer shaped pulses from the visible and the near infrared to the far infrared, however, the fidelity of the transfer process and the factors influencing the fidelity is not clear. In this paper difference frequency mixing (DFM) of shaped femtosecond pulses in non-linear crystals is simulated, the transfer of the shaped pulses to the far infrared wavelength is investigated and factors are identified that have an influence on the transfer fidelity. Difference frequency generated pulses, using a non linear crystal, is generated in the laboratory and measured for different double pulse separations and the transfer efficiency is investigated.

44 - Design optimization of an actuator pattern for a unimorph deformable mirror

Session V: AO Techniques - Wednesday 04 September 2013 09:30

Primary authors: *APPELFELDER, Michael (Friedrich Schiller Univ. of Jena, Inst. of App. Physics)*
Co-authors: *REINLEIN, Claudia (Fraunhofer Inst. for Applied Optics and Precision Engineering); BECKERT, Erik (Fraunhofer Inst. for Applied Optics and Precision Engineering); EBERHARDT, Ramona (Fraunhofer Inst. for Applied Optics and Precision Engineering); TüNNERMANN, Andreas (Fraunhofer Inst. for Applied Optics and Precision Engineering)*

For a high order correction of laser beams usually a deformable mirror (DM) is used. A lot of different concepts exist for the design of these mirrors. Especially unimorph deformable mirrors feature low cost, low power consumption and a high stroke capability for the correction of large wave front aberrations.

Additionally our approach is using technologies based on wafer level manufacturing of ceramic substrate materials which potentially leads to low cost deformable mirrors.The optical performance of a DM is commonly stated by the capability to reproduce Zernike polynomials with respect to the amplitude and the precision of the individual coefficients. These values are determined by the actuator pattern of the DM. A pre-optimization of electrode patterns which was used as an input for finite element analysis (FEA) has been done. This pre-optimization was done with the help of the symmetry properties of the Zernike polynomials, adapted to our fixed edge mirror mount boundary condition. For the verification of the FEA model, the computed values have been compared to an analytical model. A high agreement between these values has been found. The deflection shapes for each individual actuator were calculated with the FEA software CoventorWare.The result was the maximum adjustable Zernike coefficients which can be represented with the deformable mirror. Also the precision, indicated by the RMS error and the purity have been evaluated. We've computed these values for five different actuator layouts. Based on the results two actuator patterns with 41 actuators, consisting of 40 actuators located in the middle and one outer actuator ring have been selected. With the inner 40 actuators a concave deformation can be achieved. While applying a voltage to the outer actuator, the mirror deforms convex. This effect can be used for increasing the working range of a deformable mirror.Furthermore the electrical contacting of the actuators has been optimized. A reduction of the feed lines dimensions for contacting the actuators with the contact pads located at the rim has been achieved. These contact pads were used for a global electrical connection of the DM. A larger and a more uniform deflection of the actuators is expected.First measurement results obtained with these mirrors are also presented and are compared to the values obtained by the optimization process.

