ACOLS ACOFT DS 2009

29th November – 3rd December 2009 ▪ The University of Adelaide, South Australia

Book of Abstracts

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Plenary

Elder Hall, 08:45 – 10:30, Monday

The Power of Light — The Fiber Laser Revolution

David Richardson; University of Southampton, UK

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I review recent advances in high power fiber laser technology that have led to the development of efficient, compact and robust laser systems of unprecedented levels of brightness and versatility.

Over recent years the powers that can be achieved from fiber lasers have grown rapidly due to parallel advances in the high-power semiconductor laser diodes used to energize fiber lasers, diode-to-fiber coupling schemes and doped fiber design and fabrication. Whilst the headline results have generally related to the possibilities of scaling continuous-wave fiber lasers, with 10kW now possible from an effectively single-mode core, advances in many aspects of pulsed laser performance have been just as spectacular. For example, using the fiber Master Oscillator Power Amplifier (MOPA) approach it is now possible to realise fs and ps pulsed fiber systems operating at the multi-100W level with pulse energies in excess of the 1 mJ level. In the nanosecond regime multi-100W systems have also been achieved with single mode pulse energies of several mJ, and by relaxing the mode-quality higher pulse energies are now possible.

Within this talk I shall review the state-of-the-art in high power fiber laser systems. I shall describe the key benefits of fiber lasers relative to the more established competitor technologies, describe some of the issues limiting further power and energy scaling and review the use of both temporal pulse and spatial mode shaping technology to achieve improved performance. I shall also review the wavelength coverage frequency conversion options for fiber lasers and describe specific applications of the technology in both science and engineering — these include amongst others use in directed-energy applications, counter-measure systems for military platforms, medicine and, of course, industrial materials processing which represents the primary driver for the technology.

I shall conclude by speculating as to likely future developments and the ultimate levels of performance achievable.

Single Molecule Laser Spectroscopy — From Probes to Polymers

Kenneth P. Ghiggino, Toby D.M. Bell; University of Melbourne, Australia

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Advances in imaging and photon detection methods have enabled the observation of fluorescence from single molecules (SM) dispersed in condensed media by optical microscopy methods. When combined with pulsed laser excitation, spectral dispersion of fluorescence and photon timing detection, the technique provides a powerful tool for studying the distribution of molecular behaviours that make up bulk photochemical properties. Examples presented include investigations of new fluorescence probes and single conjugated polymer chains that show the role of molecular structure and environment on excited state dynamics. In both cases SM studies reveal surprising behaviour that is obscured in bulk photophysical measurements.

1A ACOLS : Xray & XUV

N102, 11:10 – 12:30, Monday

Crystal Growth to Fully Digital Systems — A New Enabling Technology for Imaging X-Rays and Gammas

Ralph B. James; Brookhaven National Laboratory, USA

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Cadmium zinc telluride (CZT) is one of the most promising materials for the production of large-volume gamma-ray spectrometers and imaging arrays operable at room temperature. The performance of CZT devices, the global capacity for growth of detector-grade crystals, and the size of the commercial market have progressed steadily over the past 5–10 years. Because of deficiencies in the quality of the material, commercial high-resolution CZT spectrometers are still limited to relatively small dimensions (< 3 cm^3), which makes them inefficient at detecting high photon energies (> 1 MeV) and somewhat ineffective for weak radiation signals except in proximity to the source. The detectors are very attractive for a much broader range of spectroscopic and imaging applications; however, increases in their efficiency are needed without sacrificing the ability to spectrally resolve gamma energies. Achieving the goal of low-cost efficient CZT detectors requires progress in the following areas: better uniformity of detector response, growth of large uniform single crystals, and improved device fabrication procedures. Despite the current material constraints, several types of electron-transport-only detectors have been developed: pixel, coplanar-grid, cross-strip, drift-strip, orthogonal coplanar strip, and virtual Frisch-grid, some of which are now addressing important applications. This talk summarizes the material factors limiting performance of CZT detectors and provides new insight into the critical role of small-scale defects on the energy resolution and efficiency of detectors.

Core-Electron Localization Effects in a Diatomic Molecule Interacting with Intense Ultrashort-Pulse XUV Radiation: Quantum-Dynamic Simulations

Olena Ponomarenko, Harry Morris Quiney; University of Melbourne, Australia

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In this paper, we theoretically investigate effects of intense extreme ultraviolet laser fields on dynamical properties of a core electronic density in a highly charged diatomic carbon molecular ion. We report inter-well tunnelling of the electronic wavefunction through the Coulomb barrier between nuclei driven by the field. This tunnelling is mediated by a coupling of an almost degenerate pair of lowest electronic states of opposite parity. The core electron localization dynamics is scalable for higher intensity/shorter wavelength regimes. These results are discussed in the context of applicability of the crystallographic atomic form factors in single-shot XFEL experiments.

High Harmonic Generation of Extreme Ultraviolet Radiation from Diatomic Molecules

K.B. Dinh, Peter Hannaford, L.V. Dao; Swinburne University of Technology, Australia

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We report the study of high order harmonic generation of extreme ultraviolet radiation from diatomic molecules including N_2 and O_2. The influence of frequency modulation (chirp) of the fundamental laser and the influence of orientation of the molecules on the spectrum and intensity of the extreme ultraviolet radiation are studied.

1B ACOLS : Metamaterials

G03, 11:10 – 12:30, Monday

Functional Metamaterials and Nonlinear Plasmonics

Ilya V. Shadrivov; Australian National University, Australia

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Metamaterials are artificial composite structures designed to exhibit electromagnetic properties not found in nature. Nonlinearity brings us possibilities for creating functional metamaterials. Nonlinear effects have already shown their unique usefulness in optics and telecommunications, and this suggests that the nonlinear metamaterials can also demonstrate unusual phenomena. At the same time, nonlinear plasmonic structures share many common features with nonlinear metamaterials, and we are going to overview them in this presentation.

Reversible Nonreciprocity with Liquid Crystals

Andrey Miroshnichenko [1], Etienne Brasselet [2], Yuri S. Kivshar [1]; [1] Australian National University, Australia; [2] CPMOH, France

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We suggest a novel concept for achieving nonreciprocal optical response in periodic photonic structures with liquid crystals. We

show that a variation of optical response of a liquid-crystal defect above the optical Fréedericksz transition creates an asymmetrical field distribution inside the structure and results in different thresholds for the light transmission from the left and right. This effect allows to realize color-sensitive reversible optical nonreciprocity even in symmetric structures.

Matter Wave Transport in Optical Lattices

Tristram J. Alexander, Yuri S. Kivshar; Australian National University, Australia

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Controlled condensate flow in both continuous wave and pulsed form is demonstrated along self-induced "matter waveguides" in an optical lattice. Formation of the matter waveguides, composed of truncated nonlinear Bloch states, is shown to be possible due to a suppression of transverse instabilities by the lattice. Continuous wave condensate flow along the waveguides is shown to be stable provided the flow velocity does not exceed a critical threshold. Excitation and transmission of pulses along narrow waveguides is also demonstrated, and a cross-over between nonlinear Schrödinger and Korteweg-de-Vries type behaviour is shown.

1C ACOLS : Optical Trapping

G04, 11:10 – 12:30, Monday

Optical Vortices for Trapping and Transport of Particles in Air

V.G. Shvedov, Yana Izdebskaya, Anton S. Desyatnikov, A.V. Rode, Wieslaw Z. Krolikowski, Yuri S. Kivshar; Australian National University, Australia

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We present a review of our new activity on using laser beams containing phase singularity for trapping and transport over the meter-long distance of light-absorbing particles in air. The experiments were performed with agglomerates of carbon nanoclusters with a wide range of sizes up to 100 μm. Theoretical calculations based on the photophoretic forces show good agreement with the experimental results. The distinguishing feature of the trapping strategy is that particles are trapped at the intensity minimum of the beam, thus with minimum heating, which is important for direct studies of air-born particle properties and for air-trapping of living cells.

Characterisation of Microparticle Flow in a Microfluidic Device Using Optical Trapping

Daniel Day, Jing Wu, Min Gu; Swinburne University of Technology, Australia

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We present a useful method for characterisation of the flow properties of microparticles in a microfluidic channel using optical trapping. Using the gradient force generated in an optical trap the velocity of a microparticle can be determined through the direct measurement of the Stokes force. The particle velocity profiles in straight and curved channels are measured and the results are compared with computational fluid dynamic simulations. The effect of Stokes drag force on the microparticle size and measured velocity is characterised.

Optical Paddle-Wheel

Theodor Asavei, Vincent L.Y. Loke, Timo A. Nieminen, Norman R. Heckenberg, Halina Rubinsztein-Dunlop; University of Queensland, Australia

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Optically trapped micro-objects that can be spun in a fluid are useful tools for probing fluid properties at microscale. If such a free-floating optically-driven microrotor can be moved to a desired position, it can allow the controlled application of a directed flow in a particular location, thus making it useful for potential biological applications. Here we demonstrate the control and rotation of such a device, an optical paddle-wheel, using a multiple-beam trap. In contrast to the usual situation where rotation is around the beam axis, here we demonstrate rotation normal to this axis.

To Hop or Not to Hop — That is the Question

Alexander B. Stilgoe, Timo A. Nieminen, Norman R. Heckenberg, Halina Rubinsztein-Dunlop; University of Queensland, Australia

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Parameters to allow observable Brownian hopping between beams in a dual beam optical tweezers are discussed. Hopping between the foci of dielectric particles is either enabled or disabled by the choice of parameters including particle size, optical irradiance and beam separation. Here, the theory allowing hopping between two close optical traps is discussed along with the experimental apparatus used to realize hopping and therefore the statistical mechanics of a non-equilibrium system.

1D ACOFT : Fibre Sensing 1

LG29, 11:10 – 12:30, Monday

The Use of Fibre Bragg Grating Arrays for *in-vivo* Diagnosis in the Human Gastrointestinal Tract

John W. Arkwright [1], Ian D. Underhill [1], Simon A. Maunder [1], Neil Blenman [1], Michael M. Szczesniak [2], Ian J. Cook [2], Phil G. Dinning [2]; [1]CSIRO, Australia; [2]University of New South Wales, Australia

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The advent of spectrally separated draw tower grating arrays and solid state spectrometers has enabled the development of viable in-vivo catheters for diagnosis of motility disorders in the human gut.

Our catheters contain more than 100 discrete sensing elements spaced at 1cm intervals and can span significant regions of the gut. The use of wavelength division multiplexing techniques allows us to simultaneously interrogate the entire catheter to create dynamic images of the complex nature of peristalsis in the human colon for the first time.

High Precision Microstructured Fibre Based Refractive Index Sensing: Absolute Refractive Index Measurements and Low-Index Sensing

Vincent Pureur, D.K.C. Wu, Qing Shi, A. Argyros, Benjamin J. Eggleton, Boris T. Kuhlmey; University of Sydney, Australia

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We extend the recently demonstrated technique of ultrahigh precision refractive index measurements in photonic crystal fibres using a directional coupler geometry to absolute, temperature compensated refractive index measurements. The proposed and experimentally demonstrated device contains two directional couplers in a reflection geometry, one with a sealed-in reference fluid and the other accepting the analyte. We also demonstrate sensing of refractive indices lower than the background index using a novel high index coated hole geometry. The latter has the added benefit that it does not require selective filling of holes. Precisions below 10^{-6} refractive index units are possible.

Radiation Effects in Glasses for Optical Fiber Dosimetry

Chris Kalnins, Heike Ebendorff-Heidepriem, Tanya M. Monro, Frances Williams, Nigel Spooner; University of Adelaide, Australia

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We report on the dosimetry properties of fluoride-phosphate and lead silicate glasses for fiber-based sensing of ionizing radiation.

1E ACOFT : Subwavelength Structures

LG28, 11:10 – 12:30, Monday

Fibres with Subwavelength Features: Fabrication and Novel Guidance Properties

Heike Ebendorff-Heidepriem, Shahraam Afshar V., Stephen C. Warren-Smith, Wen Qi Zhang, Yinlan Ruan, Shaghik Atakaramians, Tanya M. Monro; University of Adelaide, Australia

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This paper reviews recent progress in the fabrication, modelling and characterization of fibres with subwavelength features in the fibre cross section.

Subwavelength Soft Glass Fibres with Extremely Small Hole Size for Field Enhancement

Yinlan Ruan, Heike Ebendorff-Heidepriem, Tanya M. Monro; University of Adelaide, Australia

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We report fabrication of lead silicate glass microstructured fibres with a single subwavelength hole in the core for field enhancement. The hole size is as small as 30 nm and has been achieved by using the extrusion technique. Modelling of the near field diffraction indicates that the field enhancement can be maintained to over 30 nm distance from the fibre endfacet. The near field imaging of the field output pattern by SNOM is also explored.

Towards All-Diamond Efficient Single-Photon Sources: Part I — Theory

C.-H. Su[1], Mark P. Hiscocks[2], Brant C. Gibson[1], Andrew D. Greentree[1], Lloyd C.L. Hollenberg[1], François Ladouceur[2]; [1]University of Melbourne, Australia; [2]University of New South Wales, Australia

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Colour centres in diamond have rapidly emerged as one of the most important potential enablers for practical quantum tasks, including quantum key distribution and quantum metrology. They have the advantages of long photo-stability, room temperature operation and very high count rates. The integration of such sources into practical devices, however, still needs to be refined. Here we discuss the importance of optimising atomic properties against quantum metrics, and the imperatives of cavity design for high-fidelity sources.

DS Workshop

LG24, 11:10 – 12:30, Monday

Spatial Optical Solitons in Layered Thermal Media

Yaroslav V. Kartashov[1], Victor A. Vysloukh[2], Lluis Torner[1]; [1]ICFO, Spain; [2]Universidad de las Americas, Mexico

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We address properties of solitons forming in the bulk and at the surface of layered thermal medium made of alternating focusing and defocusing layers. Such structures support robust bright solitons even if the averaged nonlinearity is defocusing. Non-oscillating solitons may form in any of the focusing domains, even in those located close to the sample edge, in contrast to uniform thermal media where light beams always oscillate when not launched exactly on the sample center. Stable bulk and surface multipole solitons may include more than four spots in layered thermal media.

Spatially Localized Structures in Finite Domains

G. Kozyreff[1], P. Assemat[1], S.J. Chapman[2]; [1]Université Libre de Bruxelles, Belgium; [2]OCIAM, UK

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We analyze asymptotically localized structures arising from a subcritical Turing instability in a large but finite domain. These structures are patches of spatial oscillations enclosed by slow switching fronts on an homogeneous background. The effect of the distant boundaries balances with the exponentially small pinning forces affecting the fronts. With this balance, general boundary conditions can be treated analytically. We find that the locations available to localized structures form a discrete set which develops from a cascade of bifurcations as their size is varied. This limits the information capacity of this nonlinear system.

Mathematical Models for Ultrashort Optical Pulses

Uwe Bandelow, Shalva Amiranashvili, Alexander Mielke; WIAS, Germany

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Rational approximation is superior to Taylor expansion if singularities occur, as for optical response functions in the complex frequency domain. We construct a rational approximant for the complex refractive index using only local information close to a carrier frequency, but which accurately represents the global medium dispersion and absorption together with causality. Our results are relevant for spectrally broad optical pulses where resonances with related absorption become important. As an application we derive a nonlocal envelope model for ultrashort pulses that naturally bridges between local envelope equations and models operating directly with the electric field.

2A ACOLS : Spectroscopy

N102, 13:40 – 15:00, Monday

Quantification of Myosin in Cardiomyocytes Using Nonlinear Optical Microscopy

Samuel J. Wallace[1], Kimberley J. Botting[2], Janna L. Morrison[2], Tak W. Kee[1]; [1]University of Adelaide, Australia; [2]University of South Australia, Australia

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Second harmonic generation (SHG) and two photon excitation fluorescence (TPEF) microscopy have been used to quantify the myosin content in individual cardiomyocytes. We determine the dependence of measured myosin area on the signal to noise ratio (SNR) of the image to find the real myosin content. We find the average myosin content does not change between mononucleated and binucleated cardiomyocytes. Cardiomyocytes from the left ventricle have a lower average myosin content of 70.8% compared to the right ventricle 76.4% (p-value < 0.08).

Photodegradation of Nonlinear Optical Organic Films with Varying Optical Intensity

My T.T. Do, S. Janssens, S.G. Raymond, G.V.M. Williams, D.H. Bhuiyan, A.J. Kay; Industrial Research Ltd., New Zealand

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Photostability measurements have been made on host-guest films containing amorphous polycarbonate and an organic chromophore (PYR-3) with a high 2nd order nonlinear optical figure of merit. We find that the photodegradation quantum efficiency deceases for intensities up to 500 mW mm^{-2} and thermal degradation occurs for higher optical intensities.

Effects of Solvent on Laser-Induced Fluorescence in the Context of Two-Line Atomic Fluorescence

Qing N. Chan, Paul R. Medwell, Zeyad T. Alwahabi, Peter A.M. Kalt, Bassam B. Dally, Graham J. Nathan; University of Adelaide, Australia

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This work aims to improve on the quality of the fluorescence images of the non linear regime two-line atomic fluorescence (NTLAF) technique, with the use of methanol as seeding solution. The use of methanol yields a three-fold enhancement in the signal intensity, as compared to the signal intensity observed when water is used. A two-fold enhancement in the signal-to-noise ratio (SNR) is also obtained with the use of methanol. The use of methanol provides superior signal and hence reduces the uncertainty of NTLAF technique in resolving temperature.

Quantitative Measurement of C^{12} and C^{13} Ratios Using a New Data Analysis Technique for the Fourier Transform Infrared Spectrometer

K.J. Conroy [1], T.K. Boyson [1], A. Lee [2], M.E. Calzada [2], T.G. Spence [2], K.P. Kirkbride [3], C.C. Harb [1]; [1]University of New South Wales, Australia; [2]Loyola University New Orleans, USA; [3]Australian Federal Police, Australia

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The proceeding work involves quantitatively measuring carbon isotopic ratios with a standard Fourier Transform Infrared (FT-IR) spectrometer. We have devised an approach for data analysis that manipulates the FT-IR interferogram with precision that rivals that of a mass spectrometer. This technology is more accurate and more versatility of applications. The broadband light source generates rapid, yet accurate, data over a wide spectral range. Using ^{13}C doped benzoic acid, we have generated a calibration curve with a correlation value of 0.99992. Data was collected with a Nicolet 6700 FT-IR from Thermo Electron and analysed in Matlab.

2B ACOLS : Metamaterials 2

G03, 13:40 – 15:00, Monday

Tilted Response of Fishnet Photonic Metamaterials at Near-Infrared Wavelengths

Alexander Minovich [1], Dragomir N. Neshev [1], David Powell [1], Ilya V. Shadrivov [1], Mikhail Lapine [1], Ian McKerracher [1], Haroldo T. Hattori [2], Hark Hoe Tan [1], Chennupati Jagadish [1], Yuri S. Kivshar [1]; [1]Australian National University, Australia; [2]University of New South Wales, Australia

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We study experimentally the transmission properties of fishnet metamaterials in the near-infrared spectral range. We analyse the change of fishnet resonances at varying angles of incidence for different polarisations. The results show that the shift of the main transmission resonance to longer wavelengths occurs for TE incidence, while no changes are observed for TM incidence. These effects are observed in the fishnet structure configuration which can exhibit negative refraction.

Folded Bands in Metamaterial Photonic Crystals

P.Y. Chen [1], Ara A. Asatryan [2], Christopher G. Poulton [2], Michael J. Steel [3], R.C. McPhedran [1], Lindsay C. Botten [2], C. Martijn de Sterke [1]; [1]University of Sydney, Australia; [2]University of Technology Sydney, Australia; [3]Macquarie University, Australia

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We present band structure calculations of photonic crystals composed of both positive and negative refractive index materials. These structures exhibit bands that feature both positive and negative group velocities, producing folded bands that do not span the entire Brillouin zone. We derive a mathematical condition for the existence of folded bands from an energy flux relation, which shows that modal group velocity changes sign as field intensity transitions from the positive to the negative group index material. These band topologies are shown to persist when loss is added to the simulation.

Nitrogen Effect on Gain and Threshold Current of 1.31μm GaInNAs/GaAs Multiple-Quantum-Well Semiconductor Laser

S.M. Mitani, Mohd Sharizal Alias, A.A. Manaf, F.M. Exhsan, M.R. Yahya, A.F.A. Mat; TM Research & Development, Malaysia

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A quality improvement of the III-V dilute nitride semiconductor alloy, GaInNAs, grown on a GaAs substrate with different nitrogen contents is reported for 1.31 μm wavelength lasers. It is expected that for GaInNAs, which is lattice matched to InP, band gaps from $\approx$ 0.3–0.7 eV should be achievable if a few percent of N could be incorporated to the structure. In this communication, we report the influence of nitrogen incorporation on the microstructure of dilute nitride films. The PL spectrum and material optical gain for GaInNAs with different N percentage have been investigated and reported.

Parametric Study of GaInNAs Quantum Wells for Long Wavelength VCSEL

Mohd Sharizal Alias [1], Benjamin Damilano [2], S.M. Mitani [1], Nor Azlian Abd Manaf [1], Farha Maskuriy [1]; [1]TM Research & Development, Malaysia; [2]CHREA, France

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Parametric analysis of GaInNAs quantum wells properties is performed to investigate GaInNAs application in long wavelength Vertical-Cavity Surface-Emitting Laser (VCSEL) operating at 1310 nm wavelength. The optimized GaInNAs quantum well is incorporated into double intra-cavity device structure for VCSEL device analysis. The GaInNAs VCSEL exhibits sub-milliampere operating current and single-mode emission at 1310 nm.

2C ACOLS : Optics

G04, 13:40 – 15:00, Monday

Advances in Interferometric Surface Measurement

James C. Wyant; University of Arizona, USA

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A major limitation of precision interferometry for metrology is the sensitivity to the environment. This talk discusses different techniques for reducing the effects of vibration and atmospheric turbulence on interferometric measurements enabling precision interferometric measurements in uncontrolled environments. The application of these techniques for the measurement of surface vibration, the testing of optical components including DUV lithographic components, the phasing of segmented optical components, and the measurement of deformations of diffuse structures will be described.

Interferometric Ellipsometry

Lionel R. Watkins; University of Auckland, New Zealand

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A heterodyne interferometric ellipsometer is described which requires only a single reflection from the sample surface. A reference beam is created in one arm of a modified Michelson interferometer such that the p- and s-polarisations in this arm have a common phase and fixed relative amplitude, irrespective of the sample. When this beam is recombined interferometrically with the measurement beam, the spatially separated p and s fringes have an amplitude ratio and relative phase that are directly proportional to $\tan\Psi$ and Δ, respectively. Measurements made with this instrument of a native oxide layer on a silicon substrate are in excellent agreement with those obtained using a commercial ellipsometer.

Direct Measurement of the Coherent Modes of a Partially Coherent Wavefield

Samuel Flewett [1], Harry Morris Quiney [1], Chanh Q. Tran [2], Andrew G. Peele [2], Lachlan Whitehead [1], Ian McNulty [3], Keith A. Nugent [1]; [1]University of Melbourne, Australia; [2]La Trobe University, Australia; [3]Argonne National Laboratories, USA

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We have developed a method for the direct measurement of the coherent modes of a partially coherent beam from the measurement of Fresnel diffraction patterns at a range of distances from an aperture. Our studies of the nature of coherent modes in cases where the intensity across the aperture is slowly varying such as with a synchrotron beam, has shown us that the modes are also slowly varying and can therefore be represented as a linear combination of orthogonal Legendre Polynomials. We use this representation to demonstrate a new means of efficiently characterising the coherence properties of a partially coherent wavefield.

2D ACOFT : Fibre Sensing 2

LG29, 13:40 – 15:00, Monday

A Hydrogen Peroxide Fibre Optic Dip Sensor for Aqueous Solutions

Erik P. Schartner, Markus Pietsch, Andrew D. Abell, Tanya M. Monro; University of Adelaide, Australia

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We demonstrate and characterise a simple new optical fibre based dip-sensing system for rapid detection of hydrogen peroxide in aqueous materials. Through the reaction with a chosen fluorescent dye we are able to quantify the amount of H_2O_2 to levels as low as several nM.

Distributed Fluorescence Sensing with Exposed-Core Microstructured Optical Fibres

Stephen C. Warren-Smith [1], Elena Sinchenko [2], Paul R. Stoddart [2], Claire E. Davis [3], Tanya M. Monro [1]; [1]University of Adelaide, Australia; [2]Swinburne University of Technology, Australia; [3]DSTO, Australia

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We report on fluorescence-based distributed sensing using exposed-core microstructured optical fibres. The optical fibre consists of a suspended optical micro-wire surrounded by a solid jacket where a portion of the jacket is absent to allow access to the evanescent field from the external environment. We demonstrate time-domain distributed sensing by immersing the fibre in a fluorescent liquid.

Practical Performance Aspects of Real-Time Distributed Fibre-Optic Perimeter Intrusion Detection Systems

Seedahmed S. Mahmoud, Yuvaraja Visagathilagar, Jim Katsifolis; Future Fibre Technologies Pty. Ltd., Australia

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The implementation of fibre-optic perimeter intrusion detection systems in real environments presents some interesting challenges. We discuss the importance of sensor installation and the use of event classification to achieve acceptable system performance. A real-time fibre optic perimeter intrusion detection system is presented that employs novel event classification techniques to minimise nuisance alarms without compromising sensitivity.