45 - Large Scale Deformable Mirror Based on Bimorph and Stack Actuators

Session V: AO Techniques - Wednesday 04 September 2013 09:50

Primary authors: *SAMARKIN, Vadim (Active Optics NightN Ltd.)*
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Main element of any adaptive optical system is the corrector which determines the properties and ability of the system. The bimorph deformable mirror (DM) is intended to reproduce and thus correct for low order aberrations [1]. Such mirrors have large deformation stroke (up to 100 microns), wide dynamic range (up to several kHz), ability to hold the intensities up to 20 J/cm2 for pulsed beam and up to 50 kW/cm2 for CW radiation and the possibility to correct for the low-order aberrations by small number of actuators.Aperture for bimorph DM up to 150 mm is usual now. The 180 mm bimorph DM showed good performance of the wavefront correction in laser systems with sub PW level of intensitiy [2]. But some applications need the DMs of far bigger sizes (about 500 mm), for example, when it substitutes for the final mirror in multi cascade laser system. As the big bimorph DM is rather thin, the surface shape is usually not perfect and stable. We propose the design of large scale DM using both PZT bimorph and stack actuator technologies. The stacks actuators support the DM and allow to change and correct for the surface shape either by open and/or closed loop control. The results of study of the prototype of such DM will be presented. The DM size was 220 x 220 mm, the thickness was 4 mm, the ratio thickness to aperture was 1/55. Number of bimorph electrodes was 60. Bimorph type DM was glued on the tops of stack actuators. The stacks are arranged on the thick glass base and supported mirror at the periphery outside of the bimorph electrodes. The number of stacks was 12. Initial surface parameters were PV = 19 μ, RMS = 3.4 μ. Part of these aberrations has been introduced by gluing of stack actuators. Correction of the surface by using of 12 stacks actuators only gave us the surface quality PV = 2.6 μ and RMS = 0.3 μ. In the second step this surface was perfectly flattened by all 60 bimorph electrodes to the quality PV = 0.25 μ and RMS = 0.038μ that was about lambda/30. 1] A.Kudryashov, V.Shmalhausen, Opt. Eng., vol. 35(11),
3064 (1996).[2] A.Alexandrov, V.Zavalova, A.Kudryashov et al., LEI2009 Proc. of the Conference, Brasov, Romania, 16-21 October 2009, Editor D.Dumitras, 123 (2010).

46 - Wide field wavefront sensing on extended scenes and possible applications

Wednesday 04 September 2013 14:00

Authors: *RAGAZZONI, Roberto (INAF - Astronomical Observatory of Padova - Italy)*

Multi Conjugated or Multi Object (that translates into Multi Zonal in several possible industrial and medical applications) Adaptive Optics requires wavefront sensing over an extended scenes for complex objects that span much more than the isoplanatic patch. Whenever the scenery is complex the number of pixel requested for a Shack-Hartmann like application (or whenever the wavefront sensor detects on the focal plane) can easily approach untreatable figures. I propose to use a pupil plane wavefront sensing in which an intermediate filter is located in the focal plane and that has to be adjusted by the singal collected by an auxiliary detector looking through the whole aperture to the scene and hence conjugated to the focal plane while the gain of the signal per each subaperture will be given by a tip-tilt modulation introduced artificially in the wavefront sensing channel.This approach takes, to some extent, advantage from the sharpening of the image and can handle a slowly changing scenery.The possible applications of this approach to medical and strategic imaging are briefly reviewed.

47 - Localization and image reconstruction of inclusions embedded in biological tissue (turbid media) by means of adaptive optical system

Wednesday 04 September 2013 14:00

Primary authors: *GALAKTIONOV, Ilya (Student)*
Co-authors: *KUDRYASHOV, Alexis (Head of laboratory)*

Localization of alien inclusions embedded in near-surface layers of tissue and noninvasive parameter reconstruction of biological tissue structure elements in the normal and in the diseased state are important biological and medical tasks. Information about the light-scattering and absorption properties of tissue is necessary for both diagnostic and therapeutic methods, such as laser-induced ■ uorescence to diagnose malignant tissue and laser-induced hyperthermia and photodynamic therapy to treat diseased biological tissue.The aim of this work is image reconstruction of inclusions, embedded in turbid media. To improve image quality we used well known effect called «coherent backscattering». This effect is the sharp increase of backscattered light intensity in the opposite direction to the incident beam and is observed, when coherent light propagates through turbid media. Therefore, since the backscattered light is still coherent, we can consider its phase (or, to be more precise – some averaged phase) and thus we can use adaptive optical system to detect and recognize the investigated object. In our experiments we used adaptive optical system that consists of bimorph deformable mirror and Shack-Hartmann wavefront sensor. The principle of its work is the following: the turbid media is radiated with collimated laser beam. Some part of the light is absorbed, other part is scattered in all directions, including the reverse. Then we measured the current phase distribution of the backscattered light by means of wavefront sensor. And after this, according to the phase distribution information, we applied phase conjugation algorithm to compensate for existing wavefront aberrations using deformable mirror. The use of adaptive optical system together with image reconstruction applying Wiener filter resulted in almost ten time increase of the measure of image sharpness.

48 - Real-time high speed adaptive optical system for imaging and laser beam control

Session IV: Adaptive Control - Tuesday 03 September 2013 18:00

Primary authors: *KUDRYASHOV, Alexis (Head of the Lab)*
Co-authors: *SAMARKIN, Vadim (Senior Researcher); RUKOSUEV, Alexey (Senior Researcher); NIKITIN, Alexander (Researcher)*

In this paper we consider the low-cost high-speed adaptive optical system to be used for a real-time turbulence correction. It consists of standard, high-speed (up to 2 kHz frame rate) Shack-Hartmann wavefront sensor, electronics, software and … stacked actuator deformable mirror. We discuss the advantages and disadvantages of the use of such a correctors compare to standard bimorph mirrors. Also, various algorithms of correction are considered. We suggest to use simple phase conjugation method to obtain the best speed result. Though, for better correction simple hill-climbing approach would be preferable. Timing diagrams of correction are presented and discussed. Important question – how fast should be adaptive system if we want to compensate turbulence changing with the frequency f is considered. As a result – we built the adaptive system that can compensate for real-time aberrations with the closed-loop frequency of 200 Hz. The amplitude of corrected aberrations is in the range of +/- 1.5 μ (local wavefront distortions). Maximum phase aberrations could be compensated are up to 8 μ.

49 - Artificial model of human eye aberrations proceeded in real-time

Wednesday 04 September 2013 14:00

Primary authors: *LYLOVA, Anna (Student)*
Co-authors: *KUDRYASHOV, Alexis (Head of laboratory)*

Human eye is non-ideal optical system. Cornea, lens and vitreous body are sources of optical aberrations. There are several medical tasks where the precise measurements of aberrations is important, for example, excimer laser vision correction, clinical diagnosis of the retina etc.In fact, real human eye aberrations are not static because of various factors, such as state changing of tear firm, fluctuations accommodations, etc.By now many investigations aimed on high accuracy human eye modeling techniques exist. However, dynamics of phase distortions is not studied in these works.In our work for human eye model reconstruction an open adaptive optical system including wavefront sensor (Shack-Hartmann type) and wavefront corrector (flexible mirror) was used. The principle of system working is following: we got the information about wavefront shape presented by vector of Zernike coefficients (from a standard aberrometer). As all known the basic aberrations of human eye are of course low-order aberrations like defocus, astigmatism, coma, spherical aberration. And thus it is suitable to use deformable mirror with modal response function of actuators in order to reproduce these low-order aberrations. So in our work we applied bimorph deformable mirror. This kind of wavefront corrector can easily reproduce first 15-25 Zernike polynomials. To model wavefront profile we simply calculate and apply control voltages to our bimorph mirror electrodes.That need to be account during real-time reproduction of the artificial human eye wavefront. The time of deformable mirror response also has an influence on system dynamics.In our case in experiment the frequency of aberrations modeling is similar to the human eye aberrations (5-25 Hz). So we are able to say that our model of phase distortions reconstruction is real-time.

50 - Recent Advances in MEMS Deformable Mirror Technology

Session V: AO Techniques - Wednesday 04 September 2013 10:10

Authors: *BIERDEN, paul (boston micromahcines)*

With the continual expansion in the use of adaptive optics in the fields of biological imaging, ophthalmic instrumentation and laser communication, the demands on the wavefront corrector has also continued to grow. This paper will describe the design, manufacture, and testing results of the latest generation of optical quality micromachined deformable mirrors (DMs) that have been manufactured to meet these needs. We will also discuss the latest in the area of packaging and high voltage drive electronics to make the MEMS DMs more easily integrated into advanced research operations. Finally, new test procedures and modeling of these devices for open loop operation will be presented.