2E ACOFT : Fibre Gratings 1

LG28, 13:40 – 15:00, Monday

Functionalizing Fibre Lasers by Exploiting Direct Written Fibre Bragg Gratings

Nemanja Jovanovic [1], Robert J. Williams [1], Jens Thomas [2], M. Åslund [3], Michael J. Steel [1], Graham D. Marshall [1], Alexander Fuerbach [1], Stuart Jackson [3], S. Nolte [2], Andreas Tünnermann [2], Michael J. Withford [1]; [1]Macquarie University, Australia; [2]Friedrich Schiller University of Jena, Germany; [3]University of Sydney, Australia

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In this work we discuss the application of directly written fibre Bragg gratings, via the point-by-point technique, as cavity mirrors in fibre laser technology. We demonstrate the ability to easily inscribe the gratings directly into rare-earth doped laser fibres of various sizes, compositions and geometries, and show stable high power fibre laser scaling. Ultra narrow laser linewidths (of the order of 13 pm) and the possibility of linearly polarising a low birefringence fibre laser by exploiting the polarisation dependent properties of the gratings are also demonstrated. The wide range of properties of point-by-point fibre Bragg gratings make it possible to realize fibre lasers with a broad range of wavelength selectivity limited only by the gain material, broad wavelength tunability, ultra narrow laser linewidths, great thermal stability for high power scaling, and fibre laser polarisability, all in highly simplified and extremely robust cavity arrangements.

Soliton Mediated Optical Quantization of Fibre-Bragg-Gratings

Falk Eilenberger, C. Martijn de Sterke, Benjamin J. Eggleton; University of Sydney, Australia

137

We demonstrate, in experiment and simulation, that gap-solitons mediate a quantization of the transmission through 1-dimensional photonic crystals, in our case Fibre-Bragg-Gratings and derive expressions for the transmission quanta.

Fabrication of Polysiloxane Grating Waveguides Using Soft Lithography

Ting Han [1], Steve Madden [1], Matthew Zhang [1], Barry Luther-Davies [1], Robbie Charters [2]; [1]Australian National University, Australia; [2]RPO Inc., Australia

138

We demonstrate the fabrication of small core high index contrast Polysiloxane waveguide grating devices using single step Ultraviolet Nanoimprint Lithography for the first time, and report zero process induced excess loss at 1550nm in the finished devices. Imprinted grating waveguides were designed to operate at telecommunication wavelengths and achieved 10dB rejection ratio in the first attempt.

DS Workshop

LG24, 13:40 – 15:00, Monday

External Forcing and Feedback Control of Nonlinear Dissipative Waves

Takao Ohta, Yosuke Tonosaki; Kyoto University, Japan

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Based on a model system undergoing phase separation and chemical reactions, we investigate the dynamics of dissipative propagating waves under external forcing and feedback control which are periodic both in space and time. A phase diagram of synchronization for external forcing is obtained numerically. Theoretical analysis is carried out to show that desynchronization by changing the external frequency occurs not only through a saddle-node bifurcation but also through a Hopf bifurcation. Feedback control is also investigated both numerically and theoretically.

Influence of Boundary Conditions on Localized Solutions of the Cubic-Quintic Complex Ginzburg-Landau Equation

Helmut R. Brand [1], Orazio Descalzi [2]; [1]University of Bayreuth, Germany; [2]Universidad de los Andes, Chile

140

We investigate the influence of the boundary conditions and the box size on the existence and stability of various types of localized solutions (particles and holes) of the cubic-quintic complex Ginzburg-Landau equation as it arises as a prototype envelope equation near the weakly hysteretic onset of traveling waves.

Partial Annihilation of Dissipative Solitons

Orazio Descalzi [1], Helmut R. Brand [2]; [1]Universidad de los Andes, Chile; [2]University of Bayreuth, Germany

141

Partial annihilation, where only one pulse survives the collision of two counter-propagating pulses, has been observed in binary fluid convection and chemical reactions. By means of two stochastic coupled complex subcritical cubic-quintic Ginzburg-Landau equations for counter-propagating waves we investigate the influence of noise on the parameter range over which partial annihilation is observed.

Front Propagation in Spatially Forced Media

U. Bortolozzo [1], M.G. Clerc [2], F. Haudin [1], R.G. Elías [2], S. Residori [1], R.G. Rojas [3]; [1]INLN, France; [2]Universidad de Chile, Chile; [3]Pontificia Universidad Católica de Valparaíso, Chile

142

We study front propagation in one-dimensional spatially periodic media. Based on an optical feedback with spatially amplitude modulated beam, we setup a one-dimensional forced experiment in a nematic liquid crystal cell. By changing the forcing parameters, the front exhibits pinning effect and oscillatory motion. A spatially forced dissipative ϕ^4-model, derived at the onset of bistability, accounts qualitatively for the observed dynamics.

3A ACOLS : Spectroscopy 2

N102, 15:40 – 17:00, Monday

Molecular Fingerprinting of Trace Gases

T.K. Boyson [1], K.J. Conroy [1], A.G. Kallapur [1], I.R. Petersen [1], M.E. Calzada [2], T.G. Spence [2], Yabai He [3], Brian J. Orr [3], K.P. Kirkbride [4], C.C. Harb [1]; [1]University of New South Wales, Australia; [2]Loyola University New Orleans, USA; [3]Macquarie University, Australia; [4]Australian Federal Police, Australia

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We shall report on the research aiming to develop Cavity Ring-down Spectroscopy as a high-throughput screening tool for trace detection of explosives and post-blast residues. This approach will be implemented in the mid-infrared region of the electromagnetic spectrum, between 4 and 12 micrometers, where we can take advantage of chemically specific molecular vibrations to unambiguously identify explosives and explosive-related compounds in terms of each compound's molecular fingerprint. Particular applications of this spectroscopic technique include security screening, forensics, perimeter protection, and mitigation of threats from large-vehicle-borne improvised explosive devices.

Saturation in Multi-Level Atoms from First Principles

Dustin Stuart [1], Andre N. Luiten [1], Thomas M. Stace [2], Eric F. May [1], Gar-Wing Truong [1]; [1]University of Western Australia, Australia; [2]University of Queensland, Australia

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It is well known that laser absorption measured in the vapours of multi-level atoms show the effects of saturation at much lower intensities due to optical pumping of the atoms. We have developed a rate-equation model for laser spectroscopy of the Cesium D1 line in a vapour cell, which allows for exchange of atoms between the laser beam and the surrounding gas. We improve upon previous efforts by correctly accounting for the Gaussian spatial profile of the beam, and predict the onset of saturation in agreement with experimental data.

Laser Induced Ionising Collisions with Cold Metastable Neon

R.D. Glover, Dane E. Laban, Robert T. Sang; Griffith University, Australia

145

Modification of the ionising collision rate is demonstrated with cold (~1 mK) metastable neon (Ne*) $^3P_2$ gas in a magneto-optical trap (MOT). A laser tuned close to the $^3P_2$ to $^3D_3$ cooling transition is used as a 'catalysis' to induce collisions between a pairs of trapped metastables. A complex spectrum is observed which demonstrates a dependence on the magnetic sublevels of the transition that the catalysis laser is exciting.

A Complete Determination of the Decay Rates of the 2^3P and 2^3S_1 Atomic Excited States of Helium

Sean S. Hodgman, Robert G. Dall, Lesa J. Byron, Kenneth G.H. Baldwin, S.J. Buckman, Andrew G. Truscott; Australian National University, Australia

146

Here we present the first complete measurement of the radiative decay rate to the ground state of the lowest four triplet states of helium i.e. the metastable 2^3S_1 state and the 2^3P manifold. The metastable state is the longest lived neutral excited state yet measured. These measurements are conducted using laser cooling and trapping techniques in an ultra high vacuum apparatus normally used to produce Bose Einstein condensates of metastable helium. All are in excellent agreement with theoretical quantum electro-dynamical predictions.

3B ACOLS : Nanocrystals

G03, 15:40 – 17:00, Monday

Ultrafast Dynamics of CdSe Core/Shell Nanocrystals: A 3-Pulse Photon Echo Peakshift Study

Lachlan J. McKimmie, Craig N. Lincoln, Jacek Jasieniak, Trevor A. Smith; University of Melbourne, Australia

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In this paper the results of 3-pulse photon echo peakshift measurements are discussed for a series of core/shell quantum dots (QDs): CdSe cores capped with CdS, CdZnS and Zns or a combination of these. It is found that capping the QDs significantly influences the particle morphology, band structure, ultrafast dynamics and phonon modes which are sustained within the nanocrystals. The particle morphology is correlated with the observed peakshift and modelling is undertaken to recover coupling strengths, vibrational frequencies and damping times, as well as a static inhomogeneity parameter which represents the distribution of transition frequencies within the samples.

Fluorescence Lifetime Characterisation of Nitrogen-Vacancy Centres

Luke A. Stewart, Carlo Bradac, Judith M. Dawes, Michael J. Steel, James R. Rabeau, Michael J. Withford; Macquarie University, Australia

148

We investigate the fluorescence properties of nitrogen-vacancy (NV) centres in diamond nanocrystals. In particular, we focus on measuring the fluorescence lifetime of the NV centres in various dielectric environments. We measure a distribution of lifetimes for NV centres on a coverslip, the standard deviation of which can be reduced significantly by placing the emitters on a "rough" surface. We also measure an increase in the lifetime for NV centres in opal photonic crystals, which is attributed to a reduction in the local density of states.

Capped ZnO Quantum Dot Langmuir Blodgett Film

Matt Shortell, Eric Waclawik, Esa A. Jaatinen; Queensland University of Technology, Australia

149

Langmuir-Blodgett films of dodecanethiol capped ZnO quantum dots were fabricated for applications in miniature light source devices. The films are ideally suited for optically pumped microdisk resonators with a UV gain medium which could be made using focussed ion beam milling. Langmuir-Blodgett films allow for a high concentration of QDs and precise control of the number of layers. This would ensure high quality optical cavities and low cavity volume to decrease minimum pump power. The proposed process is not only simple and inexpensive, but can easily be extended to on-chip integration with optical waveguides.

Fingerprinting Semiconductor Nanocrystals Using Spectral Fine Structure

Mark J. Fernée, Bradley N. Littleton, Halina Rubinsztein-Dunlop; University of Queensland, Australia

150

We show that significant information is contained in the spectral fine structure of single CdSe nanocrystal photoluminescence at cryogenic temperatures. Details of the charge state, exciton spin relaxation rates and hole confinement are readily obtained using various properties of the fine structure emission.

3C ACOLS : Optics 2

G04, 15:40 – 17:00, Monday

Numerical Modelling Fields with Forced Gaussian Spatial Distributions When They Propagate Through Nonlinear Media

M.W. Jones, Esa A. Jaatinen, G. Michael; Queensland University of Technology, Australia

151

Numerical modelling is often resorted to in many areas of physics when analytical solutions are not possible. For example, understanding of various spatial nonlinear photorefractive phenomena is only possible through numerical means. However, implementing these algorithms is far from straightforward and can lead to results that are inaccurate or unstable. Here, we show that if the field distribution is known and maintained as it propagates through the medium, the numerical model can be greatly simplified. This paper shows that the results produced by this method are in good agreement with experimental observations when low power cw Gaussian fields propagate through photorefractive barium titanate.

Three-Dimensional Light Patterns for Multi-Site Energy and Momentum Transfer

Vincent Ricardo Daria, Christian Stricker, Steve Redman, Hans A. Bachor; Australian National University, Australia

152

We demonstrate a combined system capable of multiple site energy transfer via multi-photon excitation of biomolecules as well as transfer of light momentum on mesoscopic particles. We use phase-only holographic projection and a Ti:Sapphire laser operating in femtosecond pulse mode to show that the projected light patterns have sufficient spatiotemporal photon density for multi-site multi-photon excitation of biological fluorescent markers. Using the same laser operating in continuous-wave mode, we can use the same light patterns for non-invasive transfer of both linear and orbital angular momentum on a variety of mesoscopic particles.

Characterization of Optically Addressed Light Valve Using Poincare Sphere

W.J. Lai[1], P.B. Phua[1], B. Loiseaux[2], J.P. Huignard[2]; [1]Nanyang Technological University, Singapore; [2]Thales Research & Technology, France

153

We study the phase characteristics of an optically addressed light valve at 635 nm using a polarimetric measurement technique developed in house, and obtain a phase shift of $\sim 5.3\pi$ for a full range of addressing intensities. Director orientation, initial polarization rotation and slow axis orientation are derived from the Poincare sphere. We also generate the cylindrical vector beam by using the phase relationship of the light valve.

Large-Scale Quantum Computing with Phase Fresnel Lenses

Erik W. Streed, Benjamin Norton, Justin J. Chapman, D. Kielpinski; Griffith University, Australia

154

Efficient ion-photon coupling is an important component for large-scale ion-trap quantum computing. We propose that phase Fresnel lenses (PFLs) are a favorable optical coupling technology to match with multi-zone ion traps. Both are scalable technologies based on conventional micro-fabrication techniques. Large numerical aperture (NA) PFLs can reduce the readout time for ion qubits and provide good coherent coupling to a single optical mode. From optical characterization of a suitable PFL we predict a coherent coupling efficiency of >0.64%, twice the best experimental efficiency achieved to date. In addition, high NA entanglement fidelity limits can be removed by optical filtering.

3D ACOFT : Fibre Sensing 3

LG29, 15:40 – 17:00, Monday

Towards a Microstructured Optical Fibre Fluorescence Sensor Based on Photoinduced Electron Transfer — Photobleaching

Florian V. Englich, Tze Cheung Foo, Heike Ebendorff-Heidepriem, Christopher J. Sumby, Tanya M. Monro; University of Adelaide, Australia

155

We report fluorescence and photobleaching characteristics of a new 4-aminonaphthalimide fluorophore in soft-glass, small-core wagon-wheel fibres. The fluorophore, which is suitable for incorporation into photoinduced electron transfer-based sensor architectures, shows a better photobleaching response compared with Rhodamine B when excited with micro-watt level laser radiation within a microstructured fibre. Photostability of the organic fluorophore within the microstructured optical fibres is critical for the successful development of a fibre sensor.

Comparison of Surface Functionalization Techniques on Silica and Soft Glasses for Optical Fibre Sensing Applications

Tze Cheung Foo, Alexandre François, Heike Ebendorff-Heidepriem, Christopher J. Sumby, Tanya M. Monro; University of Adelaide, Australia

156

We report the comparison of three different surface functionalization processes using two different organosilanes, 3-mercaptopropyltrimethoxysilane (MTS) and 3-aminopropyltriethoxysilane (APTES) and polyelectrolytes (PE) on the internal surface of tellurite, bismuth, lead silicate F2 and silica glass capillaries. We find that polyelectrolyte and organosilane coatings can be attached on the internal surfaces of the capillary of all four glass materials. Furthermore, PE provides more specific binding sites for streptavidin than MTS and APTS for all four glass materials.

Chemical Deposition of Silver for the Fabrication of Surface Plasmon Microstructured Optical Fibre Sensor

Jonathan Boehm, Alexandre François, Heike Ebendorff-Heidepriem, Tanya M. Monro; University of Adelaide, Australia

157

We examine the Tollens reaction, a simple chemical coating method, with the more commonly used RF sputtering technique for use in creating surfaces suitable for sensing applications based on the use of surface plasmon resonance. Experimentation has shown that these two surfaces produce similar SPR signals, and therefore that this is a viable method for the coating of the interior of a microstructure fibre. This technique was applied to a microstructure fibre and a 60nm silver layer is produced. This is the first step towards the realisation of a SPR microstructure fibre sensor.

Multiplexed Fibre-Accelerometer Array for Large Area Oil Reservoir Monitoring

Ian C.M. Littler [1], Malcolm B. Gray [2], Timothy T.-Y. Lam [1], Jong H. Chow [1], Daniel A. Shaddock [1], David E. McClelland [1]; [1]Australian National University, Australia; [2]National Measurement Institute, Australia

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A fibre-accelerometer array is presented with an unprecedented breakthrough combination of high acceleration resolution after 100 km of fibre, in a bandwidth down to the infrasonic, with high multiplexing density and low crosstalk. The demonstrated resolution is better than 60 ng/$\sqrt{Hz}$ (0.59 μm s^{-2}/$\sqrt{Hz}$) for all channels down to 10 Hz, even after the 100 km length of fibre. Moreover, the system can accommodate 80 channels per fibre in wavelength division multiplexed operation with better than -64 dB crosstalk. The dynamic range is 120 dB in a 300 Hz bandwidth.

3E ACOFT : Novel Fibres

LG28, 15:40 – 17:00, Monday

Higher Order Guided Modes in Solid-Core Photonic Bandgap Fibers

Vincent Pureur [1], J.C. Knight [2], Boris T. Kuhlmey [1]; [1]University of Sydney, Australia; [2]University of Bath, UK

160

We experimentally and theoretically study the guidance of higher order modes in solid-core photonic bandgap fibres. We demonstrate the existence of frequency ranges in which only higher order modes, but not the fundamental mode, are guided. We propose an analytic model to determine the number of guided modes in such fibres with good agreement with full numerical simulations.

Extruded Soft-Glass Hollow-Core Microstructured Optical Fibres; Fabrication and Light Guidance Properties

Kristopher J. Rowland, Heike Ebendorff-Heidepriem, Shahraam Afshar V., Tanya M. Monro; University of Adelaide, Australia

161

We demonstrate light guidance within a hollow-core microstructured fibre fabricated from a lead-silicate soft-glass via the extrusion process. Surrounding the circular hollow core are solid glass rings supported by radial struts, producing a structure reminiscent of a spider-web. Resonant interactions of the core-guided modes with the cladding structure produce discrete peaks in the transmission spectrum. This is the first demonstration of guidance within an extruded hollow-core soft-glass microstructured fibre and also the highest refractive index used for a single-material hollow-core fibre to date. Details of the fabrication process will be discussed.

DS Workshop

LG24, 15:40 – 17:00, Monday

Cavity Solitons in Semiconductor Lasers: Applications and Perspectives on the Future

F. Pedaci [1], P. Genevet [1], E. Caboche [1], G. Tissoni [2], S. Barland [1], M. Giudici [1], L. Lugiato [2], J.R. Tredicce [1]; [1]INLN, France; [2]CNR-INFM, Italy

162

Cavity solitons (CS) are single-peak localised structures which form over a homogeneous background in the section of broad-area non linear resonator. The possibility to address CS individually and to control their location and motion makes them interesting for all-optical processing units. In this presentation we will report on several functionalities of CS that have been implemented in a Vertical Cavity Surface Emitting Laser (VCSEL) biased below threshold and driven by an external field. We will describe the effects of device defects on CS existence and motion. Future developments of CS applications will be discussed.

Nonlinear Patterns in Complex Periodic Potentials with Linear Pump

Yuli V. Bludov [1], Vladimir V. Konotop [2]; [1]Universiade do Minho, Portugal; [2]Universidade de Lisboa, Portugal

163

We consider one-dimensional nonlinear Schrödinger equation with a dissipative lattice, nonlinear losses and linear pump. It is shown that the system allows for the existence of stable nonlinear Bloch states which are attractors. The emergent patterns appear to be related to the band structure of the conservative part of the periodic potential. The model describes a Bose-Einstein condensate with inelastic two-body interactions placed in an optical lattice with losses.

Dissipative Soliton Bound States Under the Influence of External Phase Modulation in Passively Mode-Locked Lasers

Wonkeun Chang [1], N. Akhmediev [1], Stefan Wabnitz [2]; [1]Australian National University, Australia; [2]Università di Brescia, Italy

164

We study the effect of a periodic external phase modulation on an already existing dissipative soliton pair of the complex cubic-quintic Ginzburg-Landau equation. The external modulation influences the pair separation as well as their phase difference without destroying the two-soliton bound state. The soliton pair may exist in different regimes of evolution, depending on the size of the modulation depth. The transition from one regime to another occurs in a form of bifurcation consisting of a hysteresis loop.

Reflectionless Soliton Potentials in Coupled-Resonator Waveguides

Andrey A. Sukhorukov; Australian National University, Australia

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We present a family of reflectionless potentials for coupled-resonator optical waveguides or optical waveguide arrays with modulated coupling. Such special modulations fully transmit all incident waves of arbitrary wavenumbers or frequencies, We present a general analytical approach for calculating reflectionless potentials using a specially developed transformation of Ablowitz-Ladik soliton solutions. It is shown that the transmitted phase can be tuned by varying the soliton parameter. We also prove that a modulated waveguide supports a pair of cavity modes, which beating can be used to perform beam switching.

Plenary

Elder Hall, 08:45 – 10:20, Tuesday

Few-Body Physics with Ultracold Atoms: Efimov's Dream and 40 Years Later

Rudolf Grimm; University of Innsbruck, Austria

201

Almost 40 years ago, Vitaly Efimov theoretically considered a system of three identical bosons near a two-body scattering resonance [1] and predicted weakly bound quantum states with surprising and bizarre properties. His results are universal in the sense that they do not depend on interaction details. In the last four decades, Efimov's scenario became the paradigm of universal few-body physics [2], but it remained elusive to experimentalists until 2006.

The first experimental signatures of Efimov states were obtained at the University of Innsbruck in an optically trapped, ultracold gas of cesium atoms. The states manifest themselves in resonances in atomic three-body decay [3] and in inelastic atom-dimer collisions [4]. Few-body physics with ultracold atoms has emerged as a new exciting research field, and meanwhile several other groups have found traces of Efimov states in various other ultracold atomic systems [5], highlighting the more general nature of such states.

I will review the exciting story of Efimov states with particular emphasis on our results on cesium atoms and on very recent developments in the field. This also includes the recent discovery

of universal four-body states [6, 7], which represents an important step beyond Efimov's scenario.

Where Next for Photonics-Based Technologies: What Lessons Can We Learn from the Past to Help Us Prepare for the Future?

Simon Poole; Finisar Australia, Australia
202

Photonics, particularly optical fibre transmission, is now established as a core technology underpinning the current era of high-bandwidth communications. Whilst the economic events of the past 18 months have affected all industries, the underpinning economic driver of the photonics industry, bandwidth consumption, is continuing to double every 18 months, driven by the dramatic rise in on-line video consumption, particularly on-demand video on mobile platforms (smart-phones, netbooks, etc).

This presentation will review how external (non-technological) events can influence the development and deployment of photonics using examples from the past 20 years and link these to current technological developments to provide pointers as to the direction of photonics over the next decade.

4A ACOLS : BEC Expt 1

N102, 11:00 – 12:20, Tuesday

Temperature Dependence of Pairing in Strongly Interacting Fermi Gases

Eva Kuhnle, Paul Dyke, Michael Mark, Hui Hu, Xia-Ji Liu, Peter D. Drummond, Chris J. Vale; Swinburne University of Technology, Australia
203

We have used Bragg scattering to experimentally characterise pairing in strongly interacting Fermi gases near a broad s-wave Feshbach resonance. Bragg spectroscopy provides a direct link to two-body correlations via the static structure factor. We show how these correlations build up as the temperature is lowered and compare our results to the theoretical predictions for the Bose-Einstein condensate to Bardeen-Cooper-Schrieffer crossover.

Time Averaged Optical Traps for the Investigation of Superfluidity in BEC

S.K. Schnelle, K.J. Weegink, E.D. van Ooijen, Matthew J. Davis, Norman R. Heckenberg, Halina Rubinsztein-Dunlop; University of Queensland, Australia
204

We present a realization of a time averaged optical trap for use with Bose-Einstein condensates (BEC). The trap uses a two dimensional acousto-optic modulator (AOM) to spatially scan a tightly focused red-detuned laser beam to create arbitrary two dimensional static or dynamic potentials. We discuss the optical and electronic design of these traps as well as a scheme to measure the critical velocity of BEC more precisely than has previously been achieved. First results, theoretical as well as experimental, will be shown for a line potential with a moving barrier to excite the BEC with different barrier velocities.

A Dual Species Rubidium-Metastable Helium Cold Atom System

Lesa J. Byron, Robert G. Dall, Ju-Kuei Wu, Andrew G. Truscott; Australian National University, Australia
205

We present the first results from our rubidium-metastable helium (He*) cold atom system. We describe the apparatus, describe the dual species collision dynamics and present a measurement of two body light assisted He*-Rb loss rate. As well as this we have produced a dual species Rb-He* magnetic trap and we report on our investigation into the spin suppression of Penning Ionization.

4B ACOLS : Waveguides

G03, 11:00 – 12:20, Tuesday

Impurity Free Stress Induced Waveguides in Lithium Niobate

Vijay Sivan, Tolga Mese, Lam Bui, Arnan Mitchell; RMIT University, Australia
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We report observation of a new waveguiding phenomenon under trenches in $LiNbO_3$ etched using standard Ti diffusion technique. The mechanism has yet to be confirmed, but it is hypothesised that localised stress in the vicinity of etched features yields a high refractive index core region.

Simulation of Coupling Between Chacolgenide and Diffused Lithium Niobate Waveguides

Naser Dalvand, Lam Bui, Thach G. Nguyen, Arnan Mitchell; RMIT University, Australia
207

Titanium-diffused lithium niobate waveguides are widely used in current integrated photonic devices such as couplers, switches and electro-optic modulators. In this paper, a rigorous three-dimensional, semi vectorial coupled mode theory (CMT) model is used to simulate the coupling between a weak Titanium-diffused $LiNbO_3$ waveguide and a strong Chacolgenide waveguide. Considering the low refractive index contrast between the core and the substrate of the Titanium-diffused $LiNbO_3$ waveguide, we achieved relatively high coupling of the power between two waveguides.

Erbium Doped Fluoride Glass Strip Waveguides

Maike Waldmann, Reinhard Caspary, Wolfgang Kowalsky; Technische Universität Braunschweig, Germany
208

Low loss fluoride glass planar waveguides on monocrystalline CaF_2-substrates have been fabricated by hot dip spin coating. The surface of the 30 to 50 μm thick glass films was very smooth. Structuring by photolithography and etching led to additional losses, due to the edge roughness. Improvement of the etching process and the use of a poly(methyl methacrylate) cladding render the realization of a compact diode-pumped waveguide laser imaginable.

Ultrafast Laser Modification of Phosphate Glass: Influence of Polarisation on Waveguide Morphology

Douglas J. Little, Martin Ams, Peter Dekker, Michael J. Withford; Macquarie University, Australia
209

Waveguides were written in ytterbium-doped phosphate glass (Kigre QX) using a femtosecond laser with different polarisations; linear and circular, and then characterised using refractive near-field profilometry to compare the waveguide morphology. Circularly polarised femtosecond beams were observed to induce a higher refractive index change at than linearly polarised femtosecond beams at higher irradiances (> 50 TW/cm^2), whereas the opposite was observed at lower irradiances (< 40 TW/cm^2). It is hypothesised that this behaviour is due to the fundamental polarisation-dependence of photo-ionisation rates.

4C ACOLS : Optical Measurements 1

G04, 11:00 – 12:20, Tuesday

Optical Frequency Metrology on the West Coast

J.J. McFerran [1], Gar-Wing Truong [1], Clayton Locke [1], Eugene Ivanov [1], Dustin Stuart [1], Fred Baynes [1], Christopher Perrella [1], Anna Lurie [1], Eric F. May [1], P. Light [2], Fetah Benabid [2], Andre N. Luiten [1]; [1] University of Western Australia, Australia; [2] University of Bath, UK
210

Precision measurement is one of the defining features of our modern technological society. The most precise measurements have long been based on time and frequency protocols because of the superb precision and accuracy of these types of techniques. In this talk I will present an overview of a several aspects of our research in this area; in particular, our work on optical frequency standards which is aimed at satisfying applications in industrial and commercial applications.

Ultra-Stable Detection Scheme for Microtoroid Based Single Molecule Sensing

Joachim Knittel, Kiran Kohosla, Kwan H. Lee, T.G. McRae, Warwick P. Bowen; University of Queensland, Australia

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Optical microtoroids are attractive for label-free, ultra-sensitive biological and chemical sensing. Such sensing is based on resonance frequency shifts induced by the biomolecules on the optical mode. However, due to the small magnitude of the shifts, extremely frequency stable laser sources are required, and environmental factors such as temperature and refractive index fluctuations cause serious degradation. We solve those problems using the relative frequency shift of split mode resonances for detection. Absorbed biomolecules shift the difference frequency that is insensitive to laser frequency and temperature drifts. We developed a practical implementation based on a single laser source.

Optical Determination of the Boltzmann Constant Using Alkali Metals

Gar-Wing Truong, Dustin Stuart, Andre N. Luiten, Eric F. May; University of Western Australia, Australia

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We report on the first results of a recent attempt to measure the Boltzmann constant (k_B) using quantitative spectroscopy of rubidium (Rb) and cesium (Cs). Tunable laser diodes were used to probe the D_2 and D_1 transitions of Rb and Cs, respectively, and the absorption as a function of frequency was recorded. By using non-linear regression to fit the spectra, we have been able to determine k_B to within 1%. We will discuss our insights into how unresolved transitions, optical pumping and frequency calibration can lead to systematic errors and how they can be eliminated.

4D ACOFT : Nonlinearity in Fibres 1

LG29, 11:00 – 12:20, Tuesday

Similariton Generation in Fibre Optic Amplifiers and Lasers

John Harvey, C. Aguergaray, Vladimir I. Kruglov; University of Auckland, New Zealand

213

Self similar solutions of nonlinear partial differential equations have been found with applications in many areas of Physics. The techniques used to find these solutions have been recently been applied to develop solutions of the Nonlinear Schrodinger Equation (NLSE) governing optical pulse propagation, where they are known as similaritons. This talk will review these solutions, and their applications in high power amplifiers, and similariton lasers.

Simple Analysis for Optimizing Soliton Self-Frequency Shift in Photonic Crystal Fibers

Ravi Pant, A.C. Judge, Eric C. Mägi, Boris T. Kuhlmey, C. Martijn de Sterke, Benjamin J. Eggleton; University of Sydney, Australia

214

A simple model is developed to analyze and optimize the soliton self-frequency shift in photonic crystal fibers. The model is used to predict the frequency shift in two different fibers. Experimental results agree well with the simulation results obtained using the generalized nonlinear Schrödinger equation, confirming the predictions of our analysis.

Mode-Locked Parabolic Raman Fiber Oscillator

C. Aguergaray, Vladimir I. Kruglov, D. Méchin, John Harvey; University of Auckland, New Zealand

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The generation of self-similar parabolic pulses (similaritons) has so far only been obtained in single-pass Raman amplifier configurations by Fermann *et al.* 2000 and Finot *et al.* 2003, or in rare-earth doped fiber lasers by Ilday *et al.* 2004 and Nielsen *et al.* 2005. We report here the first demonstration of a mode-locked parabolic pulse fiber laser, which can potentially be run at any wavelength using Raman gain. This new all-fiber ring similariton laser scheme [cf. Fig. 1] has been designed using a full theoretical model. The output similariton pulses have a true parabolic shape and a linear chirp.

4E ACOFT : Advances in Waveguides

LG28, 11:00 – 12:20, Tuesday

Planar Fluid Infiltrated Waveguide Arrays in SU8 Epoxy Polymer

Eike Zeller [1], Francis H. Bennet [2], Dragomir N. Neshev [2], Wieslaw Z. Krolikowski [2], Yuri S. Kivshar [2], Arnan Mitchell [1]; [1] RMIT University, Australia; [2] Australian National University, Australia

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We report on a novel platform for the realisation of planar fluid infiltrated waveguide arrays with applications in sensing and nonlinear optical propagation. This platform provides a planar 1-D analogue to 2-D fluid-inflitrated "holey" photonic crystal fibres. The waveguides were fabricated in SU8 epoxy using a combination of photolithography and dry film lamination. We demonstrate fluid infiltration, waveguiding and temperature sensing in this platform.

Cavity Mode Control in Coupled Periodic Waveguide Cavities: Theory and Experiment

Sangwoo Ha, Andrey A. Sukhorukov, Andrei V. Lavrinenko, Yuri S. Kivshar; Australian National University, Australia

217

We demonstrate that the mode properties of coupled cavities created in periodic waveguides can depend critically on the lateral waveguide shift. In the absence of such shift, the modes feature symmetric or antisymmetric profiles, and their frequency splitting generally increases as the cavities are brought closer. Our coupled-mode theory analysis reveals that the detuning can be reduced and even completely vanish even for strongly coupled laterally shifted cavities. We confirm experimentally that the longitudinal shift enables flexible control over the frequency detuning and profiles of the fundamental modes.

Low Loss Nonlinear Planar Tellurite Waveguides

Khu Vu, Steve Madden; Australian National University, Australia

218

Tellurium dioxide films were produced by reactive RF sputtering and low loss rib waveguides fabricated from these with reactive ion etching. Losses ~0.1dB/cm at 1550nm were achieved for the first time and significant nonlinearity demonstrated.

DS Workshop

LG24, 11:00 – 12:20, Tuesday

Dissipative Solitons of the Cubic-Quintic Ginzburg-Landau Equation in Fiber Lasers

Frank Wise; Cornell University, USA

220

The properties of dissipative solitons in normal-dispersion fiber lasers are presented. Lasers based on dissipative solitons outperform lasers based on other pulse evolutions in many of the critical parameters.

Domain Walls and Domain Wall Solitons in Fiber Lasers

D.Y. Tang, H. Zhang, L.M. Zhao, X. Wu; Nanyang Technological University, Singapore

221

Formation of domain walls and domain wall solitons in various erbium-doped fiber lasers were experimentally investigated. In case of a birefringence cavity fiber laser, polarization domain walls between the two stable orthogonal polarization states of the cavity were identified and domain wall solitons were obtained. Under coherent coupling even the phase-locked fundamental domain-wall solitons either in the form of dark-bright or dark-dark vector solitons was first experimentally revealed. Domain wall solitons were also obtained on a dual-wavelength fiber laser as a result of the strong incoherent coupling of the laser beams. Features of the domain wall solitons in fiber lasers are reported and numerically simulated.

Dark Soliton Fiber Lasers

H. Zhang, D.Y. Tang, L.M. Zhao, X. Wu; Nanyang Technological University, Singapore

222

We report on the experimental observation of stable dark pulse emission in an all normal dispersion fiber laser. We found experimentally that, like the bright soliton formation in the mode locked fiber lasers with anomalous cavity dispersion, dark pulse emission is a generic feature of the normal dispersion fiber lasers under strong continuous wave (CW) emission. Through appropriately controlling the pump strength and cavity feedback stable single or multiple dark pulses have been experimentally obtained. The dark pulse emission of the fiber laser could be well numerically reproduced. Moreover, numerical simulations suggest that the observed dark pulses are the nonlinear Schrödinger equation (NLSE) type of dark solitons.

Dynamics of Vortex Ring Solitons with High Value of Vorticity in Dissipative Media

N. Devine [1], N. Akhmediev [1], J.M. Soto-Crespo [2], C. Mejía-Cortés [2]; [1]Australian National University, Australia; [2]CSIC, Spain

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We have found regions of stability for ring solitons with vorticity m ranging from 1 to 5 and additionally for $m = 9$. The existence of vortex ring solitons with m from 1 to 5 and the fact that their region of existence does not shrink when increasing m to 9 shows clearly that such structures can exist for any higher value of m. The unique property of dissipative ring structures is their bifurcation patterns. Radially symmetric ring structures can be transformed into ring structures which are modulated or bent along the ring. They can also pulsate periodically or chaotically. Despite all these transformations, they remain stable as a single ring with given m. These properties make them distinctively different from any known vortex solitons in conservative media.

5A ACOLS : BEC Expt 2

N102, 13:30 – 15:10, Tuesday

Formation Dynamics of a Bose-Einstein Condensate in a Dimple Trap

Michael C. Garrett, Adrian Ratnapala, E.D. van Ooijen, Chris J. Vale, Otto Vainio, Norman R. Heckenberg, Halina Rubinsztein-Dunlop, Matthew J. Davis; University of Queensland, Australia

224

We study the dynamics of Bose-Einstein condensate formation from the sudden application of a tightly focused laser optical dipole potential to a Bose gas above the critical temperature in a cigar-shaped magnetic trap. Due to the altered density of states, a condensate forms despite the net transfer of energy to the gas. We measure temperature and condensate fraction over a range of times after applying dimple traps of various sizes. We find no delay before the initiation of condensation, in contrast to several other condensate formation experiments. We simulate the dynamics of condensate formation using a quantum kinetic theory approach.

Vortex Dipoles in a Bose-Einstein Condensate

T.W. Neely [1], E.C. Samson [1], Ashton S. Bradley [2], Matthew J. Davis [3], B.P. Anderson [1]; [1]University of Arizona, USA; [2]University of Otago, New Zealand; [3]University of Queensland, Australia

225

We report experimental observations and numerical simulations of the formation, dynamics, and lifetimes of quantized vortex dipoles in highly oblate dilute-gas Bose-Einstein condensates (BECs). Vortex dipoles were nucleated by forcing superfluid flow around a blue-detuned laser beam. By varying the velocity of superfluid flow, we measured a critical velocity for the nucleation of a single pair of vortices (a vortex dipole) in the BEC, with excellent agreement between experimental and numerical results. We present measurements of vortex dipole dynamics in a BEC, finding that the vortex cores of opposite circulation can exist for many seconds and that annihilation is inhibited in our pancake-like trap geometry. For sufficiently rapid flow velocity clusters of like-charged vortices aggregate into long lived dipolar flow structures.

Towards an All Optical BEC and Optical Ring Traps

Leif Humbert, M. Peron, J.S. Butcher, E.D. van Ooijen, Matthew J. Davis, Norman R. Heckenberg, Halina Rubinsztein-Dunlop; University of Queensland, Australia

226

We report the current status of a new Bose-Einstein condensate (BEC) experiment at UQ to be used to study superfluidity and phases of BECs in a versatile optical scanning trap. A BEC is achieved in an optical dipole trap to provide a fast and spin independent formation [Kuppens]. Afterwards the sample is loaded into a scanning optical trap that provides potentials of arbitrary geometries [Schnelle]. Within this project we focus on toroidal traps of variable diameters, widths and depths.

Nonlinear Dynamics of a Two-Component Bose-Einstein Condensate

Russell Anderson, Mikhail Egorov, Chris Ticknor, Brenton Hall, Peter Hannaford, Andrei Sidorov; Swinburne University of Technology, Australia

227

We report on the nonlinear dynamics and spatial evolution of a two-component Bose-Einstein condensate magnetically trapped using an atom chip. We apply microwave and radiofrequency fields to prepare a coherent superposition of two hyperfine states in ^{87}Rb and interrogate their coherence with Ramsey interferometry. The observed decay of the interference contrast is associated with the inhomogeneous growth of the collective phase and the corresponding dephasing of the component wavefunctions. The observed behaviour is well described by a mean-field theory. We discuss the progress of our experiment with small atom numbers where the mean-field is likely to break down.

Coupled Wave Dynamics in Superradiant Light Scattering

A. Hilliard [1], F. Kaminski [2], R. le Targat [2], E.S. Polzik [2], J.H. Müller [2]; [1]University of Otago, New Zealand; [2]QUANTOP, Denmark

228

We investigate experimentally superradiant Rayleigh scattering by a Bose-Einstein condensate (BEC) in a new parameter regime where depletion of the pump beam and the exchange of photons between the endfire modes are important. Through experiments and simulations we show that collective atom light coupling leads to the self-organized formation of dynamic Bragg gratings within the sample. These gratings lead to an efficient back-scattering of pump photons and optical resonator structures within the BEC.

5B ACOLS : Fabrication

G03, 13:30 – 15:10, Tuesday

Fabrication of Sub-Wavelength Holes in Chalcogenide Glasses by Using a Femtosecond Laser

Qiming Zhang [1], Guangyong Zhou [2], Han Lin [2], Lei Xu [1], Min Gu [2]; [1]Fudan University, China; [2]Swinburne University of Technology, Australia

229

We report on the fabrication of sub-wavelength holes with diameters of less than 550 nm on the surface of the chalcogenide glasses (As_2S_3) by using femtosecond laser irradiation and the subsequent chemical etching process. The holes were characterised by using atomic force microscope.

Characteristics of Ultrafast Laser Written DFB Waveguide Lasers

Martin Ams, Graham D. Marshall, Peter Dekker, Michael J. Withford; Macquarie University, Australia

230

Monolithic waveguide lasers were fabricated in doped phosphate glasses using the femtosecond laser direct-write technique. In particular, a waveguide laser based on a distributed feedback (DFB) architecture and fabricated in Ytterbium doped phosphate glass is demonstrated. The device lased at 1.032 μm with an output power of 102 mW and a bandwidth < 2pm. In this paper we report on lifetime studies of the laser's intrinsic waveguide Bragg grating and the relative effects of thermal- and photo-annealing on waveguide laser performance.

Design and Application of SLM-Based Adaptive Optics for Direct Laser Writing

Ben Cumming [1], Guangyong Zhou [1], Alexander Jesacher [2], Martin Booth [2], Tony Wilson [2], Min Gu [1]; [1]Swinburne University of Technology, Australia; [2]University of Oxford, UK

231

Aberrations in optical imaging systems are well known to cause deterioration to image quality and have led to the development of numerous adaptive optics systems capable of real time correction of these errors. Here we report on the design and application of adaptive optics using a spatial light modulator for direct laser writing systems where the aberrations can be less variable, but much stronger than in typical imaging systems.

Parallel Direct Laser Writing Assisted by a Spatial Light Modulator

Han Lin, Guangyong Zhou, Ben Cumming, Min Gu; Swinburne University of Technology, Australia

232

Parallel femtosecond laser fabrication with a computer-generated hologram displayed on a spatial light modulator is demonstrated. The spatial light modulator can produce any arbitrary and variable phase patterning in laser processing. Combined with the computer generated hologram technique, two-dimensional array fabrication by a single-shot irradiation in polymer is demonstrated and the processing performance is analysed.

Dynamics of Write and Erasure of Information Masks in Lithium Niobate

Daniel Sando, Esa A. Jaatinen; Queensland University of Technology, Australia

233

We report on the reversal of degradation of information masks stored in photorefractive lithium niobate. After a long writing time, the degradation appears as the splitting of the refractive index patterns stored in the medium. The reversal is achieved by simply illuminating the crystal with a halogen lamp; thereby erasing the complex structures that caused the splitting. We present analysis of the formation and degradation of the various spatial frequencies in the pattern during the writing and erasure process. Furthermore we discuss the presence of a 'fundamental' spatial frequency for this particular crystal, and parameters (e.g. writing intensity) that affect its properties.

5C ACOLS : Optical Measurements 2

G04, 13:30 – 15:10, Tuesday

Testing Lorentz Invariance Using an Asymmetric Optical Resonator

Fred Baynes, Michael Edmund Tobar, Andre N. Luiten; University of Western Australia, Australia

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Recent experiments utilizing resonant cavities have produced remarkable results which limit the level of any possible of violation of Lorentz Invariance [1]. However, within the framework of the Standard Model Extension (SME) one parameter $\tilde{\kappa}_{tr}$ remains significantly under-constrained compared to the other parameters. An asymmetric optical resonator will be sensitive to violations of LI and specifically much more sensitive to $\tilde{\kappa}_{tr}$ than conventional resonators. In this experiment such an asymmetric resonator is compared to a linear sapphire cavity with both cavities in temperature controlled environments. The measurement system is based on a 1064 nm YAG laser locked to the resonances of both cavities.

Multipoint Fibre Optic Voltage Sensor

Zourab Brodzeli [1], Harpreet K. Bal [1], Fotios Sidiroglou [1], Stephen F. Collins [1], Vladimir Chigrinov [2], Anatoli Murauski [2], Fei Fan [2]; [1]Victoria University, Australia; [2]Hong Kong University of Science & Technology, China

235

In this paper we propose a new approach to fibre optic voltage sensors via a voltage-controlled Liquid Crystal (LC), which would allow direct measurement of up to 400 kV/m electric fields at multiple points along a power line.

Mode-Quenching in Thin-Ridge Silicon-on-Insulator Disk Resonators with Lateral Leakage

Thach G. Nguyen [1], Ravi S. Tummidi [2], Thomas L. Koch [2], Arnan Mitchell [1]; [1]RMIT University, Australia; [2]Lehigh University, USA

236

By utilising the 'magic' radius and 'anti-magic' radius phenomena in thin-ridge silicon-on-insulator (SOI) disk resonators with lateral leakage behaviour, it is possible to design relatively large disk resonators with only a single low-loss whispering gallery mode. We show that an effectively monomodal disk resonator can be achieved when the fundamental whispering gallery mode of the disk is at 'magic' radius to minimise its lateral leakage loss.

Complete and Accurate Characterisation of a High Finesse Fabry-Perot Cavity

Clayton Locke, Dustin Stuart, Eugene Ivanov, Andre N. Luiten; University of Western Australia, Australia

237

With the recent development of very high finesse Fabry-Perot cavities, $F \sim 10^6$, it has become a significant challenge to characterise their properties accurately. A similar challenge is encountered when trying to measure the properties of cavities in which either the probing laser or the cavity length is intrinsically unstable. We demonstrate the means by which the finesse, free spectral range, mirror transmissions, dispersion and coupling may be measured easily and accurately with a laser or cavity with a relatively poor intrinsic frequency stability.

The Interaction of the Electromagnetic Radiation with Two Non-Homogenous Cylindrical Particles and Induced Effects

Liudmila A. Uvarova [1], Irina V. Krivenko [2], Alexander F. Ivannikov [2]; [1]MSTU "Stankin", Russia; [2]Tver State Technical University, Russia

238

An influence of an electromagnetic monochromatic radiation on aerosol systems contained two-layer absorbed cylindrical particles was considered. It is supposed that the surface and the inner layers for each from such cylindrical particles differ in the absorbed ability significantly. The solution of this problem we carry out in the bi-cylindrical co-ordinate system. We assume that the radiuses of cylinders are less than the length of the fall wave. The electric vector and value of electromagnetic energy in each layer were found. The calculations of electric and magnetic vectors at different values of permittivity and permeability (positive and negative), and frequency were received. With help the found the electromagnetic energy sources the induced effects (the heating, the dynamics) were considered. The approximate solutions for non-linear dependence dielectric permittivity of type $\varepsilon = \varepsilon_0 + |\alpha| f(\vec{E})$ (where α is parameter of non-linearity) were determined too.

5D ACOFT : Nonlinear Effects

LG29, 13:30 – 15:10, Tuesday

Slow-Light Enhanced Optical Limiting at 10Gbit/s in a Silicon Photonic Crystal Waveguide

B. Corcoran [1], C. Monat [1], D. Pudo [1], Mark D. Pelusi [1], David J. Moss [1], Benjamin J. Eggleton [1], T.P. White [2], L. O'Faolain [2], T.F. Krauss [2]; [1]University of Sydney, Australia; [2]University of St Andrews, UK

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We report a nonlinear power transfer function at 10Gbit/s provided by slow-light enhanced nonlinear loss in a silicon photonic crystal waveguide. This optical limiting functionality can be used to reduce amplitude distortion of the logical '1' level of a high bit rate optical signal. We investigate the dependence of this effect on the frequency of applied amplitude distortion.

High Efficiency Harmonic Generation in $LiNbO_3$ Membranes

Alexander S. Solntsev [1], Andrey A. Sukhorukov [1], Dragomir N. Neshev [1], Rumen Iliew [1], Thomas Pertsch [2], Yuri S. Kivshar [1]; [1]Australian National University, Australia; [2]Friedrich Schiller University of Jena, Germany

240

We predict that mode dispersion can be flexibly controlled in $LiNbO_3$ thin slab waveguides through an interplay of structural and material birefringence, enabling efficient harmonic generation based on quadratic nonlinear response. We show that simultaneous matching of phase and group velocities is possible for fundamental and second-harmonic waves, facilitating frequency doubling for ultra-short pulses in the telecom frequency range. We also demonstrate completely phase-matched cascaded third-harmonic generation, and show that the effective nonlinear coefficient for generation attains the maximum value when the parametric interactions between three participating waves are phase-matched.

Continuous Wave Four Wave Mixing in Highly Nonlinear As_2S_3 Waveguides

Barry Luther-Davies, Xin Gai, Steve Madden, Duk-Yong Choi, Douglas A.P. Bulla; Australian National University, Australia

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We report experiments on CW four-wave mixing in an As_2S_3 nonlinear waveguide. Using total launch powers ≈360mW we obtained FWM efficiencies of 1–2% over the C-band in a single device and an idler powers at the output > -10dBm.

Strong Raman and Four Wave Mixing Gain in As_2S_3 Chalcogenide Glass Waveguides

Xin Gai, Barry Luther-Davies, Steve Madden, Duk-Yong Choi, Douglas A.P. Bulla; Australian National University, Australia

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We report experiments on and numerical modelling of the contributions of Raman and four-wave mixing to high gain observed in nonlinear dispersion-engineered As_2S_3 chalcogenide glass rib waveguides pumped by ≈4ps pulses at 1550nm with peak powers in the range of a few 10s of watts.

Observation of Competing Quadratic Nonlinearities in Lithium Niobate Waveguide Arrays

Frank Setzpfandt [1], Dragomir N. Neshev [2], Roland Schiek [3], Falk Lederer [1], Andreas Tünnermann [1], Thomas Pertsch [1]; [1]Friedrich Schiller University of Jena, Germany; [2]Australian National University, Australia; [3]University of Applied Sciences Regensburg, Germany

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We demonstrate experimentally the existence of competing focusing and defocusing nonlinearities in a double resonant system with quadratic nonlinear response. We use an array of periodically-poled coupled lithium niobate optical waveguides and observe inhibition of nonlinear beam self-action, independent on power. This inhibition is demonstrated in both regimes of normal and anomalous beam diffraction.

5E ACOFT : Mid-Infrared Fibres and Lasers

LG28, 13:30 – 15:10, Tuesday

Fibre Lasers That Emit CW Light at Wavelengths Approaching 3 μm

Stuart Jackson; University of Sydney, Australia

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In this review, I will highlight past achievements in the field of 3 μm fibre laser research. I will summarise some recent developments and I will indicate possible areas of further investigation.

Thick Fluoride Fiber for MIR-Spectroscopy

Maike Waldmann, Reinhard Caspary, Wolfgang Kowalsky; Technische Universität Braunschweig, Germany

245

Fiber-coupled mid infrared spectrometers can be used for in-situ monitoring of the reaction progress in chemical production processes. The absence of an adequate fiber led to the exploration of thick fluoride glass fibers for this purpose. 670 μm thick fluoride fibers with 500 μm core diameter have been fabricated. The fibers showed a bending radius of approximately 15 cm, a tensile strength of 90 MPa and a minimum loss of 0.7 dB/m at 3.1 μm.

Large Mode Area Fluoride Microstructured Fibres: Towards Single-Mode Guidance in the Mid-Infrared

Heike Ebendorff-Heidepriem [1], Tze Cheung Foo [1], Kevin Kuan [1], Roger C. Moore [1], Tanya M. Monro [1], Alexander Hemming [2], Jim Richards [2], David G. Lancaster [2]; [1]University of Adelaide, Australia; [2]DSTO, Australia

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We report on progress in the development of a fluoride microstructured fibre with large mode area, good beam quality and low loss in the mid-infrared. The fibre demonstrates reduced loss of 7 dB/m and beam quality of M^2 ~2.4 at 4.7 μm in a basic mid-IR beam delivery geometry.