51 - Superpenetration Multiphoton Microscopy Enabled Through MEMS DM Technology

Session II : Imaging and Microscopy - Tuesday 03 September 2013 12:40

Authors: *BIERDEN, paul (boston micromahcines)*

Paul Bierden1*, Steven Cornelissen1, Thomas Bifano1,2, Hari Paudel2, John Taranto3, Ben Potsaid31 Boston Micromachines Corporation, 30 Spinelli Place, Cambridge, MA 021382 Department of Mechanical Engineering, Boston University, 110 Cummington St. Boston, Massachusetts 02215, USA3 Thorlabs Inc , 56 Sparta Avenue,Newton, New Jersey 07860*pab@bostonmicromachines.comThis paper will discuss the development and demonstration of a superpenetration multiphoton microscope (S-MPM) that will more than double the imaging depth achievable in highly scattering biological tissue. MPM technology has revolutionized the field of subsurface biological imaging, but its depth of penetration is limited. The severe scattering introduced by biological tissue – especially neural tissue – prevents most commercial MPM instruments imaging beyond a few scattering mean free paths. With this limitation, research on cells and cell networks at the frontier of neuroscience is constrained. A recent breakthrough in coherent light propagation and control through highly scattering media demonstrated the possibility of enhancing focal intensity by factors of several hundred on the far side of a medium, despite any amount of scattering, by using a spatial light modulator to modify the phase of the coherent light on the near side of the medium. In this paper we will discuss the combination of MPM and BMC's fast microelectromechanical spatial light modulators (MEMS SLMs) to offer a compelling way to exploit this breakthrough in optical science that will make a substantial impact on biomedical and neurobiological research.

52 - A novel technique to generate and temporally shape multiple pulsed laser beams using 2D-SLMs

Session VIII : Spatial Light Modulators - Thursday 05 September 2013 12:20

Primary authors: *SPANGENBERG, Dirk-Mathys (University of Stellenbosch)*
Co-authors: *ROHWER, Erich (Stellenbosch University); NEETLING, Pieter (Stellenbosch University)*

It has been shown that a two dimensional phase only spatial light modulator (SLM) can be used to do arbitrary temporal beam shaping. This is significant because the transfer function in general requires both amplitude and phase modulation to be applied to the spectrum of a laser pulse. The amplitude and phase modulation is implemented using blazed gratings in a specific configuration to affect spectral shaping. We build on this technique by introducing the ability to split the input light beam into multiple beams with another 2D SLM at the input. Each individual beam can now be temporally shaped using the same spectral shaping technique and a single 2D SLM in a standard 4f geometry in combination with the appropriate gratings. We further show how the central wavelength of the beams can be offset linearly with respect to each other, allowing each beam to have its own central wavelength. This technique has applications in high power physics where lasers with ultra short pulses and ultra high instantaneous power are used to selectively excite and probe specific energy level transitions, which in turn has application in coherent control as well as fluorescence microscopy.

59 - ADAPTIVE OPTICS FROM MICROSCOPY TO NANOSCOPY

Session II : Imaging and Microscopy - Tuesday 03 September 2013 11:00

Authors: *MARTIN, Booth (University of Oxford)*

High resolution microscopy relies on the use of high quality optics with the goal of obtaining diffraction-limited operation, working at the physical limits imposed by the wavelength of the light. Yet in many cases this goal is not achieved as aberrations, distortions in the optical wavefront, blur the focus and reduce the resolution of the system. Aberrations can arise from imperfections in the optics, but are often introduced by the specimen, particularly when imaging thick specimens. One common source is a planar mismatch in refractive index, such as that between the microscope coverslip and the specimen mounting medium, which introduces spherical aberration. Biological specimens also exhibit variations in refractive index that arise from the three-dimensional nature of cells and tissue structures. In general, these aberrations become greater in magnitude and more complex in form as the focusing depth is increased. The induced wavefront aberrations distort the focus causing a reduction in resolution and, often more importantly, reduced signal level and contrast. These effects limit the observable part of the specimen to a region near the surface.Adaptive optics systems enable the dynamic correction of aberrations through the reconfiguration of an adaptive optical element, for example a deformable mirror or liquid crystal spatial light modulator. Adaptive optics was originally introduced to compensate for the optical effects of atmospheric turbulence on telescope imaging. The overall operation is based upon the principle of phase conjugation: the correction element introduces an equal but opposite phase aberration to that present in the optical system. As the sum of these two aberrations is zero, diffraction limited operation should be restored. Various adaptive schemes have been developed for a range of different modalities including confocal, multiphoton and widefield microscopes. We review the methods and applications of these systems in biological and other areas. We also present recent developments in adaptive optical methods for super-resolution nanoscopy. In particular, this includes new image-based adaptive schemes for stimulated emission depletion (STED) microscopy.