Investigation of a Wavelength and Repetition Rate Tunable Passively Mode-Locked Fibre Laser at Ultrahigh Repetition Rates

Jochen Schröder, Trung D. Vo, Benjamin J. Eggleton; University of Sydney, Australia

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We experimentally demonstrate a passively mode-locked fibre laser with tunable wavelength and repetition rate. Optical autocorrelation measurements and power spectra using a cross-phase modulation technique demonstrate the mode-locked operation at up to 640 GHz repetition rate. This is to the best of our knowledge the first demonstration of a tunable repetition rate laser at such ultra-high repetition rates as well as the first measurements of a power spectrum of a laser at these repetition rates.

DS Workshop

LG24, 13:30 – 15:10, Tuesday

Transverse Nonlinear Effects with Microcavity Polaritons

D.V. Skryabin[1], A.V. Gorbach[1], R. Hartley[1], O.A. Egorov[2], Falk Lederer[2]; [1]University of Bath, UK; [2]Friedrich Schiller University of Jena, Germany

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Here we review our recent results on pattern forming instabilities, localised structures and vortices generated in semiconductor microcavities operating in the strong coupling regime, when photons and excitons entangle and give birth to a new half-light half-matter quasiparticle - polariton.

Fourth Order Dispersion Stabilizes Dark Localized Structures in Photonic Crystal Fiber Cavities

M. Tlidi[1], A. Vladimirov[2]; [1]Université Libre de Bruxelles, Belgium; [2]WIAS, Germany

249

To study modulational instability in photonic crystal fiber cavities we extend the Lugiato-Lefever model by including the fourth order dispersion term. We show that the fourth order dispersion induces a second modulational instability which allows for the stationary state to restabilize itself at large injection levels. In this regime we found stable dark localized structures exhibiting a homoclinic snaking behavior.

Spontaneous Motion of Dissipative Solitons Under the Effect of Delay

M. Tlidi[1], A. Vladimirov[2]; [1]Université Libre de Bruxelles, Belgium; [2]WIAS, Germany

250

We investigate the properties of 2D cavity solitons in a coherently driven optical cavity subjected to a delayed feedback. The delay is found to induce motion of localized structures that are otherwise stationary and stable. When two cavity solitons are bounded together, in addition to a forward motion they exhibit a rotation. We have derived an analytical formula for the speed of a moving soliton. Numerically we study this phenomenon in two models: the Swift-Hohenberg equation and the Lugiato-Lefever model.

Two Universal Limits of Wave Segment Propagation in Two-Dimensional Excitable Media

Vladimir Zykov, Alexander Kothe, Harald Engel; Technical University of Berlin, Germany

251

A free-boundary approach is applied to derive universal relationships between the medium excitability and the velocity and the shape of stabilized wave segment. In the earlier studied low excitability limit the segment width diverges and wave segments approach critical fingers (spiral waves with an infinitely large core radius). We demonstrate the existence of a second universal limit (motionless circular shaped spot) in highly excitable media. Between two excitability limits segment velocity and shape are determined by a single dimensionless parameter characterizing the medium excitability. Analytically obtained relationships are in good quantitative agreement with the results from numerical simulations.

Self-Bending Self-Confined Light Beams

Alessandro Alberucci, Armando Piccardi, Gaetano Assanto; Università di Roma Tre, Italy

252

We investigate novel self-bending optical spatial solitons in dye-doped nematic liquid crystals, a dissipative nonlinear anisotropic nonlocal medium. Taking advantage of the Janossy enhancement in reorientational response, self-confined beams are able to steer themselves in angle by modifying anisotropy and walk-off in propagation. This striking effect enables self-readdressing through all-optical soliton bending. The phenomenon is described by a non-paraxial nonlinear model accounting for the longitudinal beam components.

6A ACOLS : BEC Theory 1

N102, 15:50 – 17:10, Tuesday

Dynamical Behaviour of Ultra-Cold Bose Gases

R.J. Ballagh, T.M. Wright, C.E. Sahlberg, C.W. Gardiner; University of Otago, New Zealand

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Recently, a methodology based on the truncated Wigner approximation has been developed into a powerful tool for treating effects arising from quantum and thermal fluctuations in trapped ultra-cold bosons. This so-called c-field method has been successfully used to describe a wide range of equilibrium and dynamical phenomena. In this talk I will present our recent developments, including a quantitative treatment of the coupled dynamics of vortices and thermal clouds in non-equilibrium Bose condensates. I will also present a treatment of Bragg scattering from condensates near a Feshbach resonance, explaining recent experimental results that differ manifestly from the predictions of simple mean-field approaches.

Controlled Vortex Formation in an All-Optical Bose-Einstein Condensate

J.S. Butcher, Leif Humbert, E.D. van Ooijen, S.A. Haine, Norman R. Heckenberg, Matthew J. Davis, Halina Rubinsztein-Dunlop; University of Queensland, Australia

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We are currently building an All-Optical Bose Einstein Condensate (BEC) and a scanning beam trap which can be used to trap the BEC in potentials of arbitrary shape. Using this setup, we will implement a new method of vortex creation. This involves splitting the BEC into four parts using the scanning beam trap. After splitting, the relative phases of the four parts are changed in such a way that, when the four parts are brought back together, a vortex forms. We have modeled our method in 2D using the Gross-Pitaevskii equation and are now choosing parameters that will meet technical requirements in the lab.

Feedback Control of a Bose-Einstein Condensate Using Phase-Contrast Imaging

Stuart Szigeti, M.R. Hush, André R.R. Carvalho, Joseph J. Hope; Australian National University, Australia

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We present the theory of feedback control of a Bose-Einstein condensate (BEC) confined in a harmonic trap under a continuous measurement constructed via non-destructive imaging. A stochastic master equation (SME) for the system is derived from a general Hamiltonian based upon system-bath coupling. Numerical solutions for this SME in the limit of a single atom and under the semiclassical approximation are presented. We show that the final steady state energy is dependent upon the measurement and feedback strengths and the ratio of photon and atomic kinetic

energies. Simulations indicate that feedback can be used to drive a BEC towards the ground state.

6B ACOLS : Nonlinear

G03, 15:50 – 17:10, Tuesday

Carrier-Phase Dependence of Self-Focusing in Air with Intense, Few-Cycle Light Pulses

Dane E. Laban, William C. Wallace, R.D. Glover, D. Kielpinski, Robert T. Sang; Griffith University, Australia

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We investigate the nonlinear optical phenomenon of self-focusing in air with intense, few-cycle light pulses. This is the first investigation where the role of carrier-envelope phase in self-focusing is explored in the few-cycle regime. We measure the critical power for self-focusing to be 15 ± 2 GW for 6.3 fs pulses centered at 800 nm. Using this value and a basic first order theory, we predicted that the self-focusing distance should deviate by 480 μm as the carrier-envelope phase is shifted from 0 to π rad. This did not agree with the experimental results, which showed only a 80 μm shift.

Generation of Terahertz Radiation by Excitation of GaBiAs by Near-Infrared Femtosecond Pulses

K. Radhanpura [1], S. Hargreaves [1], R.A. Lewis [1], M. Shafi [2], R.H. Mari [2], S. Novikov [2], M. Henini [2]; [1]University of Wollongong, Australia; [2]University of Nottingham, UK

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We report on the emission of terahertz (THz) frequency electromagnetic radiation from samples of GaBiAs under excitation by short (12 fs) pulses of near-infrared (790 nm) radiation. In transmission geometry, emission from (100) crystal faces is not expected. Emission from (311)*B* crystal faces is observed in all cases, and tends to increase with Bi content. The observations are consistent with the THz emission being a result of optical rectification and enhancement of nonlinear optical constants by further alloying may lead to still more efficient THz emitters.

A Multi-Watt Continuous-Wave, Frequency-Doubled, Self-Raman Yellow Laser

A.J. Lee, H.M. Pask, J.A. Piper; Macquarie University, Australia

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We report the generation of multi-Watt, continuous-wave (CW) yellow output from an Nd:$GdVO_4$ intracavity-doubled, self-Raman laser. By carefully managing the thermal load in the laser crystal, optimising the pump diode wavelength, accurately controlling the temperature of the frequency-doubling crystal, and using an intracavity mirror for efficient collection of the second harmonic, we demonstrate yellow (λ=586.5 nm) output powers of 4 W CW, and 5 W (when modulated at 50% duty cycle) laser emission, with optical (diode to yellow) conversion efficiency over 17%.

Third Harmonic Generation via the Broadband Cascading in Random Media

W. Wang [1], V. Roppo [1], K. Kalinowski [1], Dragomir N. Neshev [1], C. Cojocaru [2], J. Trull [2], R. Vilaseca [2], K. Staliunas [2], Wieslaw Z. Krolikowski [1], Yuri S. Kivshar [1]; [1]Australian National University, Australia; [2]Universitat Politècnica de Catalunya, Spain

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We study nonlinear frequency generation in media with random ferroelectric domain structure. We show that randomness enables one to realize broadband third harmonic generation via cascading of two second order quasi-phase matched nonlinear processes. We investigate spatial and polarization properties of the emitted waves and find them to be in agreement with theoretical predictions.

6C ACOLS : Optical Measurements 3

G04, 15:50 – 17:10, Tuesday

Selectivity in Measuring the Mechanical Oscillations of a Cavity Opto-Mechanical System

Kwan H. Lee, Glen I. Harris, T.G. McRae, Joachim Knittel, Warwick P. Bowen; University of Queensland, Australia

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The realization of silica based microtoroids with high optical and mechanical quality factors has enabled the interaction between light and the mechanical degrees of freedom in these macrocavities. Typical technique in characterising the mechanical oscillation involves utilising the thermomechanical (Brownian) noise to excite the mechanical modes and then detecting the oscillation with an optical measurement technique. In this study we demonstrate that selectivity exists in measuring the mechanical modes, which is dependent on the optical mode used. We consider a number of mechanisms that may be responsible for the selectivity and applications in future cavity opto-mechanical experiments.

Comparison of Alkanethiol Resist Layers for use in Atom Lithography

Joshua P. Beardmore [1], Adam J. Palmer [1], Corine G.C.H.M. Fabrie [2], Robert T. Sang [1]; [1]Griffith University, Australia; [2]Eindhoven University of Technology, The Netherlands

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The viability of using ethyl-mercaptan (ET), the shortest chain alkanethiol, as the resist layer in an atom lithography experiment was investigated. Ethyl-mercaptan was compared to both a longer chain alkanethiol, dodecanethiol (DDT), and a bare lithographic sample without a resist layer. Positive contrast patterning was only observable on samples using a DDT resist, and negative contrast patterning, due to the formation of a contamination resist, is observable for all resists. It was found that the dosage requirements for negative contrast patterns was comparable for both ET and bare sample resists. Samples utilizing the DDT resist layer required larger dosages to form negative patterns, however it produced patterns of the greatest quality.

Comparative Performance of Four-Mirror Parabolic and Spherical Afocal Relays

Galiya Sharafutdinova, John Holdsworth, Samuel Legge, Dirk van Helden; University of Newcastle, Australia

262

The performance of two four-mirror afocal relay candidates for fast scan engines is compared. The absence of spherical aberrations when incorporating 90 degree off-axis parabolic optics is shown to result in a demonstrably superior design of scan engine.

Is the Ultra-Fast Melting of Bismuth Non-Thermal?

E.G. Gamaly, A.V. Rode; Australian National University, Australia

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Transient state of femtosecond laser excited bismuth has been studied by various groups with time-resolved optical, x-ray, and electron probes at the deposited energy density from below through up to several times the equilibrium enthalpy of melting. However, the interpretations of the experimental results are controversial: the optical probes reveal the absence of transition to the melting phase while the authors of x-ray and electron diffraction experiments claim the observation of ultrafast non-thermal melting. The presented analysis, based on temperature dependence of bismuth optical properties, unequivocally shows a purely thermal nature of all the observed fs-laser induced transformations in bismuth.

6D ACOFT : Optical Data Processing 1

LG29, 15:50 – 17:10, Tuesday

Optical Performance Monitoring at 160Gb/s via Slow Light Enhanced Third-Harmonic Generation in Silicon Photonic Crystal Waveguides

C. Monat [1], B. Corcoran [1], Mark D. Pelusi [1], Christian Grillet [1], T.P. White [2], L. O'Faolain [2], T.F. Krauss [2], Benjamin J. Eggleton [1], David J. Moss [1]; [1]University of Sydney, Australia; [2]University of St Andrews, UK

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We report all-optical in-band OSNR monitoring at 160Gb/s by exploiting slow-light enhanced third harmonic generation in a 2D silicon photonic crystal waveguide. These results show how dispersion engineering of photonic crystal waveguides allows us to apply these devices for all-optical nonlinear signal processing, even at high bit rates well in excess of 40Gbit/s.

Stable Optical Frequency Transfer for Advanced Interferometer Lock Acquisition

Adam J. Mullavey, Bram J. Slagmolen, Daniel A. Shaddock, David E. McClelland; Australian National University, Australia

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We present a new alternative method for the stable transfer of an optical frequency reference via an optical fibre link over distances on the order of a few kilometres. This promising technique implements highly sensitive phase-meters, and negates fibre fluctuations using bi-directional passing of two lasers through the fibre. Our method has a direct application in the lock acquisition of advanced interferometric gravitational wave detectors. We also present results for a bench top experiment, where this technique is implemented to phase-lock two Nd:YAG lasers, through a 4.6km optical fibre, with a relative optical frequency noise level of 70 $\mathrm{mHz/Hz^{-1/2}}$ for fourier frequencies a few hundred hertz.

6E ACOFT : New Structures

LG28, 15:50 – 17:10, Tuesday

Nonreciprocal Band Structures in Low-Symmetry Two-Dimensional Magnetic Photonic Crystals

Alexander B. Khanikaev, Michael J. Steel; Macquarie University, Australia

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Magnetooptical materials provide the only intrinsic linear source of nonreciprocal propagation in optics. The weak response of magnetic dielectrics may be enhanced through resonant periodic structures, but nonreciprocal behaviour also requires low symmetry structures. For the first time, we calculate the dispersion of photonic bands in two-dimensional magneto-photonic crystals using a low-symmetry checkerboard design. We find that significant nonreciprocity is obtained throughout the band structure, but that it is strongest in slow-light regions. The interaction of slow light enhancement and the Floquet-Bloch condition leads to extremely fine structure in the dispersion.

Self-Assembling Hydrogels for Flexible Display Technology

Scott Jones, François Ladouceur, Pall Thordarson, Martina Stenzel; University of New South Wales, Australia

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The next generation of display technology will be lighter, cheaper and require less energy. Advanced passive displays would exhibit the quality of printed paper but would extend its capabilities: it would herald a new technological age where every surface in the modern world, flat or curved, can be a moving picture. However, the right medium for such a grand idea is still anyone's guess. One promising new avenue is the use of hydrogel as a material that can reversibly change its transparency under certain stimulus. Integrated into a flexible polymer base, this medium could be cheap and effective as the optical switching component of flexible passive displays.

Design of an Optical Hyperlens with Metallic Nanocylinders

Alessandro Tuniz, P.Y. Chen, Simon C. Fleming, Boris T. Kuhlmey; University of Sydney, Australia

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We present a novel design for an optical hyperlens to image sub-diffraction limited objects in the far field. Our hyperlens is composed of metallic nanocylinders embedded in a dielectric medium, resulting in an artificially anisotropic optical metamaterial. The anisotropic effective permittivity emerges due to the resonant behaviour of metallic nanocylinders. We present numerical results illustrating an optical hyperlens composed of silver nanocylinders in silica glass.

Discrete Time RF Photonic 90° Hybrid Coupler

Kushan Dayaratne, Lam Bui, Arnan Mitchell; RMIT University, Australia

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A novel broadband RF photonic 90° hybrid coupler based on the discrete time realisation of RF photonic transversal scheme is proposed and demonstrated. Only a single optical source is employed to implement several different time taps. This approach could be extended to many taps with a moderate increase in component count.

DS Workshop

LG24, 15:50 – 17:10, Tuesday

Solitonets: Complex Networks of Interacting Solitons

Ido Kaminer, Mordechai Segev, Alfred M. Bruckstein; Technion – Israel Institute of Technology, Israel

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We propose complex networks constructed from interacting solitons: solitonets. Such networks exhibit a variety of novel phenomena, such as noise-enhanced memory and self-synchronization even for random inputs. When such networks have very large random topology, they display self-similar dynamics. Surprisingly, the structure of the stochastic self-similar dynamics of the entire random networks is determined by the solitonic interaction rule at the single-node level. To emphasize this concept, we provide an analytical example for the simplest network, use it to predict the dynamics of very large networks, and further explore the dynamics of two connected solitonets.

Diffraction Managed Polychromatic Solitons

Ivan L. Garanovich [1], Xinyuan Qi [1], Andrey A. Sukhorukov [1], Dragomir N. Neshev [1], Wieslaw Z. Krolikowski [1], Arnan Mitchell [2], Guoquan Zhang [3], Yuri S. Kivshar [1]; [1]Australian National University, Australia; [2]RMIT University, Australia; [3]Nankai University, China

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We study theoretically and experimentally the nonlinear propagation of polychromatic and supercontinuum light in curved waveguide arrays. We show that at moderate supercontinuum powers the nonlinear self-action breaks the left-right symmetry of the beam profile that results in different spatial reshaping for different spectral components. At high supercontinuum powers, we observe formation of diffraction-managed polychromatic solitons. Our results suggest possibility for tunable demultiplexing and spatial filtering of supercontinua.

Higher Order Azimuthons in Nonlocal Nonlinear Media

F. Maucher [1], D. Buccoliero [2], S. Skupin [1], M. Grech [1], Anton S. Desyatnikov [2], Wieslaw Z. Krolikowski [2]; [1]MPI-PKS, Germany; [2]Australian National University, Australia

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We study the formation of azimuthons, i.e., rotating spatial solitons in media with nonlocal focusing nonlinearity. We show that whole families of these solutions can be found by considering internal modes of classical non-rotating stationary solutions, namely vortex solitons. This offers an exhaustive method to identify azimuthons in a given nonlocal medium. We demonstrate formation of azimuthons of different vorticities and explain their properties by considering the strongly nonlocal limit of accessible solitons.

Plenary

Elder Hall, 08:45 – 10:20, Wednesday

Shedding Light on Surface Reactions: Real Time Imaging and Control of Pattern Formation by Laser Heating

Harm Hinrich Rotermund; Dalhousie University, Canada

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Simple surface reactions like the CO-oxidation on single crystal Pt surfaces show a rich variety of pattern formation under specific reaction parameters. The reaction is kept far from thermodynamic equilibrium by maintaining an elevated constant temperature and a steady flow of the reactants through the reaction chamber.

The interaction of a multitude of micrometer scale concentration waves and fronts, like spirals, target patterns, solitons, standing waves etc., on the surface complicate our understanding of the underlying mechanisms for such patterns. Experiments with modified catalytic activity using stationary, inactive boundaries have therefore been designed to isolate individual features (for example single pulses) and interaction mechanisms in order to study them quantitatively [1]. Since 2001 we have been able to dynamically change the surface catalytic activity in real time and space by focusing an addressable laser beam to differentially heat a Pt(110) single crystal surface [2].

Imaging the reactants local coverage with an ellipso-microscope [3] enabled us to close the loop between sensing and actuation, both being spatial-temporally resolved. Pulses and fronts, the basic building blocks of patterns, can now be formed, accelerated, modified, guided and destroyed at will. A temperature heterogeneity moving along a line may ignite waves along its path, or can drag preexisting pulses [4].

Recently, by further improving the resolution of our reflection anisotropy microscope, we have been able to combine the fixed boundary conditions created by microlithography, with the real time control of the reaction by laser beam heating [5].

Optical Quantum Computing: Science-Fiction, Horror-Story or News?

Andrew G. White; University of Queensland, Australia

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Quantum computing is the lovechild of quantum physics and computer science. In this talk we look at what quantum computation is, why physicists, chemists and computer scientists might want to do it, and where we are today. There are many possible physical architectures for realising a quantum computer, we will focus on optical quantum computing, where the information is encoded and manipulated using single photons. For many years this was thought to be science-fiction, but with the discovery of measurement-induced nonlinearity there has been an explosion of interest world-wide, and a slew of "firsts" in demonstration systems. Scaling up from these small systems to a large error-free computer is possible in principle: at first it was thought it would take horrific numbers of "physical" gates per "logical" gate. Recently proposed schemes reduce these overhead requirements from the order of 10,000 to 50, and possibly even 1 — great news if you're an experimentalist! Finally, we will look briefly at some of the scientific and technological challenges ahead, and present our latest experimental results where we build a small optical quantum system for quantum chemistry, calculating the properties of molecular hydrogen to an accuracy of 20 bits.

7A ACOLS : BEC Theory 2

N102, 11:00 – 12:20, Wednesday

Collisions of Bose-Einstein Condensates of Metastable Helium: Recent Results

Valentina Krachmalnicoff [1], Jean-Christophe Jaksula [1], Guthrie Partridge [1], Marie Bonneau [1], Denis Boiron [1], Chris Westbrook [1], Piotr Deuar [2], Karén Kheruntsyan [3]; [1]LCFIO, France; [2]LPTMS, France; [3]University of Queensland, Australia

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We present a theoretical analysis of recent experiments on the production of correlated atom pairs in the collision of metastable helium condensates. Previous experiments have demonstrated that such pairs are produced; in the recent experiments the collision geometry has been modified to enable a more complete study of the effects of the anisotropy of the condensate on the correlations and on the shape of the scattering halo. For the current configuration we are able to perform first-principle simulations for the entire duration of the collision; the results confirm the surprising experimental observation that the scattering halo renders as an ellipsoid.

Spontaneous Soliton Formation in the Growth of a Bose-Einstein Condensate

G.M. Lee, S.A. Haine, Matthew J. Davis; University of Queensland, Australia

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We investigate the formation and evolution of solitons in the Bose-Einstein condensate phase transition. We utilise the Stochastic Gross-Pitaevskii Equation to simulate the condensate growth process resulting from a temperature quench of a thermal Bose gas. Our results indicate the spontaneous formation of solitons within the growing condensate, but these are observed to collide and decay as the gas reaches equilibrium. We present the number of solitons observed in the condensate as functions of the growth time and of the quench rate.

Superfluidity in Trapped Bose-Einstein Condensates

Chao Feng, Matthew J. Davis; University of Queensland, Australia

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One quantifier for the loss of superfluidity in Bose-Einstein condensates is the sudden onset of excitations or drag forces as an obstacle is moved through the condensate faster than a critical velocity. However, it has been difficult to quantitatively reconcile experiments and theory due to the complexities imposed by an inhomogeneous condensate profile resulting from the atom trapping potentials. We present investigations of the loss of superfluidity in harmonically trapped Bose-Einstein Condensates using real experimental parameters. We describe the mechanisms and discuss the regimes for various excitations such as dark soliton and vortex formation.

Simulating Bose Gases with Tensor Product States

Andy Ferris, Matthew J. Davis, Ian McCulloch; University of Queensland, Australia

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We present the application of advanced simulation techniques to continuous, strongly interacting Bose gases. Employing a compact "tensor network representation" of the wavefunction allows one to efficiently simulate one-dimensional systems, but until now this approach has been applied mainly to lattice-based condensed matter Hamiltonians. We demonstrate the power and accuracy of these methods in this continuous context by comparing to the analytic results of the 1D Bose-gas. A Monte Carlo-like technique for achieving finite temperature results is implemented. Finally,

we perform a dynamical simulation of damped trap oscillations in the presence of an optical lattice, and compare with experimental results [Fertig *et al.*, Phys. Rev. Lett. 94, 120403 (2005)].

7B ACOLS : Nonlinear 2

G03, 11:00 – 12:20, Wednesday

High Order Transverse Modes in Second Harmonic Generation

C. Gabriel[1], Jiri Janousek[1], Hans A. Bachor[1], V. Delaubert[2], M. Lassen[3], P. Buchhave[3], D.R.N. Pulford[4], C.C. Harb[5]; [1]Australian National University, Australia; [2]LKB, France; [3]Technical University of Denmark, Denmark; [4]DSTO, Australia; [5]University of New South Wales, Australia

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In this work we will extend our earlier demonstration of spatial mode conversion and show that the SHG process is highly dependent on the magnitude of the pump depletion. We can simulate mode conversion at lower powers with a simple analytical model and we show that there are parameter regimes in which different, and more complex, numerical models are required to predict the behavior of the system. We demonstrate with our experiments the accuracy of these models and investigate the validity of the model for different pump powers.

Spatial Properties of Second Harmonic Pattern Generated in Disordered Nonlinear Media

K. Kalinowski[1], V. Roppo[1], W. Wang[1], J. Trull[2], C. Cojocaru[2], Dragomir N. Neshev[1], Wieslaw Z. Krolikowski[1], R. Vilaseca[2], K. Staliunas[2], Yuri S. Kivshar[1]; [1]Australian National University, Australia; [2]Universitat Politècnica de Catalunya, Spain

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In this work we study theoretically and experimentally the second-harmonic generation by randomly distributed ferroelectric domains in nonlinear material. We show that particular characteristics of domain distribution greatly influence the spatial properties of the second-harmonic emission.

Boosting the Efficiency of a Mid-Infrared Optical Parametric Amplifier Through Signal Recycling

Malte Duering, Vesselin Kolev, Barry Luther-Davies; Australian National University, Australia

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We report a three stage high-power Optical Parametric Amplifier (OPA) based on periodically poled MgO-doped Lithium Niobate (PPLN) for the generation of radiation tuneable between 3346nm and 3498nm. The first two OPA stages were pumped by the 1064nm output of a MOPA system (1.5MHz, 15ps) and seeded with a tuneable cw diode laser around 1540nm, while the third stage is seeded by the idler output of the second stage and pumped by the generated signal output. A new signal wavelength around 2720nm is generated in the process. This signal recycling process enhances the mid-infrared output by 55%, to 3.1W.

Collimated Blue Light Generated by Four-Wave Mixing in Rb Vapour

Alexander Akulshin, Andrei Sidorov, Russell McLean, Peter Hannaford; Swinburne University of Technology, Australia

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We present an investigation of frequency up-conversion of low intensity cw resonant laser radiation in Rb vapour using the process of stimulated wave mixing at various experimental parameters. Atomic coherence prepared on a dipole-forbidden transition is responsible for generation of spatially and temporally coherent blue light. Velocity-selective excitation to the 5D level via step-wise and two-photon processes results in blue light generation that has Doppler-free dependence on the frequency detuning of the applied laser field from corresponding dipole-allowed transitions. It is shown that the collimated blue light is generated along a light-induced wave-guide.

7D ACOFT : Nonlinearity in Fibres 2

LG29, 11:00 – 12:20, Wednesday

Quantum and Classical Light Sources Based on Parametric Processes in Optical Fibres

Jay E. Sharping, Chenji Gu, Christiane Pailo, Liely Kiani, Jeremy R. Sanborn, Yan-Hua Zhai; University of California at Merced, USA

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We report progress in ultra-short pulsed fibre optical parametric oscillators exhibiting pulses as short as 65 fs. A system configured to operate in either the vicinity of 950 nm or 1250 nm is described in detail. The output from this system is fully characterized using second-harmonic generation frequency resolved optical gating. We also summarize some potential applications of this light source. Finally we discuss opportunities to adapt this system for applications in quantum information.

Pulse Re-Shaping by Nonlinear Switching in Phase-Shifted Fiber Bragg Grating

Irina V. Kabakova, C. Martijn de Sterke, Benjamin J. Eggleton; University of Sydney, Australia

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We experimentally demonstrate all-optical switching of sub-nanosecond pulses in a fiber Bragg grating with a π phase-shift in silica fiber. The shift acts as a cavity and the grating provides a nonlinear feedback leading to bistable behaviour. The grating strength is optimized for high intensity enhancement, while the grating length is kept short to minimise the cavity settle-time. We observe a 4.8 dB nonlinear change in transmission at a peak power of 1 kW. A distinct reshaping of the transmitted pulse is attributed to self-switching of the pulse due to the ultrafast Kerr effect.

Design of a Tellurite Microstructured Optical Fibre for Self-Seeded Multicasting for Ultra-Fast Signal Processing

H. Tilanka Munasinghe[1], Wen Qi Zhang[1], Nikola Alic[2], Camille-Sophie Bres[2], Stojan Radic[2], Tanya M. Monro[1], Shahraam Afshar V.[1]; [1]University of Adelaide, Australia; [2]University of California at San Diego, USA

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We propose and model a Tellurite microstructured fibre design for 1-to-16 multicasting from a single, dual-pump source for use in ultra-fast (640 Gb/s) signal processing applications. Utilising a genetic algorithm model, we optimise the fibre design to maximise the parametric gain. Multicasting an input signal into sixteen copies is demonstrated numerically with ~5 dB gain ripple across twelve of the copies.

7E ACOFT : Fibre Gratings 2

LG28, 11:00 – 12:20, Wednesday

Tunable Fibre Bragg Gratings by Resonant Optical Pumping: Applications for Fibre Lasers

Robert J. Williams, Nemanja Jovanovic, Graham D. Marshall, Michael J. Withford; Macquarie University, Australia

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We report on a novel, all-optical, all-fibre switchable erbium laser. The laser cavity consists of two fibre Bragg gratings, spliced on to either end of an erbium-doped fibre: an output-coupler grating in an undoped fibre, and a high-reflector grating in a ytterbium-doped fibre. The erbium fibre is resonantly pumped at 976 nm to provide gain. The ytterbium fibre is also resonantly pumped at 976 nm

(using a second pump diode), to tune the HR grating off-resonance from the OC grating. By modulating the pump for the ytterbium fibre, the erbium laser was switched at 4 kHz.

Preservation of Nanoscale Resolution After Macro-Scale Thermal Annealing and Regeneration of Bragg Gratings in Silica

John Canning [1], S. Bandyopadhyay [2], M. Stevenson [1], P. Biswas [2], J. Fenton [1], M. Åslund [1]; [1]University of Sydney, Australia; [2]CSIR, India

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Strong regenerated gratings with a maximum grating strength exceeding (40–50) dB are fabricated inside an optical fibre by bulk macro thermal processing ~900°C using a UV-laser seeded Bragg grating. Further annealing between 1000 and 1100°C leads to a stabilised grating ~18dB in strength. This suffers no further degradation at 1100°C for the period monitored, over 4 hrs. The potential resolution of this process is demonstrated by regenerating two complex profiles. Phase information is retained between seed and regenerated structures. This opens the way for nano-engineering of materials using thermal processing and seed templates.

Direct Laser Written Bragg-Grating Couplers

Sangwoo Ha [1], Martin Ams [2], Graham D. Marshall [2], Dragomir N. Neshev [1], Andrey A. Sukhorukov [1], Yuri S. Kivshar [1], Michael J. Withford [2]; [1]Australian National University, Australia; [2]Macquarie University, Australia

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Directional couplers containing Bragg gratings in each of the waveguides are fabricated using direct-laser writing method in the glass. Both gratings feature first-order Bragg resonance at telecommunication wavelength around 1537 nm, and we realize for the first time high-precision control over the lateral shift between the gratings. We observe the strong effect of the grating shift on light coupling between the waveguides under the conditions of Bragg scattering. We show that antisymmetric grating alignment facilitates robust light coupling, in agreement with theoretical predictions, demonstrating the feasibility for spatio-temporal control of slow-light pulses which velocity can be reduced due to Bragg reflection.

Broadband Cladding Mode Reflections of Asymmetric Intracore Fibre Bragg Gratings

Jens Thomas [1], Nemanja Jovanovic [2], Michael J. Steel [2], Ria Becker [1], Graham D. Marshall [2], Michael J. Withford [2], S. Nolte [1], Andreas Tünnermann [1]; [1]Friedrich Schiller University of Jena, Germany; [2]Macquarie University, Australia

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The spectrum of a fibre Bragg grating (FBG) that has an asymmetric transversal profile differs considerably from that of a transversally uniform FBG. We present an asymmetric intracore FBG inscribed with focussed ultrashort pulses using the so-called point-by-point technique. The cladding mode resonances are pronounced (deeper than 5 dB) over a very broad spectral range and the entire manifold of peaks can span a full octave. Coupled mode calculations suggest that this strong coupling is due to resonant coupling into cladding modes of higher azimuthal order. Indeed, the images of the reflected cladding modes show interference of cladding modes of different azimuthal order. Exploiting the properties of transversally asymmetric FBG allows for many new sensing applications.

DS Workshop

LG24, 11:00 – 12:20, Wednesday

Dissipative Nonlinear Structures in Optical Fiber Systems I: Dissipative Dispersion Managed Solitons in Mode-Locked Lasers

Brandon G. Bale, Sonia Boscolo, Sergei K. Turitsyn; Aston University, UK

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In this first talk on dissipative structures in fiber applications, we extend theory of dispersion-managed solitons to dissipative systems with a focus on mode-locked fibre lasers. Dissipative structures exist at high map strengths leading to the generation of stable, short pulses with high energy. Two types of intra-map pulse evolutions are observed depending on the net cavity dispersion. These are characterized by a reduced model and semi-analytical solutions are obtained.

Dissipative Nonlinear Structures in Optical Fiber Systems II: Self-Similar Parabolic Pulses in Active Fibers

Sonia Boscolo, Brandon G. Bale, Sergei K. Turitsyn; Aston University, UK

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In this second talk on dissipative structures in fiber applications, we overview theoretical aspects of the generation, evolution and characterization of self-similar parabolic-shaped pulses in fiber amplifier media. In particular, we present a perturbation analysis that describes the structural changes induced by third-order fiber dispersion on the parabolic pulse solution of the nonlinear Schrödinger equation with gain. Promising applications of parabolic pulses in optical signal post-processing and regeneration in communication systems are also discussed.

Dissipative Nonlinear Structures in Optical Fiber Systems III: Dissipative Solitons via Nonlinear Mapping

Sergei K. Turitsyn, Brandon G. Bale, Sonia Boscolo; Aston University, UK

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In the third and final talk on dissipative structures in fiber applications, we discuss mathematical techniques that can be used to characterize modern laser systems that consist of several discrete elements. In particular, we use a nonlinear mapping technique to evaluate high power laser systems where significant changes in the pulse evolution per cavity round trip is observed. We demonstrate that dissipative soliton solutions might be effectively described using this Poincaré mapping approach.

Mode-Locked All-Positive-Dispersion Long-Resonator Fiber Lasers: Features of Femto- and Picosecond Pulses Generation Regimes

Sergey Kobtsev [1], Sergey Kukarin [1], Sergey Smirnov [1], Sergei K. Turitsyn [2], Anton Latkin [1]; [1]Novosibirsk State University, Russia; [2]Aston University, UK

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We present new operational regime in all-fiber all-positive-dispersion laser mode-locked due to effect of non-linear polarization evolution. Using the same laser scheme, we observed both generation of picosecond pulse train and a new lasing regime with generated picosecond wave-packets, each being a train of femtosecond sub-pulses. In the latter case, the auto-correlation function has a non-usual double (femto- and picosecond) scale shape. We discuss mechanisms of laser mode-locking and switching of generation regimes and demonstrate a good qualitative agreement between experimental results and numerical modeling based on modified nonlinear Schrödinger equation.

8A ACOLS : BEC Theory / Fermi Gasses

N102, 13:30 – 15:10, Wednesday

First and Second Sound in a Strongly Interacting Fermi Gas

E. Taylor[1], Hui Hu[2], Xia-Ji Liu[2], L.P. Pitaevskii[1], A. Griffin[3], S. Stringari[1]; [1]CNR-INFM, Italy; [2]Swinburne University of Technology, Australia; [3]University of Toronto, Canada

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Using a variational approach, we solve the equations of two-fluid hydrodynamics in a unitary Fermi gas trapped by a harmonic potential. We show that the in-phase density oscillations (first sound) weakly couple to out-of-phase temperature oscillations (second sound) of the system, giving rise to a typical hybridization effect where the frequencies cross. We predict the value of the frequency splitting caused by hybridization and show how the coupling results in a beating effect in the density response. This gives a promising way of exciting and detecting second sound in this system.

Kibble-Zurek Mechanism in a Spin 1/2 Bose-Einstein Condensate

Jacopo Sabbatini, Matthew J. Davis; University of Queensland, Australia

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The Kibble-Zurek (KZ) mechanism is a universal theory estimating the density of topological defects in both quantum and classical phase transitions. Recent experiments in ultra-cold gases have suggested the possibility of exploring the KZ scenario in ultra-cold atoms. We propose realising a KZ scenario by ramping of the Raman coupling in a two-component Bose-Einstein condensate resulting in pattern formation. The density of the resulting domain walls is related to the ramp rate, and we numerically test the scaling law predicted by the KZ mechanism from the critical exponents of the system.

Virial Expansion for a Strongly Correlated Fermi Gas

Xia-Ji Liu, Hui Hu, Peter D. Drummond; Swinburne University of Technology, Australia

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Using a semiclassical virial expansion, we present a controllable study of the thermodynamics of strongly correlated Fermi gases at BEC-BCS crossover. We propose a practical way to determine the expansion coefficients for both harmonically trapped and homogeneous cases, and calculate the third order coefficient $b_3(T)$ at finite temperatures. At resonance, $b_{3,\infty}(T) \approx -0.29095295$ is determined in free space. These results are compared with a recent thermodynamic measurement for ^{6}Li atoms, at temperatures below the degeneracy temperature, and with Monte Carlo simulations. We discuss also the virial expansion for dynamical properties, including the dynamical structure factor and spectral function.

Time Evolution of Gaussian Pulses in the One-Dimensional Jaynes-Cummings-Hubbard Hamiltonian

M.I. Makin[1], Jared H. Cole[2], Charles D. Hill[1], Andrew D. Greentree[1], Lloyd C.L. Hollenberg[1]; [1]University of Melbourne, Australia; [2]Universität Karlsruhe, Germany

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The Jaynes-Cummings-Hubbard (JCH) system describes a network of single-mode photonic cavities connected via evanescent coupling. We focus in particular on a linear chain, which describes a coupled cavity waveguide. Each cavity contains a single two level system which can be tuned into resonance with the cavity. We explore the behavior of a single excitation (either photonic or atomic) prepared as a Gaussian pulse. Unusual behavior of this system is predicted in the time domain, including splitting of the excitation into two distinct pulses, which travel at distinct speeds.

8B ACOLS : Plasmonics 1

G03, 13:30 – 15:10, Wednesday

Interaction of Beams with Aperture Arrays

Ann Roberts, Marko Milicevic; University of Melbourne, Australia

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Here we present the results of an investigation into the interaction of electromagnetic beams with a spatial intensity variation with arrays of apertures in metallic films. We see that the transfer function is strongly dependent on wavelength and, hence, the angular spectrum of a beam transmitted through such an array can be strongly modified by interaction with the film. This is particularly evident at wavelengths where there is significant excitation of surface waves. The beam is transmitted largely unaltered, however, at wavelengths where localised resonances facilitate high transmission.

Control of Light Propagation Using Spatially Modulated Aperture Arrays in a Metal Film

X.M. Goh, Ling Lin, Ann Roberts; University of Melbourne, Australia

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We show that localized aperture resonances existing in perforated metal films can be utilized for beam manipulation. These resonances exhibit wavelength-dependent phase shifts in the transmitted waves that are governed by the geometry of the aperture and optical properties of the filling material. By spatially varying the aperture size around the resonant dimension of the specific wavelength, a desired spatial phase modulation of transmitted light can be obtained.

Propagation and Dispersion of Plasmonic Pulses on a Flat Metal-Dielectric Interface

Shiaw Juen Tan[1], Dmitri K. Gramotnev[2], Esa A. Jaatinen[1]; [1]Queensland University of Technology, Australia; [2]Nanophotonics Pty. Ltd., Australia

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In this paper, using the Fourier analysis, we investigate the characteristics and propagation of Gaussian plasmonic pulses on a flat metal-dielectric interface. In particular, it is demonstrated that the shape of a plasmonic pulse may be significantly affected when the pulse frequency spectrum approaches the cut-off frequency which is usually near the plasma frequency of the metal. Thus, ultra-short Gaussian plasmonic pulses cannot exist near the cut-off frequency. In addition, we show that the pulse penetration depth into the surrounding media could also be significantly affected. Pulse dispersion during its propagation along a metal surface is also studied.

Surface Plasmon Resonance Enhanced Nanoparticle Trapping

Jingzhi Wu[1], Xingyu Gao[2], Xiaosong Gan[1]; [1]Swinburne University of Technology, Australia; [2]Tianjin University, China

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Nanoparticle trapping based on plasmonic nanostructures is demonstrated in this paper. Three dimensional finite difference time domain simulations indicate considerably enhanced optical forces due to the field enhancement provided by surface plasmon resonance of the nanostructure which consists of pairs of vertically aligned metallic nanorods illuminated by tightly focused laser beam. Our trapping approach can achieve three dimensional nanoscale control of nanoparticles at significantly smaller laser powers and can be applied for single molecule assays.

Photocatalysis Using Au Nanoparticles

Michael Larkins, Xi Chen, Huai Yong Zhu, Xue-Bin Ke, Esa A. Jaatinen; Queensland University of Technology, Australia

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We investigate nanoparticle catalysis driven by visible light for environmental and industrial applications. Ideally the goal is to develop systems, driven by sunlight, which breakdown target volatile organic compounds. We have performed experiments using low intensity cw UV and visible laser light sources to drive these reactions with Au nanoparticles supported on oxides. Results to date indicate that while Localised Surface Plasmons in Au play an important role, it is not clear whether optical processes such as field enhancement drive the reactions or whether the root mechanism of energy and electron transfer to the target molecules is thermal in nature.

8C ACOLS : Remote Sensing / Lasers 1

G04, 13:30 – 15:10, Wednesday

Spectral Measurements of Resonance, Rayleigh and Aerosol Scattering from the Troposphere to the Mesosphere by LIDAR

Jens Lautenbach [1], Josef Höffner [2], Michael Gerding [2], Franz-Josef Lübken [2]; [1]University of Adelaide, Australia; [2]IAP, Germany

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Laser remote sensing is a powerful tool for the ground-based exploration of our atmosphere up to heights of 110 km. A large number of dynamic processes in our Earth's atmosphere as well as long-period changes can be explored only if the used lidar allows night and daylight operation with high data quality. Most lidar systems are limited to darkness due to high solar background during the day. Continuous daylight measurements with the mobile scanning Fe-Doppler lidar of the IAP will be reported. Daylight measurements which are nearly background free have been accomplished with an in house developed laser system, efficient narrowband spectral filters and a small field of view of the receiving telescope.

Coherent Laser Radar for Air Pollution Transport Studies

David Ottaway, Matthew Heintze, Andrew MacKinnon, Peter J. Veitch, Jesper Munch; University of Adelaide, Australia

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We have developed a coherent laser radar system operating at 1.5 microns using an Er:Yb:glass laser. This paper describes new high signal to noise single shot measurements of the atmospheric boundary layer and includes comparisons with measurements obtained from a VHF boundary layer radar.

Passive Stand-Off Imaging and Quantification of Chemical Vapour Plumes

Cameron Bowles, Robert Hall, Vladimir Perejogin, Tim Bubner; DSTO, Australia

333

Remote passive detection and quantification of chemical vapours is of importance for both industrial and defence applications. Fourier transform infrared (FTIR) spectroscopy is identified as a technology that can be used for this application by exploiting the vapours' characteristic vibrational spectral transitions (Flannigan 1996). DSTO has developed an Imaging FTIR Spectrometer (IFTIR) (Wegener *et. al.*2003) that maintains a signal-to-noise and spectral resolution comparable to current commercial single pixel spectrometers and can be used to collect spectral imagery for this application. In the paper we present detection and quantification results obtained from this system by application of theoretical modelling, and analysis algorithms.

Er:YAG Lasers for Coherent Remote Sensing

Nick Chang, Matthew Heintze, David J. Hosken, Jesper Munch, David Ottaway, Peter J. Veitch; University of Adelaide, Australia

334

Stable, single frequency lasers with wavelengths suitable for use with high peak-power pulsed lasers in the eye-safe band are essential for coherent remote sensing of the environment. Currently, low power diode lasers are used as the reference oscillators, but their broad line-widths do not allow the required single-shot velocity resolution. We shall describe an Er:YAG laser that produces a polarized, single frequency, diffraction limited beam at 1.64 μm with a line-width of < 12 kHz, and the development of a diode-pumped, Q-switched, high power slave laser.

8D ACOFT : Optical Data Processing 2

LG29, 13:30 – 15:10, Wednesday

Aberration-Free, Ultrafast, All-Optical Oscilloscope

Aisling Clarke [1], Jochen Schröder [1], Eva Ryckeboer [1], Fan Wang [1], Mark D. Pelusi [1], Michaël A.F. Roelens [2], Benjamin J. Eggleton [1]; [1]University of Sydney, Australia; [2]Finisar Australia, Australia

335

We experimentally demonstrate an ultrafast, aberration-free, all-optical oscilloscope, based on the concept of a time lens. By combining a time lens based on four-wave mixing in a highly nonlinear fibre with a programmable Fourier domain pulseshaper, as the dispersive element, we are able to overcome aberrations associated with the traditional method of attaining quadratic dispersion by propagation inside a fibre. The achieved resolution of the oscilloscope is 612 fs well below the resolution of electronic oscilloscopes.

Wavelength Conversion of 40 Gb/s DPSK and 160 Gb/s OOK Signals in a Chalcogenide Glass Chip

Mark D. Pelusi [1], Feng Luan [1], Steve Madden [2], Duk-Yong Choi [2], Douglas A.P. Bulla [2], Barry Luther-Davies [2], Benjamin J. Eggleton [1]; [1]University of Sydney, Australia; [2]Australian National University, Australia

336

We demonstrate broadband wavelength conversion of amplitude and phase-shift keyed signals at 40-160 Gb/s using the optical Kerr-effect in a photonic chip for the first time. This is enabled by a dispersion-shifted, highly nonlinear As_2S_3 waveguide.

OSNR and Residual Chromatic Dispersion Monitoring for DQPSK Signal Based on Wiener-Hopf Equation

Yuan Zhou [1], Bipin Sankar Gopalakrishna Pillai [2], Ampalavanapillai Nirmalathas [1]; [1]University of Melbourne, Australia; [2]National ICT Australia, Australia

337

We describe a new method to perform simultaneous monitoring of OSNR and residual chromatic dispersion for differential quadrature PSK (DQPSK) signals by solving the Wiener-Hopf equation using matrix inversion.

Optical Performance Monitoring in Optical Label Switched Networks

Kerry Hinton, Rodney S. Tucker, Peter M. Farrell, Wayne Sorin; University of Melbourne, Australia

338

Due to the nature of traffic in an optical label switched networks, traditional optical performance monitoring methods will not work in these networks. It is shown that payload error rate monitoring in these networks requires asynchronous sampling of the payload at the payload bit rate.

Multi-Impairment Monitoring at 320 Gb/s via Cross Phase Modulation Based Radio Frequency Spectrum Analyser

Trung D. Vo, Mark D. Pelusi, B. Corcoran, Benjamin J. Eggleton; University of Sydney, Australia

339

We introduce a novel scheme for multi-impairment performance monitoring at ultrahigh-bit rates based on cross-phase modulation (XPM) in a nonlinear medium. We demonstrate that we can simultaneously monitor in-band optical signal-to-noise ratio and group velocity dispersion at bit-rates of 320 Gb/s (return-to-zero). Our approach retrieves the autocorrelation of the signal via the RF spectrum, which is captured via XPM in highly nonlinear fiber.

8E ACOFT : Measurement

LG28, 13:30 – 15:10, Wednesday

Broadband Optical Signal Processing in Chalcogenide Planar Waveguides

Mark D. Pelusi[1], Feng Luan[1], Trung D. Vo[1], Steve Madden[2], Duk-Yong Choi[2], Barry Luther-Davies[2], Benjamin J. Eggleton[1]; [1]University of Sydney, Australia; [2]Australian National University, Australia

340

We review the latest advances in Chalcognide glass (ChG) planar waveguides for enabling high-speed, all-optical signal processing in compact devices. The underpinning large nonlinear response in cm length circuits, stems from the high nonlinear refractive index of ChG, and the enhancement gained from shrinking the waveguide dimensions to reduce the mode size. The latter also has the favourable effect of increasing waveguide dispersion to cancel the large material dispersion of ChG. Combining these features in a shorter length waveguide is shown to improve the broadband performance for applications such as waveform spectrum analysis, high-resolution optical sampling, and broadband wavelength conversion.

Frequency-Time Mapping for Broadband Frequency Measurement

Linh Nguyen; DSTO, Australia

341

A broadband microwave photonic frequency measurement receiver concept based on an incoherent frequency-time mapping technique is reported for electronic warfare application. This photonic technique directly maps the frequency information of the incoming electronic-warfare signal to a time delay utilising a dispersive medium. No pre-filtering of the input or known frequency reference is required. Cascaded chirped fibre Bragg gratings are investigated to improve the frequency measurement capability of the frequency-time mapping technique at low frequencies. Microwave frequency measurement near the theoretical limit is demonstrated at 3 GHz despite the presence of beat signals at the output photodetector.

MM-Wave Frequency Measurement of Pulsed Signals Using Photonic Technique

Manik Attygalle, Daniel Borg, Linh Nguyen; DSTO, Australia

342

We present for the first time the frequency measurement of mm-wave frequency signals with short pulse-width and varying input powers using the dispersion induced power fading in optical fibre. The practical implementation outlines the required calibration procedures. It is shown that a sensitivity of < -50 dBm with pulse-widths of < 100 ns can be achieved for frequency bandwidth from 29 to 40 GHz with potential for further improvement.

Non-Linear Spectroscopy of Rubidium in Hollow Core Fibres for Clocks and Quantum Optics

Christopher Perrella[1], Anna Lurie[1], Fetah Benabid[2], Thomas M. Stace[3], Andre N. Luiten[1]; [1]University of Western Australia, Australia; [2]University of Bath, UK; [3]University of Queensland, Australia

343

The new technology of Hollow Core Photonic Crystal Fibres (HC-PCF) allows for a vapour to be in close contact with high intensity light over long lengths. We are using this property to drive the non-linear, 778nm 5S to 5D transitions in Rubidium which is loaded into the fibre. This particular arrangement can drive this transition strongly enough to see over a 50% absorption of the driving laser, compared to the traditional technique that scatters only 10^{-6} of incident power. This gives an excellent signal to noise ratio for creating an atomic clock and could also be extended to a quantum optics application for creating a single photon filter where the fibre absorbs two photons and lets one photon pass.