61 - Free Space propagation without the free space

Session X: Propagation and Turbulance - Thursday 05 September 2013 16:50

Primary Authors: *Christian Schulze (Institute of Applied Optics)*

Co-authors: *Daniel Flamm (Abbe Center of Photonics), Michael Duparre(Friedrich Schiller University Jena,D-07743 Jena, Germany), and Andrew Forbes (Council for Scientific and Industrial Research, National Laser Centre, P.O. Box 395, Pretoria0001, South Africa.*)

We present an all-digital approach to propagating light in the laboratory using a spatial light modulator, and use this to demonstrate a fast and easy technique for measuring the beam quality factor of laser beams. We apply this all-digital tool to propagate Laguerre-Gaussian beams by digitally simulating the free space propagation of the beam, hence getting rid of the traditional scan in propagation direction and avoiding any moving components.Our results show excellent agreement with theory thus proving the fidelity with which the M2 can be measured.

63 - Shaping ultrafast pulsed beams in space and time with programmable spatial light modulators

Session VIII : Spatial Light Modulators - Thursday 05 September 2013 11:00

Primary authors: *LANCIS, JESUS (Universitat Jaume I)*

Co-authors: *MENDOZA-YERO, Omel (Universitat Jaume I); MINGUEZ-VEGA, Gladys (Universitat Jaume I); PéREZ-VIZCAINO, Jorge (Universitat Jaume I)*

Laser pulses in the femtosecond time scale are indispensable tools in many scientific and technological disciplines. These ultrashort pulses provide unique temporal resolutions for understanding of phenomena that develop in a comparable time range. Also, optical energy squeezed into such short time window yield enormous high peak powers and intensities, paving the way to generate unprecedented interactions of light with matter and triggering a new scenario for applications in the world of photonics. However, ultrashort pulses are extremely elusive and are more unforgiving of imperfections in optical systems as compared to ordinary incoherent broadband light sources. Wave front control and correction, as well as pulse shaping, is crucial in order to be able to manipulate the ultrashort pulse in an optimal, reproducible and well-defined way and to obtain ultimate performances for ultrashort laser facilities. On the other hand, advances in spatial light modulation enable fine control of the amplitude, the phase, and/or the polarization of the light field at the micron scale. By merging the two realms, in this talk we will demonstrate pulsed laser beams with intriguing spatial and temporal waveforms by shaping the laser output by using a liquid crystal spatial light modulator.

64 - Achieving the highest intensity from the Orion Laser Facility

Seesion I : AO in Lasers - Tuesday 03 September 2013 09:40

Authors: *HOPPS, Nicholas (AWE plc)*

The Orion Laser Facility at AWE in the UK is a recently commissioned, multi-kilojoule laser facility for the study of high energy density plasma physics. It consists of ten “long pulse” beamlines, which each deliver 500 J at 351 nm and two “short pulse beams”, each capable of 500 J pulses in 0.5 ps at 1054 nm.The long pulse beams usually operate with continuous phase plates to deliver a user-defined focal profile, albeit at many times the diffraction limit. The need for wavefront correction is therefore limited to system operability issues.The short pulse beams utilise the chirped pulse amplification scheme to deliver power in excess of 1 petawatt to target. Experiments also usually require the highest possible focal intensity – greater than 10^21 Wcm^-2 has been inferred from measurements. Adaptive optics systems are of crucial importance in achieving this goal. Each short pulse beamline is fitted with a 63 element monomorph mirror and a wavefront sensor at the end of the amplifier chain. However, further downstream optics, such as the pulse compression gratings and final focussing mirror, produce aberrations and these must also be controlled.An overview of the facility will be given for context. The main theme of the talk will be a detailed discussion of the sources of aberration and the challenges faced and overcome in delivering the highest intensity on target.