DS Workshop

LG24, 13:30 – 15:10, Wednesday

Interaction of Dissipative Solitons in Oscillatory and Excitable Regimes

Adrian Jacobo, Damiá Gomila, Manuel A. Matías, Pere Colet; CSIC, Spain

344

We study the interaction of oscillatory and excitable dissipative solitons arising in a nonlinear Kerr Cavity. In the oscillatory regime there are several equilibrium distances in which symmetric antiphase oscillations, asymmetric antiphase oscillations, mixed mode beating, phase locking and in-phase oscillations are found. We also explore the realization of AND, OR and NOT gates, to perform all-optical logical operations.

Noise-Sustained Dynamics of Drifting Patterns in a Tilted Nonlinear Feedback System

Nicolas Marsal, Delphine Wolfersberger, Marc Sciamanna, Germano Montemezzani; LMOPS, France

345

We investigate experimentally the dynamics of pattern excitation in presence of an advection-like effect in a nonlinear optical system. This advection effect, created when the angle of incidence of the pump beam is not zero, causes the existence of: (i) a transition from convective to absolute instabilities, (ii) the formation of new pattern geometries, (iii) the seeding of noise-sustained structures. All these phenomena, previously observed in nonlinear Kerr-type systems, are demonstrated in our setup composed by a photorefractive nonlinear medium in a tilted feedback configuration.

Actively Mode-Locked Multi-Bound Solitons: Generation and Evolution

Le Nguyen Binh, N.D. Nguyen; Monash University, Australia

346

We report, experimental and numerical observation of the phase difference and interactions which relates to the dynamics of multi-soliton bound states from an active FM mode-locked fiber laser.

Modulational Instability and Solitons in a Periodic Dissipative Feedback System

Dragomir N. Neshev[1], Nicolas Marsal[2], Alexander Minovich[1], Delphine Wolfersberger[2], Marc Sciamanna[2], Germano Montemezzani[2], Andrey A. Sukhorukov[1], Yuri S. Kivshar[1]; [1]Australian National University, Australia; [2]LMOPS, France

347

We review our recent experimental results on control of the modulational instability, pattern formation, and solitons in a nonlinear discrete dissipative feedback system. We show that the discreteness and bandgap effects can provide efficient control of the nonlinear instability modes of the system. Furthermore, we explore the possibilities for excitation of dissipative discrete solitons in such system through seeding with a narrow addressing beam.

Pattern Formation, Dissipative Localised Structures and Spectral Narrowing of Amplified Surface Plasmons Near the Lasing Threshold

D.V. Skryabin[1], A. Marini[1], A.V. Gorbach[1], A. Zayats[2]; [1]University of Bath, UK; [2]Queen's University of Belfast, UK

348

We propose a self-consistent approach to derivation of the amplitude equation for surface plasmon polaritons in the presence of gain, loss and dissipative and Kerr nonlinearities. Our approach allows to explain recently observed spectral signatures of the threshold crossover with amplified plasmons and predicts pattern formation and localised structures of surface plasmons.

9A ACOLS : Fermi Gasses and Atom Lasers

N102, 15:50 – 17:10, Wednesday

Exact Quantum Dynamics of the Dissociation of Molecular BEC into Fermionic Atoms

Magnus Ögren, Karén Kheruntsyan, Joel Corney; University of Queensland, Australia

349

We have examined numerically the exact quantum dynamics of a condensate of bosonic dimers dissociating into fermionic atoms by applying a fermionic phase space representation. Simulations for a few-body system were first performed for comparison with a standard matrix calculation. However, we have also simulated larger systems with 10^3 atomic momentum modes, illustrating the capability of the phase-space representation for first-principles quantum dynamic simulations for fermionic systems of experimentally realistic sizes. Molecule-atom correlations and the decoherence of the initially condensed molecules are studied as time evolves, showing clear departure from mean-field results.

Ultracold Plasma Electron Source

Mark Junker, Simon Bell, Robert Scholten; University of Melbourne, Australia

350

An ultra cold plasma (UCP) can be created by photo-ionisation of atoms in a magneto-optical trap (MOT). The electrons can be extracted, with temperatures below 10 K, to form a high brightness source of ultrafast electron bunches. We are developing such a source, starting with rubidium atoms effusing from an oven, longitudinally cooled by a novel Zeeman slower and loaded into a MOT. We have measured a flux of cold atoms of 2×10^{10} atoms/s to quickly load the MOT.

9B ACOLS : Plasmonics 2

G03, 15:50 – 17:10, Wednesday

Comparative Analysis of Wedge and Groove Plasmonic Waveguides

S.J. Goodman[1], Dmitri K. Gramotnev[2], N.J. Foley[1]; [1]Queensland University of Technology, Australia; [2]Nanophotonics Pty. Ltd., Australia

354

Metallic wedges and V-grooves present one of the best options for the development of sub-wavelength waveguides because they combine relatively weak dissipation with strong sub-wavelength localization of the guided optical signals. This paper conducts a detailed comparison between wedge and groove plasmonic waveguides and determines the wavelengths and structural parameters at which either of these structures presents the best option for the design of efficient plasmonic interconnectors for the integrated nano-optics. Dissipation and localization of plasmonic modes are determined and compared in the optical and telecom ranges of frequencies, demonstrating superior features of V-grooves compared to wedges at optical frequencies.

Plasmon Nanofocusing: New Approaches in Sensing and Nanomanipulation

Dmitri K. Gramotnev[1], Michael W. Vogel[2]; [1]Nanophotonics Pty. Ltd., Australia; [2]Queensland University of Technology, Australia

355

Plasmon nanofocusing is analysed in a focusing dimple in a metal film with a nano-hole in the middle, and an inverse structure in the form of a "wizard hat" with a tapered nano-focusing metal rod formed out of a flat metal surface. It is demonstrated that these two structures combine maximal possible plasmon field enhancement (sufficient for single molecule detection) with other unique functionalities, such as nano-fluidics for the delivery of the tested molecules to the field hot spots, and the possibility of using strongly localised fields for trapping, imaging and nanomanipulation of small nanoparticles and separate molecules.

Self-Focusing of Surface Plasmons

Arthur R. Davoyan, Ilya V. Shadrivov, Yuri S. Kivshar; Australian National University, Australia

356

We study nonlinear propagation of surface plasmon polaritons along an interface between a metal and dielectric with a nonlinear Kerr response. We demonstrate numerically self-focusing of a plasmon beam at large powers and the soliton formation even in the presence of losses. We develop an analytical model for describing the spatial plasmon-solitons, and observe a good agreement with the results of numerical studies.

Light-Field Enhancement at Particle-Substrate Interface

Saulius Juodkazis; Hokkaido University, Japan

357

Light localization by micro- and nano-particles can be used to structure surfaces by ablation and to localize photo-polymerization. In the case of spherical microparticles, focusing of the incident light defines ablation location with micrometer precision. Presence of a light-field component vertical to the surface of sample plays an important part in ablation. Plasmonic nano-particles can further increase light localization especially at the edges, corners, and gaps between particles. Nano-structuring and photo-polymerization with sub-100 nm resolutions is achievable. Light-enhancement can be controlled by the shape and size of nanoparticles over wide spectral range.

9C ACOLS : Remote Sensing / Lasers 2

G04, 15:50 – 17:10, Wednesday

Pulsed Lasers Produce the Brightest Guide-Stars for Large Telescopes

Murray W. Hamilton, Nikita Simakov, Peter J. Veitch, Jesper Munch; University of Adelaide, Australia

358

Pulsed laser guide stars (LGS) are required to remove the effects of elongation in adaptive optics (AO) for extremely large telescopes (ELT). Elongation occurs due to unavoidable off-axis illumination of the 10km thick sodium layer and hampers the ability of the wavefront sensor to reconstruct the atmospheric aberration. This can be avoided by dynamically refocussing on a pulsed LGS with a duration of <3 μs. The reduced interaction time requires the fluorescent yield to be maximised such that there is sufficient return for wavefront correction. We investigate the interaction efficiency between an alkali vapour and pulsed resonant radiation. Our experiment is supported by a 2-level model of the system. We present a pulse format that provides sufficient return and does not suffer from perspective elongation.

The Development of Predictive Passive Standoff Vapour Detection Analysis Tools

Cameron Bowles, Mark Burridge, Tim Bubner; DSTO, Australia

359

Passive standoff detection of gas plumes in the long wave infrared region is an area of interest for both industry and defence. The ability to detect and characterise these plumes is influenced by a variety of limiting factors including temperature, emissivity and concentration variations, sensor system noise and the plumes' intrinsic spectroscopic properties. To make meaningful assessments of the minimum detectable quantities (MDQ) of plumes an analysis tool that considers all these influences is needed. In this paper we present a tool to predict MDQ by using fundamental modelling approaches and simulations. We then present experimental data measured under controlled conditions to test the validity of these models.

Long Range Analogue Audio Free Space Optical Communication Link in a Maritime Environment

Kenneth J. Grant [1], Harris R. Burris [2], Christopher I. Moore [2], Wayne Martinsen [1], James Giesbrecht [3], Bradley A. Clare [1], Thomas Nottage [3], Kerry A. Mudge [1], Charmaine C. Gilreath [2], William S. Rabinovich [2]; [1]DSTO, Australia; [2]Naval Research Laboratory, USA; [3]Ebor Computing, Australia

360

The Defence Science & Technology Organisation (DSTO), in collaboration with the US Naval Research Laboratory (NRL), has performed long distance experiments on analogue modulated free space optical links across Chesapeake Bay, Maryland. In the present work, pulse frequency modulation was used to transmit audio signals over a distance of 32 km (folded path across the Bay). Still images were transmitted using slow scan television (SSTV) techniques.

Direct Generation of Femtosecond Laser Pulses with a Peak Power Exceeding 18 MW Without External Amplification

Wolfgang Koehler [1], Christoph Bartylla [1], Bernd Luerss [1], Christopher Miese [2], Alexander Fuerbach [2]; [1]Femtolasers Produktions GmbH, Austria; [2]Macquarie University, Australia

361

We report on our latest results in the development of high-energy, long-cavity Chirped Pulse Oscillators (CPOs). Our concept allows the generation of ultrashort laser pulses at MHz repetition rates with a pulse duration of less then 50fs and an energy approaching the μJ-level directly out of an oscillator. Thus, our unique approach completely avoids the need for any additional amplification stages. This paper is, to the best of our knowledge, the first demonstration that laser pulses with a peak power exceeding 18MW can be generated directly out of a femtosecond oscillator.

9D ACOFT : Nonlinearity in Fibres 3

LG29, 15:50 – 17:10, Wednesday

Poling: Past, Present and Future Opportunities

Walter Margulis, Oleksandr Tarasenko, Niklas Myrén; Acreo, Sweden

362

Techniques used for inducing an optical second-order nonlinearity in glass fibres are discussed. Thermal poling results are reviewed and compared to the recently reported electrostatic charging. This novel technique to induce a $\chi^{(2)}$ in glass fibres could pave the way to a wide use of fibres in active optical components.

Mode-Locked Picosecond Pulse Generation from an Octave-Spanning Supercontinuum

D. Kielpinski [1], Michael G. Pullen [1], John Canning [2], M. Stevenson [2], P.S. Westbrook [3], K.S. Feder [3]; [1]Griffith University, Australia; [2]University of Sydney, Australia; [3]OFS Laboratories, USA

363

We generate mode-locked picosecond pulses near 1110 nm by spectrally slicing and reamplifying an octave-spanning supercontinuum source pumped at 1550 nm. The 1110 nm pulses are near transform-limited, with 1.7 ps duration over their 1.2 nm bandwidth, and exhibit high interpulse coherence. Both the supercontinuum source and the pulse synthesis system are implemented completely in fiber. The versatile source construction suggests that pulse synthesis from sliced supercontinuum may be a useful technique across the 1000 – 2000 nm wavelength range.

Structurally-Based Nonlinear Birefringence in Waveguides with Subwavelength Structures and High Index Materials

Shahraam Afshar V., Wen Qi Zhang, Tanya M. Monro; University of Adelaide, Australia

364

For the first time, we show that fibres with high index materials and sunwavelength dimensions can have high structurally-based nonlinear birefringence. We discuss this new type of nonlinear birefringence both in terms of fundamental theories and applications.

9E ACOFT : Novel Materials and Platforms

LG28, 15:50 – 17:10, Wednesday

Active Biopolymer Optofluidics

Peter Domachuk [1], Rebecca Cademartiri [2], M. Cronin-Golomb [2], D.L. Kaplan [2], F.G. Omenetto [2]; [1]University of Sydney, Australia; [2]Tufts University, USA

365

The ancient silk fibre finds new application as a bio-chemically functional optofluidic material. We demonstrate a silk protein diffraction grating doped with human haemoglobin. The haemoglobin remains chemically active within the grating and responds spectrally to ambient gas concentration. The grating performs a dual role of providing spectral analysis and a bio-chemical substrate in one component.

Soft Imprinting of Microstructured Micro-Prisms on Optical Fibre Facets

U. Chinnasamy, G. Kostovski, Arnan Mitchell; RMIT University, Australia

366

Soft-imprint lithography is used to integrate optical gratings and polymer micro-prisms onto the tips of optical fibres. Light deflection and diffraction is demonstrated.

Interaction of Nematicons in a Liquid Crystal Cell Without Bias

Yana Izdebskaya [1], V.G. Shvedov [1], Anton S. Desyatnikov [1], Wieslaw Z. Krolikowski [1], Gaetano Assanto [2], Yuri S. Kivshar [1]; [1]Australian National University, Australia; [2]Università di Roma Tre, Italy

367

We study experimentally the propagation dynamics and interaction of spatial optical solitons in a unbiased cell filled with a nematic liquid crystal. We demonstrate several types of interaction between two nematicons including phase-, surface-, and angle-dependent collisions.

High-Q Cavities in Chalcogenide Photonic Crystals by Photosensitive Post Processing

Michael W. Lee [1], Christian Grillet [1], Snjezana Tomljenovic-Hanic [1], David J. Moss [1], Eric C. Mägi [1], Benjamin J. Eggleton [1], Xin Gai [2], Steve Madden [2], Duk-Yong Choi [2], Douglas A.P. Bulla [2], Barry Luther-Davies [2]; [1]University of Sydney, Australia; [2]Australian National University, Australia

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We demonstrate a high-Q (~125000) photonic crystal (PhC) cavity formed using a post processing technique where the refractive

index of a photosensitive chalcogenide PhC is modified locally. The cavity resonances were measured using an evanescent coupling technique which allowed for flexible probing of the cavity and also *in situ* measurements during the photosensitive process.

DS Workshop

LG24, 15:50 – 17:10, Wednesday

Optical Rogue Waves: Theory and Experiments

Majid Taki [1], Arnaud Mussot [1], Eric Louvergneaux [1], Alexandre Kudlinski [1], Mikhail Kolobov [1], Marc Douay [1], N. Akhmediev [2]; [1]PhLAM, France; [2]Australian National University, Australia

369

We present an experimental and theoretical study of optical rogue waves generated in photonic crystal fibers supercontinuum under continuous-wave pumping. They correspond to sharp, rare and extremely high power pulses sharing the main features of the devastating freak waves also known as “walls of water” by seafarers, appearing in the ocean. We demonstrate that these rare events originate from convective instabilities and that their rapid appearance/disappearance results from the collision of solitons. More importantly, L-shaped probability distributions of the peak intensities and a strong dependence on initial noisy conditions have been both numerically and experimentally observed.

Rogue Waves and Their Perturbations

Adrian Ankiewicz, N. Akhmediev; Australian National University, Australia

370

We show that the nonlinear Schrödinger equation (NLSE), which describes generic nonlinear phenomena including waves in the deep ocean and light pulses in optical fibres, supports a whole hierarchy of rational solutions. We present some of these and investigate whether such solutions can survive perturbations.

Getting the Genie Out of the Bottle — How to Excite Rogue Waves?

N. Akhmediev [1], J.M. Soto-Crespo [2], Adrian Ankiewicz [1]; [1]Australian National University, Australia; [2]CSIC, Spain

371

We propose initial conditions that could facilitate the excitation of rogue waves. Understanding the initial conditions that foster rogue waves could be useful both in attempts to avoid them by sea farers and in generating highly energetic pulses in optical fibers.

Surface Solitons in Curved Waveguide Arrays

Xinyuan Qi [1], Ivan L. Garanovich [1], Zhiyong Xu [1], Andrey A. Sukhorukov [1], Wieslaw Z. Krolikowski [1], Arnan Mitchell [2], Guoquan Zhang [3], Dragomir N. Neshev [1], Yuri S. Kivshar [1]; [1]Australian National University, Australia; [2]RMIT University, Australia; [3]Nankai University, China

372

We describe theoretically and demonstrate experimentally the formation of surface waves at the edges of curved waveguide arrays with a surface defect fabricated in a $LiNbO_3$ crystal. We show that nonlinear coupling between different linear modes supported by the array leads to beam switching between output waveguides as the nonlinearity strength is increased. At high optical powers we observe formation of surface solitons.

10A ACOLS : Quantum Optics 1

N102, 9:00 – 10:20, Thursday

Quantum Optical Pulse Sequencer

Mahdi Hosseini [1], Ben M. Sparkes [1], Gabriel Hétet [1], Jevon J. Longdell [2], Ping Koy Lam [1], Ben C. Buchler [1]; [1]Australian National University, Australia; [2]University of Otago, New Zealand

404

In this paper, we present a coherent optical memory based on photon echoes induced via controlled reversible inhomogeneous broadening (CRIB). Our scheme can store multiple pulses of light within a chosen frequency bandwidth. Stored pulses can be recalled in arbitrary order with any chosen delay between each recalled pulse. Furthermore, pulses can be time-compressed, time-stretched, or split into multiple smaller pulses and recalled in several pieces at chosen times [1]. Such a quantum pulse sequencer could be used as a random time-access quantum memory and play a role in quantum repeater protocols.

Quantum Manipulations of Spatial Modes Within a Beam

Jean-François Morizur [1], Seiji Armstrong [1], Katherine Wagner [1], Lachlan Nicholls [1], Jiri Janousek [1], Thomas Symul [1], Nicolas Treps [2], Hans A. Bachor [1]; [1]Australian National University, Australia; [2]LKB, France

405

We present a new approach to build multimode entanglement using co-propagating modes instead of distinct beams. It provides a general method to convert one squeezed spatial mode to another, and to entangle multiple squeezed modes. We show that once the squeezed modes have been superposed, it is possible to apply any unitary transformation on the modes using spatial light modulators and optical fourier transforms. Since the modes are co-propagating, it is possible to use a multipixel homodyne detection to measure these modes simultaneously and synchronously (they all share the same local oscillator).

10C ACOLS : Lasers 2

G04, 9:00 – 10:20, Thursday

A Resonantly Pumped Thulium and Holmium Dual-Core Fiber Laser

David G. Lancaster [1], Stuart Jackson [2]; [1]DSTO, Australia; [2]University of Sydney, Australia

407

We demonstrate a double-clad fiber laser that incorporates a pump-light absorbing coaxially located thulium-doped outer core which reaches threshold and resonantly pumps a holmium doped inner core. Under cw diode pumping, the output from the laser displays pulse modulated behaviour at wavelengths corresponding to the Tm^{3+} transition and short gain switched pulses from the Ho^{3+} core, with mode-locked characteristics. The Ho^{3+} and Tm^{3+} fibre lasers simultaneously produced 1.5 W across 2040 nm to 2140 nm and operate at a pulse repetition frequency of ~80 KHz, and pulse widths as short as 330 ns.

Erbium-Doped Bulk Tellurite Glass Laser at 1.5 μm

Michael R. Oermann, David Ottaway, Peter J. Veitch, Heike Ebendorff-Heidepriem, Tanya M. Monro; University of Adelaide, Australia

408

We report on the development of erbium-doped tellurite glass, its characterisation and the feasibility of its use as the gain medium in a short cavity laser. These developments are an important first step to the realization of a large mode area tellurite microstructured fibre laser.

Mode-Locking Cerium Lasers: Generating Ultrafast Pulses in the Deep Ultraviolet

David J. Spence, Eduardo Granados, David W. Coutts; Macquarie University, Australia

409

The cerium-doped material Ce:$LiCaAlF_6$ has shown over the last ten years to be an able laser material in the deep ultraviolet spectral region, generating nanosecond pulses across the wavelength range 280–315 nm. We demonstrate for the first time that cerium can be mode-locked to produce picosecond pulses in this hard-to-access spectral range, and we discuss the promise of cerium to directly generate sub-femtosecond pulses.

Injection Mode-Locked, Q-Switched Nd:YAG Laser at 1319nm

Nikita Simakov, David J. Hosken, Murray W. Hamilton, Peter J. Veitch, Jesper Munch; University of Adelaide, Australia

410

There is a growing need for pulsed laser guide stars (LGS) for adaptive optics (AO) in next generation Extremely Large Telescopes (ELT). There is currently no source that simultaneously provides efficient excitation of mesospheric sodium and allows for removal of the effects of beacon elongation via dynamic refocusing. We present an injection mode-locked, Q-switched 1319 nm Nd:YAG laser, required for our novel LGS system, which provides a unique pulse format that meets all of the requirements for multi-conjugate adaptive optics in ELTs.

11A ACOLS : Quantum Optics 2

N102, 11:00 – 12:20, Thursday

Noiseless Linear Amplification and Distillation of Entanglement

G.Y. Xiang [1], T.C. Ralph [2], A.P. Lund [1], N. Walk [2], Geoff J. Pryde [1]; [1]Griffith University, Australia; [2]University of Queensland, Australia

411

We introduce and experimentally demonstrate the idea of noiseless linear amplification of a harmonic oscillator. While deterministic amplification of this kind violates the quantum no-cloning theorem, nondeterministic heralded amplification is possible. We demonstrate an experimental circuit to realize this concept, and use it for a simple distillation of field entanglement. The concept has application to the distillation of continuous-variables EPR entanglement and quantum communications tasks.

Demonstrations of Adaptive Quantum Measurements in Optics

Brendon L. Higgins [1], Dominic W. Berry [2], Byron M. Booth [1], Morgan W. Mitchell [3], Andrew C. Doherty [4], Stephen D. Bartlett [5], Howard M. Wiseman [1], Geoff J. Pryde [1]; [1]Griffith University, Australia; [2]Macquarie University, Australia; [3]ICFO, Spain; [4]University of Queensland, Australia; [5]University of Sydney, Australia

413

Quantum measurement protocols make use of the quantum nature of the universe to gain more information about a system using fewer resources than would otherwise be possible. Achieving precision at the fundamental limits imposed by quantum mechanics nevertheless remains a challenge. Adaptive quantum measurement protocols may allow us to step closer to these ultimate limits. We present an overview of some interesting recent results of quantum measurement schemes as demonstrated in single-photon optical implementations, in the contexts of unambiguous phase estimation and multiple-copy non-orthogonal state discrimination.

Quantum Model for Optical Phase Modulator

Alwin Tam, Kerry Hinton, Peter M. Farrell, Rodney S. Tucker; University of Melbourne, Australia

414

A full quantum field theoretical model of a PSK optical communications system, including the phase modulator and homodyne receiver is presented. The model explicitly delineates between the contributions due to modulation (predicted by classical analysis) and a contribution due to photon creation out of the vacuum, induced by time the dependent refractive index of the phase modulator. We find that, even with refractive index modulation rate of order 10^{13}sec^{-1} photon creation from the vacuum will have a negligible effect in PSK optical communications. However the effect may be detectable using ultra-high frequency ultra-stable clocks.

11C ACOLS : Lasers 3

G04, 11:00 – 12:20, Thursday

A High-Performance Coherent Pulsed Spectroscopic Light Source with Low Chirp and Optical Bandwidth Near the Fourier-Transform Limit

Kenneth G.H. Baldwin [1], Yabai He [2], Mitsuhiko Kono [1], Brian J. Orr [2], Richard T. White [3]; [1]Australian National University, Australia; [2]Macquarie University, Australia; [3]University of Adelaide, Australia

417

A high-performance injection-seeded optical parametric oscillator produces tunable ~25-ns light pulses at ~840 nm, with low frequency chirp and an optical bandwidth close to the Fourier-transform limit. Higher-power output is then generated at ~840 nm by a multipass Ti:sapphire laser amplifier, prior to nonlinear-optical upconversion (e.g., to ~210 nm by two second-harmonic-generation steps). Optical-heterodyne techniques are used to monitor and control the instantaneous frequency of individual pulses at ~840 nm, and sub-Doppler spectroscopic measurements are made to verify system performance at each stage. Ultimately, the seventh harmonic at ~120 nm will enable high-resolution vacuum-ultraviolet spectroscopic applications.

Piezo-Tuned Erbium-Doped DFB-PCF Laser for High-Resolution Spectroscopy

Kevin Cook [1], C.K. Poon [1], A.A.P. Pohl [2], John Canning [1]; [1]University of Sydney, Australia; [2]Federal University of Technology Parana, Brazil

418

A piezo-electric transducer (PZT) is used to tune the lasing wavelength of a photonic crystal fibre (PCF) distributed feedback laser (DFB), this allows the P11 absorption band of acetylene to be tuned with 0.45nm resolution. The wavelength may be to tuned by up to 0.22nm. The DFB exhibited remarkable performance with stable, CW, single mode, narrow-linewidth operation.

Multi-Wavelength, Rapidly Swept Continuous-Wave Cavity Ringdown Spectroscopy, Applied to Sensing of Greenhouse Gases

Brian J. Orr [1], Yabai He [1], Ruifeng Kan [2], Florian V. Englich [3], Wenqing Liu [2]; [1]Macquarie University, Australia; [2]Chinese Academy of Sciences, China; [3]University of Adelaide, Australia

419

The greenhouse-gas molecules CO_2, CH_4, and H_2O are detected by using a cavity ringdown laser absorption spectroscopy technique with rapidly swept optical cavity and multi-wavelength coherent radiation from a set of pre-tuned diode lasers. This sensitive portable instrument is applicable to environmental monitoring with adequate absolute quantitative accuracy and reliability.

12A ACOLS : Atom Lasers and Atom Optics

N102, 13:30 – 15:10, Thursday

Quantum Kinetic Theory Model of a Continuous Atom Laser

G.R. Dennis [1], Matthew J. Davis [2], Joseph J. Hope [1]; [1]Australian National University, Australia; [2]University of Queensland, Australia

421

We model a continuous wave atom laser formed by outcoupling atoms from a steady-state Bose-Einstein condensate (BEC) at finite temperature. The atoms in the reservoir that contain the BEC are replenished by transferring particles from a second non-degenerate Bose gas combined with evaporative cooling. The atom laser flux is increased by a higher replenishment rate and lower temperature for the thermal atoms. For practical sources, there is a trade-off between these two quantities. We use quantum kinetic theory to determine the limits on the temperature and phase space density of the source of atoms for a useful atom laser beam.

Generating Entangled Atom Lasers

Mattias Johnsson, G.R. Dennis, Joseph J. Hope, Robert G. Dall, Lesa J. Byron, Andrew G. Truscott; Australian National University, Australia

422

We present a method to create paired atom laser beams from a metastable helium Bose-Einstein condensate via four-wave mixing, analogous to nondegenerate parametric down conversion in optical systems. The two atomic beams are entangled upon production, although the extent to which this entanglement survives on leaving the condensate is currently uncertain. Robust number difference squeezing between the beams is expected, however. The crucial part of the scheme relies on the BEC components having differing s-wave scattering lengths, suggesting that the scheme may work for other atomic species as well.

Imaging the Guided Mode of an Atom Laser

Sean S. Hodgman, Robert G. Dall, Mattias Johnsson, Kenneth G.H. Baldwin, Andrew G. Truscott; Australian National University, Australia

423

Ultracold atoms whose de Broglie wavelength is of the same order as an extended confining potential can experience waveguiding along the potential. When the transverse kinetic energy of the atoms is sufficiently low, they can be guided in the lowest order mode of the confining potential in analogy to light guided by a single mode optical fibre. Here we present images of the transverse mode structure of matter waves guided in the lowest order modes of a confining potential. These images also exhibit interference patterns analogous to speckle when many modes are introduced into the atomic waveguide.

Beyond Short Pulse Regime with Novel Time Domain Atom Interferometer

Mikkel F. Andersen [1], Tycho Sleator [2]; [1]University of Otago, New Zealand; [2]New York University, USA

424

We demonstrate a novel atom interferometer in which atoms are laser-cooled into a 1-D optical lattice, suddenly released, and later subjected to a pulsed optical lattice. For short pulses a simple analytical theory predicts the signal. We investigate both short and longer pulses where the analytical theory fails. Longer pulses yield higher precision and larger signals and we observe a coherent signal at times that can differ significantly from the expected echo time. The interferometer measures of h/m_{Rb} and thereby the fine structure constant α.

Fabricating Atom Chips with Femtosecond Laser Ablation

Holger Wolff [1], Martin Lowe [1], Andrei Sidorov [1], Brenton Hall [1], RuGway Wu [2], Robert G. Dall [2], Andrew G. Truscott [2]; [1]Swinburne University of Technology, Australia; [2]Australian National University, Australia

425

We report on the microfabrication of atom chips using a femtosecond laser ablation technique to arbitrarily sculpture both thin conductive metal films and permanent magnetic materials. We have measured the threshold fluences for a variety of materials relevant to atom chip development. The quality of the ablation process is investigated using composite scanning electron microscope images in combination with a novel home-made magneto-resistance microscope to measure the associated magnetic field noise. Preliminary results from the trapping of ultracold metastable He on an ablated microwire atom chip will also be presented and their utility as a magnetic field microscopy probe explored.

12C ACOLS : Lasers 4

G04, 13:30 – 15:10, Thursday

Thermo-Optic Locking of a Semiconductor Laser to a Microcavity Resonance

T.G. McRae [1], Kwan H. Lee [1], M. McGovern [2], D. Gwyther [1], Warwick P. Bowen [1]; [1]University of Queensland, Australia; [2]University of Otago, New Zealand

426

We experimentally demonstrate thermo-optic locking of a semiconductor laser to an integrated toroidal optical microresonator. The lock is maintained for time periods exceeding twelve hours, without requiring any electronic control systems. Fast control is achieved by optical feedback induced by scattering centers within the microresonator, with thermal locking due to optical heating maintaining constructive interference between the cavity and the laser. Furthermore, the optical feedback acts to narrow the laser linewidth, with ultra high quality microtoroid resonances offering the potential for ultralow linewidth on-chip lasers.

Frequency Stabilized Diode Laser System for Atom Trapping Using Acousto-Optic Modulation

Peter D. McDowall, Mikkel F. Andersen; University of Otago, New Zealand

427

We report on an inexpensive commercial laser diode stabilized to the D_2-line in Rubidium using a simple scheme. The linewidth was reduced to 1.3 MHz without an external cavity, making it suitable for laser cooling and trapping. The system is very robust and the laser frequency can be changed rapidly (within 51 μs) while the laser remains in lock. The frequency of the locked laser drifts less than 850 kHz peak-to-peak over 25 hours.

Multipoint Refractive Index Sensor for Liquids Based on Optical Fiber Bragg-Gratings

Harpreet K. Bal, Zourab Brodzeli, Fotios Sidiroglou, Stephen F. Collins; Victoria University, Australia

428

The theoretical and experimental analysis of a multipoint fibre optic refractive index sensor is presented in this work. Experimental characterisation of the sensor shows excellent agreement with numerical analysis and a resolution in the order of 10^{-3}.

Mode Locking of Fiber Lasers with Atomic Layer Graphene

H. Zhang [1], D.Y. Tang [1], L.M. Zhao [1], Q.L. Bao [2], K.P. Loh [2]; [1]Nanyang Technological University, Singapore; [2]National University of Singapore, Singapore

429

We report on the performance of an erbium-doped fiber laser

passively mode-locked with an atomic layer graphene. Stable mode locked pulses with single pulse energy up to 7.3 nJ and pulse width of 415 fs have been directly generated from the fiber laser. Stability of the mode locked pulses, together with the properties of the graphene mode locker, was experimentally investigated. Our results show that the atomic layer graphene could be a promising ultrafast saturable absorber for large energy mode locking.

Uncooled, Millimeter-Scale Atomic Magnetometers with Femtotesla Sensitivity

John Kitchin [1], Svenja Knappe [1], Clark Griffith [1], Jan Preusser [1], Vladislav Gerginov [1], Peter D.D. Schwindt [1], Vishal Shah [1], Ricardo Jimenez-Martinez [2]; [1]NIST, USA; [2]University of Colorado at Boulder, USA

430

We describe recent work at NIST-Boulder to develop highly miniaturized, low-power atomic magnetometers based on micro-fabricated alkali vapor cells and diode lasers. These instruments have sensor head volumes in the range of 10 mm^3, require no cooling, and can reach sensitivities below 10 fT/rtHz, comparable to the sensitivity of SQUID magnetometers. We discuss the limits to recent measurements and applications to nuclear magnetic resonance and biomagnetic imaging.

13A ACOLS : Quantum Optics 3

N102, 15:50 – 17:10, Thursday

Appearance of Chaotic Attractors from Quantum Trajectories

Justin Bewsher, André R.R. Carvalho, Joseph J. Hope; Australian National University, Australia

431

We investigate the appearance of strange attractors starting from a quantum system whose classical analogue is chaotic. Because classical deterministic chaos is well described in terms of single trajectories in phase space, we adopt quantum approaches that behave likewise: We either evolve single stochastic wave functions, or alternatively, describe the dynamics of quantum quasi-probability distributions in terms of classical stochastic trajectories. Since these *unravellings* of the quantum system in terms of single paths are not unique, we analyse the quantum-classical transition for different trajectory-based models.

Non-Classically Correlated Photon Streams Using Rephased Amplified Spontaneous Emission

Patrick Ledingham, William Naylor, Jevon J. Longdell; University of Otago, New Zealand

432

The two pulse photon echo is a coherent transient phenomenon used as a classical memory for light. This protocol has advantages over others in that it is highly efficient, temporally multimode and wide band. In the quantum regime, these echoes exhibit noise due to amplified spontaneous emission. We show that with a rephasing pulse one can get an "echo" of the amplified spontaneous emission, leading to temporally multimode, wide bandwidth photon streams with non-classical correlations in time.

EPR Entanglement in Asymmetric Systems

Katherine Wagner, Jean-François Morizur, Jiri Janousek, Seiji Armstrong, Ping Koy Lam, Hans A. Bachor; Australian National University, Australia

433

Entangled beams of light have been proposed for use as a resource in many quantum systems. One experimental challenge encountered in continuous variable optical entanglement is the inevitable existence of losses in the system, which ultimately degrade the entanglement that can be used and measured. The deterioration of the entangled state when losses exist in different parts of the experiment is discussed. Two different measures of entanglement, inseparability and EPR entanglement, are compared.

Towards Quantum Opto-Mechanics with Integrated Microresonators

Warwick P. Bowen, Kwan H. Lee, T.G. McRae, Glen I. Harris, Joachim Knittel; University of Queensland, Australia

434

We will present experiments on the route to quantum opto-mechanics with integrated microresonators. In particular, active cooling of an integrated cavity opto-mechanical system is demonstrated for the first time, with final temperature limited to 25 K by optical shotnoise. The use of whispering gallery optical resonances allows convenient motion transduction with multiple independent probe fields at different wavelengths. This enables the first direct comparison between temperature inferences made via in-loop and out-of-loop transduced signals. Stark differences are observed, with serious over-estimation of cooling possible in the standard in-loop inference. Finally, we will discuss the route to ground-state cooling in this system.

ACOLS Posters

Union Building Eclipse/Equinox, 18:00, Monday

Role of Spatial Inhomogeneity in Dissociation of Trapped Molecular Condensates

Magnus Ögren, Karén Kheruntsyan; University of Queensland, Australia

1, Poster

We theoretically analyze dissociation of a harmonically trapped Bose-Einstein condensate of molecular dimers and examine how the spatial inhomogeneity of the condensate affects the conversion dynamics and the atom-atom pair correlations in the short-time limit. Both fermionic and bosonic statistics of the constituent atoms are considered. Using the undepleted molecular field approximation, we obtain explicit analytic results for the short-time asymptotic behavior of the second-order correlation functions and the relative number squeezing between the dissociated atoms in one, two, and three spatial dimensions.

Ionisation of Atomic Hydrogen with Few-Cycle Pulses

Michael G. Pullen [1], William C. Wallace [1], Dane E. Laban [1], Yunquan Q. Liu [1], Friedrich G. Hanne [2], Robert T. Sang [1], D. Kielpinski [1]; [1]Griffith University, Australia; [2]Westfälische Wilhelms-Universität Münster, Germany

2, Poster

We report the first ever above threshold ionisation of atomic Hydrogen (H) using few-cycle laser pulses. We focus ~6.5 fs pulses into an H beam and detect the ejected photoelectrons. We measure the dependence of ionisation rate on laser intensity.

Picosecond X-Ray Source Based on an Amplified Femtosecond Ti:Sapphire Laser

B.D. Morrison, Lachlan J. McKimmie, Trevor A. Smith; University of Melbourne, Australia

3, Poster

We report on the development of a high repetition rate picosecond x-ray source based on a femtosecond Titanium:Sapphire regeneratively amplified laser system. Factors influencing the photon flux and wavelength range achievable from such a system will be outlined. Applications in imaging and kinetic studies will be discussed.

Real-Time Dynamics of Electron Localization Observed in a Dissociating Molecule

Irina A. Bocharova, Maia Magrakvelidze, Sankar De, I.V. Litvinyuk; Kansas State University, USA

4, Poster

In a pump-probe experiment, we measured dependence of yields and kinetic energies for symmetric $N^{2+} + N^{2+}$ (2,2) and asymmetric

$N^{3+} + N^{+}$ (3,1) dissociation channels of N_2^{4+} on time delay between few-cycle 800 nm pump and probe pulses. We observe that the asymmetric (3,1) channel is produced only for delays of up to 20 fs and completely suppressed for longer delays. The symmetric (2,2) channel is efficiently produced for all studied delays. We interpret that observation as an indication that the unpaired electron in dissociating N_2^{3+} is completely localized on one of the ions after 20 fs.

Fluorescence Measurements of Christmas Island Stalagmite Banding

Kimberley Birt, John Holdsworth, Kurtis Reuter, Benjamin Duck, Bruce King, Russell Drysdale; University of Newcastle, Australia

5, Poster

The fluorescence from organic residue incorporated in seasonal growth of stalagmites offers a snapshot of climatic conditions in past millennia. Fluorescence from prepared specimens may be measured routinely with millimetre spatial precision however the residue bands contain finer detail that this work seeks to resolve. Banding is evident in measured fluorescence from humic and fulvic acids with a spatial resolution of 250 μm using multimode optical fibres and 325 nm HeCd laser excitation. Single mode fibres offer the potential for even greater resolution at the expense of signal throughput.

Optogalvanic Spectroscopy of the $^2F_{7/2}$-$^1D[5/2]_{5/2}$ Repumper Transition for Yb^+ Optical Frequency Standards

Matthew J. Petrasiunas [1], Erik W. Streed [1], Till J. Weinhold [1], Benjamin Norton [1], Wayne M. Itano [2], D. Kielpinski [1]; [1]Griffith University, Australia; [2]NIST, USA

6, Poster

Due to interest in the $^2S_{1/2}$-$^2F_{7/2}$ transition of Yb^+ for applications as a frequency standard, we have applied optogalvanic spectroscopy on the 638 nm $^2F_{7/2}$-$^1D[5/2]_{5/2}$ transition of Yb^+ in a DC discharge in order to measure isotope and hyperfine splitting of the line. We have observed optogalvanic signals at multiple pressures of Ne buffer gas, finding linewidths of approximately 2 GHz at 5 Torr and 1.5 GHz at 500 mTorr. Showing that Doppler broadening is dominant below 1 Torr, we have set up sub-Doppler optogalvanic spectroscopy and are working on applying this to resolve the splitting of the transition line.

Time Resolved Spectroscopy of Photosynthetic Mimics

B. Robotham [1], Kenneth P. Ghiggino [1], S.J. Langford [2], K. Lee [2]; [1]University of Melbourne, Australia; [2]Monash University, Australia

7, Poster

Two covalently linked dyads with a porphyrin as the donor and naphthalene diimide as the acceptor for photo induced electron transfer were investigated by both steady state and time resolved spectroscopy. Fluorescence quenching compared to the parent porphyrin compounds is attributed to ultrafast electron transfer resulting in a charge separated state. The differing extents of quenching between the two dyads are attributed to the length and flexibility of the covalent linkage.

Fabrication of Surface Relief Gratings in Azopolymer Films Using Mask Methods

Yanhua Luo [1], Wenxuan Wu [2], Xusheng Cheng [2], Zengchang Li [2], Xiaowu Yu [2], Qijin Zhang [2], Bing Zhu [2], Gang-Ding Peng [1]; [1]University of New South Wales, Australia; [2]USTC, China

8, Poster

Surface relief gratings (SRGs) (both long period and normal Bragg SRGs) have been successfully fabricated in azopolymers by amplitude and phase mask technique, due to the migration of the polymer chains. The long period SRGs have periods of about 40μm and the depth of 35nm. Normal Bragg SRGs have periods of about 546nm and a depth of 30nm. Thus we demonstrate that the azopolymer (poly(2-4-[2-(4-cyano-phenyl)-diazenyl]- phenyloxy-ethyl methacrylate)-co-methyl methacrylate)) is a promising photosensitive material for polymer WG or POF gratings.

Enhanced Absorption in Woodpile Metallic Photonic Crystals for Modified Thermal Emission

Md. Muntasir Hossain, Baohua Jia, Guangyong Zhou, Min Gu; Swinburne University of Technology, Australia

9, Poster

Metallic photonic crystals (MPCs) are artificial periodic metallic structures with unique electromagnetic (EM) features and applications. MPCs have the potential to possess large complete photonic bandgaps and also enhanced absorptions. Here, we investigate the properties of the enhanced absorption with the structural parameters of MPCs along with their bandgaps.

Femtosecond Laser Processing of Silica Glasses with Varying Hydroxyl Concentrations

M. Lancry [1], N. Groothoff [2], S. Guizard [3], W. Yang [4], B. Poumellec [1], P.G. Kazansky [4], John Canning [2]; [1]ICMMO, France; [2]University of Sydney, Australia; [3]Laboratoire des Solides Irradiés, France; [4]University of Southampton, UK

10, Poster

The infrared femtosecond laser damage threshold, along with the density and the mean trapping time of electrons excited in the conduction band, is found to be independent of OH content in pure silica glass.

Optimization of Torque Efficiency in the Design of Optically-Driven Microrotors

Vincent L.Y. Loke, Theodor Asavei, Timo A. Nieminen, Norman R. Heckenberg, Halina Rubinsztein-Dunlop; University of Queensland, Australia

12, Poster

We use a hybrid discrete-dipole approximation/T-matrix method algorithm to computationally model the torque experienced by optically-driven microrotors that are mounted to an axle. We systematically explore the effects of the most important parameters of rotors, such as the thickness, length, and width of the arms, in order to maximize the torque efficiency. We show that it is possible to use computational modelling to optimize the design of such devices.

Fabrication of Channel Waveguides in Lithium Niobate

Yi Lu, Benjamin Johnston, Peter Dekker, Judith M. Dawes; Macquarie University, Australia

13, Poster

Lithium niobate channel waveguides have been fabricated by liquid phase epitaxy using K_2O flux on laser-machined lithium niobate substrates. The laser-driven rapid-prototyping technique can be programmed to give machined features of various sizes, and liquid phase epitaxy produces high quality single-crystal, lithium niobate channels. The surface roughness of the lithium niobate channel waveguide was measured to be less than 90 nm and they exhibit propagation losses of 0.26 ± 0.04dB/mm at a wavelength of 633 nm. Second harmonic generation of 980 nm was demonstrated using the channel waveguides, indicating that these waveguides retain their nonlinear optical properties.

Quantitative Measurement of Sodium and Potassium Released from Australian Loy Yang Coal and Pine Wood by Using Laser Induced Breakdown Spectroscopy

L.J. Hsu [1], Y. Li [2], Zeyad T. Alwahabi [1], Graham J. Nathan [1], Z.S. Li [3], M. Aldén [3]; [1]University of Adelaide, Australia; [2]Jilin University, China; [3]Lund University, Sweden

14, Poster

The quantitative release of potassium and sodium of single Loy Yang coal and pine wood particles during combustion has been recorded by using laser induced breakdown spectroscopy (LIBS) with a calibration flame. Results were performed under equivalence ratio (Φ) 1.336 with air flow rate 6.45 $l \cdot s^{-1}$. The peak release of potassium and sodium from single coal, 23±3 mg, and wood, 63±3 mg, particles occurred at the end of char combustion. The strongest release amount of potassium of coal and wood were 55 and 330 ppb, respectively, and sodium of coal and wood were 130 and 190 ppb respectively.

ACOFT Posters

Union Building Eclipse/Equinox, 18:00, Monday

Impedance of Square and Triangular Lattice Photonic Crystals

Felix J. Lawrence [1], Lindsay C. Botten [2], Kokou B. Dossou [2], C. Martijn de Sterke [1], R.C. McPhedran [1]; [1]University of Sydney, Australia; [2]University of Technology Sydney, Australia

15, Poster

We give a rigorous, semi-analytic definition of impedance for square and triangular (hexagonal) lattice 2D photonic crystals (PCs). Our impedance takes the form of a small matrix, and can be used efficiently to calculate reflections and transmissions between PCs, in the basis of the PCs' Bloch modes (eigenstates). Armed with a library of PC impedances, we can quickly evaluate the reflection and transmission properties of arbitrary structural combinations of PCs, using only fast matrix calculations. In this way structures with desirable reflective or transmissive properties, such as antireflection coatings, may be efficiently found from a large pool of possible structures.

Running Rings Around Photonic Crystal Fibre

Thomas Grujic, Boris T. Kuhlmey, C. Martijn de Sterke; University of Sydney, Australia

16, Poster

We numerically predict and tailor a geometry of solid core photonic bandgap fibre capable of guiding light over an octave of frequency (in particular over the entire visible spectrum), based on an array of raised-index dielectric rings. We also give an explanation of the origin of this wide bandgap, and present a simple analytic model which reproduces the important spectral features of these fibres.

Optimisation of the Soliton Self-Frequency Shift in a Tapered Photonic Crystal Fibre

A.C. Judge [1], O. Bang [2], Benjamin J. Eggleton [1], Boris T. Kuhlmey [1], Eric C. Mägi [1], Ravi Pant [1], C. Martijn de Sterke [1]; [1]University of Sydney, Australia; [2]Technical University of Denmark, Denmark

17, Poster

Soliton propagation is simulated in a tapered photonic crystal fiber with the purpose of optimising the soliton self-frequency shift. An optimal degree of tapering is found to exist for tapers with an axially uniform waist. In the case of axially nonuniform waists, an additional enhancement of the soliton self-frequency shift is achieved by varying the taper waist diameter along its length in a carefully designed fashion in order to avoid the spectral recoil due to the emission of dispersive waves.

Point-by-Point Written Sampled Fiber Bragg Gratings

Matthias Stecher, Robert J. Williams, Graham D. Marshall, Michael J. Withford, Graham E. Town; Macquarie University, Australia

18, Poster

Sampled Fiber Bragg gratings with two predominant reflection peaks have been written into standard optical fibers (SMF-28, HI1060) by direct 'Point-by-Point' writing with a femtosecond laser. Incorporating a periodic π phase shift made it possible to cancel out the zero-order reflection and creating multiple reflection peaks. The period of the phase shift determined the spacing between the reflection peaks, enabling fabrication of sampled gratings for various applications.

Application of Full-Wave Electromagnetic Solvers to Micro/Nano-Structured Fibres

Shaghik Atakaramians, Hendrik Franke, Derek Abbott, Tanya M. Monro, Christophe Fumeaux; University of Adelaide, Australia

19, Poster

The progress of full-field electromagnetic tools coupled to increasingly powerful computing hardware offer the possibility of modelling accurately micro/nano-structured fibres. Together with the advances in fabrication methods, this opens the door to the realization of optimized designs with growing complexity. Three examples of simulations are presented here to illustrate the application of general-purpose electromagnetic solvers to the analysis of micro/nano-structured fibres. Using appropriate numerical tools, the mode propagation in a fibre, the optimised coupling into a fibre from an incident field distribution, and the near-field diffraction patterns from a fibre tip can be characterized.

Towards a Refractive Index Sensor Utilizing Nanostructures Surface Plasmon Resonance on the End-Face of an Optical Fibre

Huy Nguyen [1], Marko Milicevic [2], Ann Roberts [2], Gregory W. Baxter [1], Stephen F. Collins [1], Tim J. Davis [3]; [1]Victoria University, Australia; [2]University of Melbourne, Australia; [3]CSIRO, Australia

20, Poster

An array of nanostructure apertures was fabricated onto the end surface of an optical fibre using a focused ion beam milling technique. Interaction of light with this structured metal film leads to the development of an optical fibre surface plasmon resonance (SPR) sensor that senses the refractive index changes by means of measuring the transmission power at a metal/liquid interface.

Pump Contribution to Linewidth of Er-Doped Distributed-Feedback Fibre Lasers

Scott Foster, Alexei Tikhomirov; DSTO, Australia

21, Poster

We give a new theoretical expression for pump induced frequency fluctuations in DFB-FL and present the results of our experimental investigations on the effect of pump fluctuations on DFB-FL frequency noise and linewidth. We find that the pump contribution to frequency noise is 15dB higher for 980nm pumping than 1480nm pumping at equivalent powers, in line with theoretical predictions. Cooperative energy transfer effects are shown to have a significant impact on frequency noise and can give rise to substantial linewidth broadening.

Efficient Coupling of Emission of Embedded Single Photon Sources Within Optical Fibres

Matthew R. Henderson [1], Shahraam Afshar V. [1], Andrew D. Greentree [2], Heike Ebendorff-Heidepriem [1], Tanya M. Monro [1]; [1]University of Adelaide, Australia; [2]University of Melbourne, Australia

22, Poster

We investigate the coupling of single photon emission from diamond colour centres embedded within the fibre core into the fibre's guided modes. By approximating diamond colour centre emission

as a dipole, we investigate the capture power for different core sizes and for various locations and orientations of the emitting dipole. We then use finite-difference time domain methods to check predictions of this calculation.

Electric Field Sensor Based on a Multi-Channel Directional-Coupler with an Electro-Optic Polymer

Ravi J. McCosker, Graham E. Town; Macquarie University, Australia

23, Poster

We describe a novel electric field sensor based on a multi-channel directional-coupler buried in an electro-optic polymer cladding that infiltrates the gap region between the individual waveguides. This sensor uses the electro-optic polymer to modify the coupling between adjacent waveguides and hence the optical transmittance of the device. This new type of electric field sensor does not require electrodes and can operate in a uniform electric field. Since the device is all-dielectric, there is only minimal disturbance to the field being measured and complete electrical isolation.

Novel Splice-Free Distributed Feedback Fibre Laser Array Architecture

Alexei Tikhomirov, Scott Foster; DSTO, Australia

24, Poster

A novel splice-free distributed fibre laser array architecture using a double-core fibre where one of the cores is active is proposed. A tapered section of the fibre provides strong evanescent coupling between the cores, and transfer of both the pump and signal energy between the cores. Optimum design for typical active fibre parameters is demonstrated and light coupling during tapering process is simulated.