65 - Quantum Communications along Optical Links with Strong Turbulence

Session X: Propagation and Turbulance - Thursday 05 September 2013 15:50

Primary authors: *PAOLO, Villoresi (Department of Information Engineering, University of Padova,)*
Co-authors: *IVAN CAPRARO, DAVIDE BACCO, ALBERTO DALL'ARCHE, DAVIDE MARANGON, FRANCESCA GERLIN, ANDREA TOMAELLO, GIUSEPPE VALLONE*

The free space propagation of photonic qubits is one of the most intriguing and novel subjects, in which Quantum Physics provides the paradigm for a leap forward in Communications. However, quantum protocols as teleportation, quantum-key-distribution and entanglement swapping along free-space and satellite links are entwined with beam degradation due to turbulence [1–3], seriously hampering the quantum-bit-rates and the immunity from background noise. For instance, in QKD the quantum state that is prepared and sent at the transmitter side experiences a transformation in the spatial spectrum in addition to the vacuum diffraction, that requires strategies to be compensated.We report in a series of experiments in which the turbulence is probed and the possible countermeasures, including the use of Adaptive Optics, is investigated. The longest link was chosen between the Optical Ground Station (OGS)of the European Space Agency (ESA), in Tenerife and the Jakobus Kapteyn Telescope (JKT) in La Palma, at the The Canary archipelago, separated by about 143 km, both at the altitude of about 2400 m above the Atlantic Ocean. The level of losses is in the range of what expected in the Space-to-ground links, while the effects of turbulence aresupposedly larger.We have realized the link using a optimized refracting transmitter, whose key component is a singlet aspheric lens of 23 cm diameter with f/10 aperture [4]. The choice of the lens aims to minimize the spot size at OGS compared to the telescope primary mirror according to our observations and consequently a greater power transfer between the two sites. A near infrared (808 nm) laser coupled into single mode fiber and suitably attenuated was used as source. The receiver at OGS uses a telescope with 1m primary mirror diameter equipped with single photon detector and suitable electronics.We analyzed the overall losses of the free-space channel and temporal scintillation of the intensity at the receiver as a function of the atmospheric conditions. The intensity has been collected during many nights. From its analysis we infer that for this scale length the distribution follows the lognormal distribution [4], extending by more than a decade the observations of Ref. [5]. The scintillation index and the possible use of Adaptive Optics are discussed.

66 - Functional Imaging of Single Cells in the Living Eye

Session VI: Vision - Wednesday 04 September 2013 11:00

Authors: *WILLIAMS, David (Dean for Research in Arts, Science, and Engineering Director, Center for Visual Science William G. Allyn Professor of Medical Optics)*

The correction of the eye’s aberrations with adaptive opticshas made it possible to image the normal and diseased retina of the living eye at microscopic resolution. I will describe recent developments in the deployment of this technology, many of which combine AO and other imaging modalities with the goal of obtaining not only structural but also functional information at a cellular or subcellular spatial scale. I will illustrate the value of this approach with examples including single photon fluorescence imaging of retinal pigment epithelial cells in macular degeneration, the use of genetically encoded calcium indicators to record the neural response of individual ganglion cells in the intact eye, the use of interferometry to measure the dimensions of photoreceptors, as well as methods to measure the flow of blood cells in single capillaries noninvasively. I will also describe recent advances in two-photon imaging in the living eye, which allow us to optically probe molecular events in retinal cells that would otherwise be inaccessible.

78 - Wavefront correction in large-scale glass laser LFEX

Session IV: Adaptive Control - Tuesday 03 September 2013 16:00

Primary authors: *JITSUNO, Takahisa (Institute of Laser Engineering, Osaka University, JAPAN)*
Co-authors: *MORIO, N (Institute of Laser Engineering, Osaka University, JAPAN); MIYANAGA, N (Institute of Laser Engineering, Osaka University, JAPAN)*

LFEX laser system is a large-scale glass laser with output energy of 12 kJ and pulse duration of 1~10 ps. In this laser system, 8 deformable mirrors (DFM) are used in 4 beam-lines. We are planning to introduce additional large scale (40 x 46 cm) Bimorph DFM for pulse compression and focusing. Details of our DFM development will be reported

79 - Real-time dynamic control of laser modes

Session VIII : Spatial Light Modulators - Thursday 05 September 2013 12:40

Primary authors: *NGCOBO, Sandile (CSIR)*
Co-authors: *FORBES, Andrew (CSIR); LITVIN, Igor (CSIR NLC); BURGER, Liesl (National Laser Centre)*

Adaptive optics has been used in many optical systems to correct the amount of wavefront distortionsfor application such aslaser ranging, free space optical communication and medical imaging of retinas. In these optical systems the correction of the wavefront is usually performed using deformable mirrors wherea wavefront sensor is typically used to measure the distortions the atmosphere has introduced on the timescale of a few milliseconds. The optimal mirror shape for correcting the distortions is then calculated using a computer and thesurface of the deformable mirror will then be reshaped accordingly.The reshaping of the mirror has been shown to have a limited stroke in the phase profiles that it can accommodate and thus have found little application in laser mode shaping. We have overcome this limitation with the first digital laser comprising an electrically addressed reflective phase-only spatial light modulator (SLM) as an intra-cavity holographic mirror where the amplitude and phase of the mirror are controlled by writing a new computer generated gray scale image on the SLM. We demonstrate that a digitally controlled digital laser for on-demand laser mode can be used to generate distortion-corrected laser modes by switching between several spatial modes in a standard solid state laser resonator.

80 - Quantum communication with OAM entangled photons

Session X: Propagation and Turbulance - Thursday 05 September 2013 17:10

Primary authors: *HAMADOU IBRAHIM, Alpha (CSIR, National Laser Center)*
Co-authors: *FORBES, Andrew (CSIR); KONRAD, Thomas (UKZN); MCLAREN, Melanie (CSIR); ROUX, Filippus (CSIR National Laser Centre)*

We consider Laguerre-Gaussian modes to study the evolution of an OAM entangled bipartite photonic state in atmospheric turbulence. Photon pairs are generated via spontaneous parametric down-conversion and one photon from each pair is propagated through turbulence. To compare our results with previous work, the turbulent atmosphere is simulated with a single phase screen based on the Kolmogorov theory of turbulence and we only consider two level photonic quantum system (qubits). A full quantum state tomography is performed to reconstruct the two-qubit density matrices for a range of scintillation strengths and the concurrence is used as a measure of entanglement. Our results show how the initial OAM mode is increasingly scattered into neighbouring modes as we increase the scintillation strength. We compare the evolution of entanglement for different values of the OAM and we show how entanglement evolution in turbulence depends on the OAM value used.

81 - Producing Kaleidoscope Modes using the Digital Laser

Wednesday 04 September 2013 14:00

Primary authors: L Burger (CSIR)

Co-authors: I Litvin (CSIR), S Ngcobo (CSIR), A Forbes (CSIR)

With ruggedness inherent in its optical design, the Porro prism laser has been widely used for many years in field applications, for example in the lasers used in range finding and target designation systems. A “petal” mode is commonly produced by these systems, but until recently the formation of these modes was not understood. Our previous work uses symmetry arguments to explain how these modes are formed, and a physical optics model based on these principles produces the observed petal modes. By increasing the transverse area available to the beam this model predicts novel modes, dubbed “kaleidoscope modes”, and later shown to be Laguerre modes. However, relying as they do on perfect symmetry and alignment, these modes are difficult to produce. We demonstrate that with our new “digital laser” we are able to produce these modes on demand, opening up the field of study of high-order Laguerre modes.

IMPORTANT TRAVEL & CONTACT INFORMATION

ORGANISERS

Prof Andrew Forbes : 082 823 1836
Mr Brian Masara : 073 737 2562
Miss Linette White : 072 542 1468

STIAS CONFERENCE CENTRE & CONTACTS

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10 Marais Street, Stellenbosch
Ms Jo Venter:Phone (021) 808 2650; Cell phone: 082 850 1465
Ms Nelmarie van der Merwe:Phone: (021) 808 2652; Cell phone: 071 499 4144

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Name (in Stellenbosch)	Telephone Number
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Capitec	Shop 12, Stelmark Centre, Cnr. Merriman & Bird	0861102043

	Street	
Nedbank	Maties, Stellenbosch University, De Beer Street	021 8096240
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Bidvest Bank	Checkers Centre, Mill Street	021 886 5259
RMB	14 Louw Street	021 861 6700

FOREIGN EXCHANGE

Name	Address in Stellenbosch	Telephone Number
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Rennies Foreign Exchange	Bureau de Change, Checkers Centre, Mill Street	021 886 5259

DIRECTIONS & MAP TO STELLENBOSCH UNIVERSITY

Directions to Stellenbosch from Cape Town

It is recommended that visitors staying in Cape Town who wish to visit the Stellenbosch campus rather use rental cars for the trip to Stellenbosch. The train services to Stellenbosch are not recommended and neither are a number of the taxi services. Should you, however, have no alternative as to use a taxi service, please enquire at your hotel/guest house about a reputable service.

Directions

The distance from Cape Town centre to Stellenbosch is approximately 50 km. Follow the N1 freeway to Paarl.Turn off at Exit 39 [Stellenbosch] and turn right onto the R304. Follow the road to Stellenbosch. Reaching town, turn left at the fifth traffic light into Merriman Avenue.Turn right at the second traffic light into Ryneveld Street. Pass one building on the left. The entrance to a visitors' parking area is immediately to the left. Visitor's parking is also available at all locations indicated with a "P" on the map. The JS Gericke Library is situated behind the Administration A building which faces the parking area. The other libraries on the Stellenbosch campus may be reached either by car or on foot from there.

Directions to Stellenbosch from Cape Town International Airport

It is recommended that visitors who wish to reach the Stellenbosch campus directly from the airport rather use rental cars for the trip to Stellenbosch. No train or underground services are available from the airport. A number of taxi services are not recommended. Should you, however, have no alternative as to use a taxi service, please make enquiries in the airport terminal building about a reputable service.

Directions

The distance from Cape Town International Airport to Stellenbosch is approximately 35 km. Follow the Airport Approach Road from the airport. Turn left at the Somerset West exit onto the N2 freeway. Turn off at Exit 33 [Baden-Powell Road, Stellenbosch]. Turn left onto the R310. Follow the road (approximately 23 km) until you reach a T-junction and turn right.

Follow the road into Stellenbosch until you reach a second T-junction (immediately past the railway station to the left). Turn left onto the R44. At the second traffic light, turn right into Merriman Avenue. Turn right at the third traffic light into Ryneveld Street. Pass one building on the left. The entrance to a visitors' parking area is immediately to the left. Visitor's parking is also available at all locations indicated with a "P" on the map. The JS Gericke Library is situated behind the Administration A building which faces the parking area. The other libraries on the Stellenbosch campus may be reached either by car or on foot from there.

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Map of STIAS

Directions to the venue:

The conference will be held at the Wallenberg Centre, Stellenbosch Institute for Advanced Studies (STIAS) (no. 5 on the campus map), located in Marais Street.

From the centre of town / the university, walk up Victoria or Plein Street until you reach a T-junction with Marais Street. From Victoria Street turn right into Marais Street. STIAS will be on your left after you have passed the Jan S. Marais Park. From Plein Street, turn left into Marais Street. STIAS will be almost immediately on your right.

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