An Analytic Treatment of Shallow Photonic Crystal Waveguides

Sahand Mahmoodian [1], Christopher G. Poulton [2], Kokou B. Dossou [2], R.C. McPhedran [1], Lindsay C. Botten [2], C. Martijn de Sterke [1]; [1]University of Sydney, Australia; [2]University of Technology Sydney, Australia

25, Poster

We investigate the formation of photonic crystal waveguides (PCWs) within the framework of perturbation theory. We derive a differential equation for the envelope function of PCW modes constructed by making weak periodic perturbations, and show that it can be mapped onto an equivalent slab waveguide problem. By using this model, we demonstrate that the nature of the projected band structure and corresponding Bloch functions is central to the behaviour of PCW modes. With this understanding, we explain why the odd mode in a hexagonal PCW spans the entire Brillouin zone while the even mode is cut off.

Transverse Strain Sensing Using Transmission Dips at Twice the Fibre Bragg Grating Wavelength

Harpreet K. Bal [1], Fotios Sidiroglou [1], Sui P. Yam [1], Zourab Brodzeli [1], Scott A. Wade [2], Gregory W. Baxter [1], Stephen F. Collins [1]; [1]Victoria University, Australia; [2]Monash University, Australia

26, Poster

The effect of transverse strain on fibre Bragg gratings fabricated using a phase mask with 536-nm pitch was investigated through the study of its reflection features at twice the Bragg wavelength near 1552 nm, which are due to FBG periodicities associated with the phase mask periodicity and results in a type of π-phase-shifted grating. Both of the two peaks in the reflection spectrum exhibited splitting, in a manner that is consistent with previous results, and could be used as a practical strain sensor.

Mid-IR Sources Based on Four-Wave Mixing in Microstructured Optical Fibres

Richard T. White, Wen Qi Zhang, Shahraam Afshar V., Tanya M. Monro; University of Adelaide, Australia

27, Poster

We report progress towards realising practical, efficient mid-infrared sources based on four-wave mixing in soft-glass microstructured optical fibres with tailored dispersion.

Post-Processing of Self-Assembled Supramolecular Structures

John Canning [1], Brant C. Gibson [2], George Huyang [1], Tony Khoury [1], Tze Jing Sum [1], C. Neto [1], Maxwell J. Crossley [1]; [1]University of Sydney, Australia; [2]University of Melbourne, Australia

28, Poster

A focused ion beam (FIB) is used to process 2-D self-assembled photonic porphyrin film flats to fabricate couplers in 2-D porphyrin slabs. These self-assembled structures have an initial root mean squared (rms) values for surface roughness < 0.5 nm as measured by atomic force microscopy. Under appropriate FIB processing and cutting conditions, the rms value for surface roughness falls to < 0.4 nm.

Observation of Focusing to Defocusing Crossover in Nonlinear Two-Dimensional Periodic Structures

Francis H. Bennet, Inés A. Amuli, Dragomir N. Neshev, Andrey A. Sukhorukov, Wieslaw Z. Krolikowski, Yuri S. Kivshar; Australian National University, Australia

29, Poster

We investigate the effect of crossover from discrete to homogeneous of a two-dimensional (2D) periodic photonic structure determined by its refractive index modulation. We use the cladding of an infiltrated photonic crystal fibre (PCF) to obtain a temperature tuned hexagonal array of optical waveguides and show that the nonlinear self-action of a narrow input beam can be switched from discrete self-focusing to defocusing by tuning the refractive index contrast of the structure.

Multipole Method for Modeling Linear Defects in Photonic Woodpiles

Dougal J. Kan, Ara A. Asatryan, Christopher G. Poulton, Lindsay C. Botten; University of Technology Sydney, Australia

30, Poster

We extend the multipole method to allow for rod-type defects in woodpiles composed of cylinders. A coupled resonator optical waveguide (CROW) and a linear waveguide are considered, where each waveguide is embedded in a woodpile cladding. For both structures, low-loss waveguiding is observed ($Q \approx 1\times10^4 - 3\times10^4$). Decreasing the radius of the defect rod shifts the transmission resonances to shorter wavelengths. The reflection and transmission coefficients of the woodpile are derived for the case of normal incidence in the long-wavelength limit and it is shown that both the individual layers and the entire assemblage of layers homogenise to one-dimensional dielectric slabs having permittivities as given below.

Doped Porous Polymers on Optical Fibres for Fluorescence Based Detection of Aluminium Ions

Silvia Tejedor [1], Claire E. Davis [1], Grant McAdam [1], David Cannon [1], Ben Cumming [2]; [1]DSTO, Australia; [2]Swinburne University of Technology, Australia

31, Poster

This paper reports on strategies for optimising the sensing performance of a doped porous polymer bead attached to the end of an optical fibre. The dopant is designed to fluoresce in the presence of aluminium ions which are often an indicator of the early stages of corrosion in aluminium structures. The degree of porosity of the polymer, the level of dopant concentration and the bead size and shape are investigated as variables to maximise the fluorescence response to aluminium ions in the surrounding environment.

Tuning the Thermal Stability of Type I Fibre Bragg Gratings

John Canning, M. Åslund, M. Stevenson, Kevin Cook; University of Sydney, Australia

32, Poster

Pre-annealing of type I gratings at increasing temperatures below regeneration is shown to thermally stabilise the gratings to temperatures as high as 600°C. This allows optimisation of the grating strength and the temperature stability to suit the application. It also raises questions about the fundamental assumptions made in glass annealing studies and prediction.

Towards Microstructured-Fibre-Based Optical Parametric Oscillators for Ultra-Short-Pulse Sources in the Near-Infrared

Wen Qi Zhang [1], Jay E. Sharping [2], Richard T. White [1], Tanya M. Monro [1], Shahraam Afshar V. [1]; [1]University of Adelaide, Australia; [2]University of California at Merced, USA

33, Poster

We have designed a fibre optical parametric oscillator for efficient generation of high-peak-power ultra-short pulses in the near-infrared. A generic algorithm is used to optimise the design parameters of a tellurite microstructured optical fibre for efficient four-wave mixing. Using the optimised fibre, we predict the generation of signal pulses with 300 fs duration (FWHM) and peak power of 1.6 kW at 880 nm using pump pulses of 500 fs and peak power of 5 kW at 1560 nm.

Grating Writing with 355nm Wavelength in Polymer Optical Fibre Doped with Benzildimethylketal

Yanhua Luo [1], Huiyong Liu [1], Qijin Zhang [2], Gang-Ding Peng [1]; [1]University of New South Wales, Australia; [2]USTC, China

34, Poster

We report writing polymer optical fibre(POF) grating in photosensitive POF doped with benzildimethylketal using a 355nm laser for the first time. The photosensitive POF was made using Teflon technique, with the diameter of 290.6μm and the core diameter of 21.0μm. The gratings were written using the modified Sagnac system with a 355nm pulsed laser. The formation of FBGs was monitored in real by detecting their reflection. And due to the multimode POF used, there are four modes reflected but the reflection efficiency is not that high.

Raman Amplifier Stability

Peter M. Dower, Peter M. Farrell; University of Melbourne, Australia

35, Poster

This paper presents the main steps of a formal proof of stability for a class of Raman amplifier partial differential equation (PDE) models that find common application in the literature. The proof utilizes dissipative system theory as generalized to the infinite dimensional phase space dynamics that attends such models. The result establishes rigorously the positive invariance and stability of dynamics exhibited by these models.

Structural Relaxation and Ageing Phenomena in Silica Optical Fibres

Irina Severin [1], M. Caramihai [1], K. Chung [2], G. Tasca [1], T. Park [2], D. Yoo [2]; [1]POLITEHNICA University of Bucharest, Romania; [2]Seoul National University, Korea

36, Poster

The current study has investigated the ageing phenomena of silica optical fibres in relation to water activity which might be accelerated when exposed to a supplementary energy, such as microwaves. A controlled stress by winding fibres onto accurate diameter mandrel was applied. Taking into account that normally a decrease in fibre strength is induced in time by chemical action of water, the effects of cumulative reagents (water, applied stress, supplementary energy — microwave) in some cases acted in the opposite manner. The microwave effect as a structural relaxation catalyst appears unexpected, even if the overall gain in fiber strength is not high, but the stress corrosion factor revealed significant increase in certain simulation conditions.

Optical Phase Locking for 100Gb/s DQPSK Remodulation for Up-Stream Transmission in Passive Optical Access Networks

Le Nguyen Binh [1], Nhut Khai Hoan Tran [2]; [1]Monash University, Australia; [2]Can Tho University, Vietnam

37, Poster

This paper demonstrates a technique for upstream modulation of lightwave carrier embedded in the downstream modulated optical channels. Optical phase locking is employed to extract and lock the local oscillator to exact the frequency of the down steam channel. Advanced modulation format DQPSK is targeted for 100 Gb/s in both down- and up-stream transmission in passive optical networks.

Inscription of Bragg Gratings in Chalcogenide Optical Fibre Using 532nm Radiation

Kevin Cook [1], Nicolas Ducros [2], Sébastien Février [2], John Canning [1], Ajoy K. Kar [3]; [1]University of Sydney, Australia; [2]XLIM, France; [3]Heriot-Watt University, UK

38, Poster

The inscription of Bragg gratings in As_2S_2 optical fibre using a simple Lloyd's interferometer with the 532nm output from a frequency-doubled Nd:YAG laser is demonstrated. Grating strengths of >5dB are produced.

Laser Diode Stability

Peter M. Farrell, Peter M. Dower, Kerry Hinton; University of Melbourne, Australia

39, Poster

Standard models of laser diodes have been shown to be stable over a wide range of operating conditions.

Fabrication Process Development and Characterisation of Compact Chalcogenide Planar Waveguides Having Low Loss

Duk-Yong Choi, Steve Madden, Douglas A.P. Bulla, Barry Luther-Davies; Australian National University, Australia

40, Poster

We present the fabrication process development and the characterisation of sub-micron thick As_2S_3 waveguides. Thin PMMA and BARC were employed as protective layers prior to photo-resist patterning in order to prevent the attack of alkaline developer. The propagation losses of ~0.2 and 0.6 dB/cm were measured from 4 micron and 2 micron wide waveguides in 0.85 micron thick film. Slight higher loss in TM mode may be resulted from the etched, rough sidewalls. Compactness and low attenuation of the waveguides strongly support their application in planar integrated nonlinear optical devices.

Chirped Fibre Grating with Nonlinear Effective Index Modulation

Binbin Yan [1], Gang-Ding Peng [2], Chongxiu Yu [1], Daxiong Xu [1], Mo Li [2], Yanhua Luo [2]; [1]BUPT, China; [2]University of New South Wales, Australia

41, Poster

A direct and efficient nonlinear effective index modulation (NEIM) technique for shaping group delay characteristics of chirped fibre Bragg grating (CFBG) is presented. The characteristics of CFBG with NEIM are investigated. The NEIM technique has good flexibility to realize desirable group delay characteristics for dispersion slope compensation and other applications.

3D Mapping of Spontaneous Emission Decay Lifetime from Quantum Dots Infiltrated into Photonic Crystals

Zongsong Gan[1], Baohua Jia[1], Jiafang Li[1], Jingfeng Liu[2], Xuehua Wang[2], Min Gu[1]; [1]Swinburne University of Technology, Australia; [2]Sun Yat-Sen University, China

42, Poster

To realise three-dimensional (3D) mapping of spontaneous emission (SE) decay lifetime from quantum dots (QDs) inside photonic crystals (PCs), core/shell QDs with emission in the telecommunication region and 3D woodpile PCs with a stopgap matching the QD emission are fabricated. A system which can map the SE decay lifetime distribution three-dimensionally is built up.

A Smart Transducer Interface Module for Fibre Bragg Grating Sensors

Graham Wild, Steven Hinckley; Edith Cowan University, Australia

43, Poster

In this work we present a Smart Transducer Interface Module (STIM) for fibre Bragg grating sensors. The STIM is designed to directly detect intensity modulated signals, or convert spectrally modulated signals into intensity modulated signals. The STIM is a general purpose interface that has been designed to interface with fibre Bragg grating sensors. The STIM is made up of two optical fibre receivers, a differential amplifier and a digital signal processor. The two received signals are differentially amplified to increase sensitivity and the signal-to-noise ratio. The STIM was tested using an optical fibre Bragg grating strain sensor.

Feasibility Investigation of Innovative Photonic Crystal Fiber Sensors for Medical Application

Tommaso Palmisano, Luca A. Allegretti, Marco De Sario, Luciano Mescia, Francesco Prudenzano; Politecnico di Bari, Italy

44, Poster

The feasibility investigation of methadone detectors, based on novel photonic crystal fibers (PCFs) having a polymeric cladding, operating as sensitive layer, is performed. The sensor characteristics have been simulated by varying the optical and geometrical parameters by means of a Finite Element Method (FEM) numerical code. The obtained results suggest that a suitable fiber cross section design can enhance the evanescent field interaction with the methadone, permeated into the polymeric layer from the aqueous/biological solution, thus increasing the sensor sensitivity.

Fabrication of Phase-Shifted Fibre Bragg Gratings with Non-Uniform Etching

Zourab Brodzeli[1], Harpreet K. Bal[1], Fotios Sidiroglou[1], Nicoleta Dragomir[1], François Ladouceur[2]; [1]Victoria University, Australia; [2]University of New South Wales, Australia

46, Poster

A novel method for producing phase-shifted FBGs is proposed and demonstrated in this paper. It is based on the non-uniform etching of a fibre Bragg grating (FBG) containing optical waveguide.

High-Resolution Optical Sampling in Dispersion-Shifted Highly Nonlinear Chalcogenide Waveguides

Feng Luan[1], Jürgen Van Erps[1], Mark D. Pelusi[1], Tim Iredale[1], Steve Madden[2], Duk-Yong Choi[2], Douglas A.P. Bulla[2], Barry Luther-Davies[2], Hugo Thienpont[3], Benjamin J. Eggleton[1]; [1]University of Sydney, Australia; [2]Australian National University, Australia; [3]Vrije Universiteit Brussel, Belgium

47, Poster

We demonstrate a photonic-chip-based optical sampling system with temporal resolution <500-fs, making use of a 7-cm short chalcogenide planar waveguide. Its high nonlinearity and dispersion-shifted design enables broadband operation without compromising the achieved resolution.

Analysis and Experiment of Gradient-Index Fibre Collimators for Fibre Sensing

Mo Li[1], Jingmin Dai[2], Gang-Ding Peng[1]; [1]University of New South Wales, Australia; [2]Harbin Institute of Technology, China

48, Poster

The coupling characteristics of gradient-index fibre collimators are analysed for fibre sensing based on Gaussian field approximation and ray transformation theory. Relations between the coupling loss and the misalignments are obtained. It is predicted that the all-fibre gradient-index fibre collimators could reduce nearly 10 dB with additional tolerance to alignment, in comparison with the systems without it. Experimental tests are carried out with a 1550 nm laser source and the results agree well with the prediction.

ACOLS Posters

Union Building Eclipse/Equinox, 17:20, Wednesday

Direct Femtosecond Laser Written Waveguides in Bulk Ti^{3+}:Sapphire

Simon Gross, Michael J. Withford, Alexander Fuerbach; Macquarie University, Australia

50, Poster

We report on direct inscription of waveguides in titanium-doped sapphire with an ultrafast oscillator. The fabricated waveguides are formed in-between two damage regions, a technique which has been applied to other crystalline materials but not in Ti^{3+}:Sapphire, yet. The damage regions' sizes show a significant dependency on the writing polarization. Furthermore a strong birefringence was observed in the written structures. Two waveguides that support orthogonal polarized modes are formed between each pair of damage lines. The propagation properties are characterized in terms of their near field profiles and insertion loss with respect to the writing parameters.

Thermal Poling Studies of Phosphorous-Doped Silicon Dioxide Planar Waveguides

Huai-Yi Chen, Hung-Yi Lin; Huafan University, Taiwan

51, Poster

Phosphorous (P)-doped silicon dioxide (SiO_2) nonlinear planar waveguides on fused silica substrate were fabricated using plasma-enhanced chemical vapor deposition (PECVD) and thermal poling technique. All second-harmonic (SH) signals of poled P-doped SiO_2 planar waveguides are found stronger than those of bare fused silica for various poling conditions. The P-doped SiO_2 planar waveguides display lower/shorter threshold value of poling temperature/duration than bare fused silica.

Alkyl Chain Control of the Formation of Self-Assembled Monolayers, Iridescent Microrods and Crystals of Alkylporphyrins of Potential Use in Photonics

John Canning, Tony Khoury, Paul Jensen, George Huyang, Tze Jing Sum, Yiing Chin, Jeffrey R. Reimers, Maxwell J. Crossley; University of Sydney, Australia

52, Poster

5,10,15,20-Tetralkylporphyrins are a novel class of such compounds that are essentially planar structures with long alkyl chains that can be used to orient the molecules on surfaces, in micro rods grown on surfaces and in crystals, potentially making them useful for self-assembled photonic applications. Self-assembled monolayers of tetraalkylporphyrins formed on HOPG are shown by scanning tunnelling microscopy (STM) to form ordered close-packed planar arrays. The alkyl chains still control the self-assembly despite when one alkyl chain is replaced by a polar, essentially planar, nitro group as revealed by X-ray diffraction studies of 5-nitro-

10,15,20-triheptylporphyrin [$(C_7H_{15})_3$-NO_2P] prepared from direct precipitation from dichloromethane (CH_2Cl_2). We conclude that the observed structure also likely forms the backbone in iridescent micro-rods of $(C_7H_{15})_3$-NO_2P and the micro-wires formed by related nitro-trialkylporphyrins.

Highly Ordered, Free-Standing Silver Nano-Wire Arrays: Fabrication and Optical Properties

Jing-Hua Fang, Ling Lin, Ann Roberts, Paul Spizzirri, Steven Prawer; University of Melbourne, Australia

53, Poster

We report the fabrication of large area, free-standing silver nano-wire arrays fabricated using nano-porous alumina templates. Aqueous silver ions are initially diffused throughout the template channels followed by a chemical reduction into silver nano-particles; they then form silver nano-wires in a subsequent thermal annealing step. Nano-wires produced by this method are highly ordered with high aspect ratios making them potential candidates for optical metamaterials. Preliminary measurements of the optical properties of these nano-structures are presented.

Thermal Lens Study of CW Self-Raman Laser in Nd:$GdVO_4$ Pumped by 880nm Laser-Diode

J. Lin, H.M. Pask, A.J. Lee, David J. Spence; Macquarie University, Australia

54, Poster

We have investigated the factors affecting beam quality of a continuous-wave self-Raman/frequency-doubled laser in Nd:$GdVO_4$ based on 880nm laser-diode pumping. The thermal lens of the Nd:$GdVO_4$ crystal was measured as a function of diode pumping spots size, in both high-Q and low-Q cavities, and the results used to design intracavity Raman laser resonators for high beam quality output at 1173nm (first Stokes) and at 586.5nm (intracavity frequency-doubled first Stokes. A maximum output power was 1.25 W at 1173 nm and 800 mW at 586.5 nm. The M^2 at 1173nm is M_x^2=1.09, M_y^2=1.27, and at 586.5 nm is M_x^2=1.70, M_y^2=1.55. A Findlay-Clay analysis has also been employed to measure the overall losses of both self-Raman and frequency-doubled cavities.

A Dual Stabilized Master Laser System for DIAL

Alex Dinovitser, Murray W. Hamilton, Robert Vincent; University of Adelaide, Australia

55, Poster

Profiling atmospheric constituents with Differential Absorption LIDAR (DIAL) is a promising method for atmospheric research. Profiling atmospheric water vapor with DIAL for weather forecasting offers very high sensitivity with potentially high accuracy and resolution. However, DIAL requires very good wavelength stability at an absorption line, stabilization at another closely-spaced wavelength, and good spectral purity. In this paper we describe a novel low-cost system using two stabilized continuous-wave master lasers diodes and a single laser amplifier. The system wavelength control, timing, laser amplification and spectral purity considerations are discussed.

Instabilities and Chaos in Optically Injected Semiconductor Lasers

Furat A.M. Al-Saymari, Imad Al-Deen H.A. Al-Saidi; University of Basrah, Iraq

56, Poster

We study the stability of the optically injected semiconductor laser using the single-mode rate equations. Bifurcation sequences leading to chaos obtained through variation the laser control parameters, such as, the laser frequency detuning and the gain saturation, over a wide range of laser operating conditions. We find that variation of the ratio of the carrier and photon lifetimes can induce dramatic changes in the features of the observed instabilities and may bifurcate into a regime of sustained stable oscillations of period-one with a single limit-cycle attractor.

A Pulse Stacked and Gain-Switched Holmium-Doped Fibre Laser Operating at a High Repetition Rate

Ka Wu [1], Shayne Bennetts [2], David G. Lancaster [2], Jesper Munch [1], David Ottaway [1], Stuart Jackson [3]; [1]University of Adelaide, Australia; [2]DSTO, Australia; [3]University of Sydney, Australia

57, Poster

We demonstrate the first short pulse gain-switched Ho-doped fibre laser pumped by a gain-switched 1.9 μm Tm-doped fibre laser. Up to 21 W of peak power with a pulse width of 150 ns was obtained at a repetition rate of 80 kHz. An investigation of pulse stacking to reduce the pulse width and increase peak power resulted in shorter output pulses of 70ns, and an increased peak power of 43 W.

A High Power Composite Zigzag Slab Laser for Gravitational Wave Interferometry

David J. Hosken, Damien Mudge, Peter J. Veitch, Jesper Munch; University of Adelaide, Australia

58, Poster

We describe an end-pumped, side-cooled, double-clad cw Nd:YAG slab laser that is suitable for high output power applications. The five layer composite slab structure and end pumping minimises the effects of thermally induced birefringence while allowing optimisation of the pump geometry, gain distribution and thermal lens behaviour. This slab architecture will be used to produce a deployable, single frequency, >50 W diffraction-limited output, injection-locked laser for use at the Australian Consortium for Interferometric Gravitational Astronomy test facility in Western Australian. The latest power scaling results and beam quality measurements using an improved slab mounting technique will be reported.

Power Scaling of Cryogenically Cooled High Power Solid State Laser

Miftar Ganija, David Ottaway, David J. Hosken, Peter J. Veitch, Jesper Munch; University of Adelaide, Australia

59, Poster

Power scaling in solid-state lasers is limited by thermally induced distortion and birefringence. It is well known that the thermal characteristics of YAG improve significantly at cryogenic temperatures, but these advantages have not been exploited in robust, power scalable designs. We report on the design and preliminary results of a high power Yb:YAG slab system operation at cryogenic temperatures.

Increasing the Sensitivity of Plasmonic Sensors by Means of Nanofluidics

Martin L. Kurth [1], Dmitri K. Gramotnev [2]; [1]Queensland University of Technology, Australia; [2]Nanophotonics Pty. Ltd., Australia

61, Poster

This research evaluates the use of nanofluidics as a mechanism for the delivery of residual vapour molecules to a nanoscale aperture, for their subsequent optical detection. The finite element analysis is used to calculate and optimise the flow rate of air through the apertures of different diameters with “partial slip” boundary conditions. The rate of molecule delivery to the field hot spots in the apertures by means of nanofluidics is then evaluated and used for the determination of the enhanced detection sensitivity by optical means.

New Nano-Focusing Structure

Shiaw Juen Tan [1], Dmitri K. Gramotnev [2]; [1]Queensland University of Technology, Australia; [2]Nanophotonics Pty. Ltd., Australia

62, Poster

In this paper, we investigate a new nano-focusing structure that consists of a tapered dielectric layer on a metal surface (with the permittivity of the dielectric greater than the magnitude of the metal permittivity). It is demonstrated that when a surface plasmon propagates in the direction of increasing thickness of

the dielectric layer, not only its localisation and local field are increased, but it also experiences back-reflection from a caustic, while continuing to experience nano-focusing. This is shown to occur due to efficient transformation of plasmonic modes at the caustic.

Localised Plasmons Beyond the Electrostatic Limit

Mark Turner, Min Gu; Swinburne University of Technology, Australia

63, Poster

Localised plamon resonances (LPRs) within metallic nanoparticles are well understood in the electrostatic limit. However, in the non-electrostatic limit Coulomb interactions become significantly retarded causing red-shifts in plasmon resonances. Here we theoretically investigate retardation effects on LPRs by extending previous theoretical models based on Lagrangian formalism. We observe red-shifting of plasmon oscillation frequencies in the regime where retardation is significant and compare analytical results to other techniques such as Mie scattering and numerical simulations.

Surface Plasmon Resonance Manipulation of Microparticles in a Microfluidic Device

Stephen Weber, Daniel Day, Min Gu; Swinburne University of Technology, Australia

64, Poster

Surface plasmon resonance induced optical effects are utilised inside a microfluidic device for the manipulation of microparticles.

Coupling Between Cylindrical Surface Plasmon Polariton in Metal Nanowires

Wei Liu [1], Dragomir N. Neshev [1], Boris T. Kuhlmey [2], Jing Hou [3], Yuri S. Kivshar [1]; [1]Australian National University, Australia; [2]University of Sydney, Australia; [3]National University of Defense Technology, China

65, Poster

We study numerically the coupling between two metallic nanowires of equal and different radii. We show that such plasmon coupling breaks the symmetry of the cylindrical surface plasmon polartion (SPP) modes for both even and odd modes. While in the case of equal radii of the metallic nanowires, coupling occurs only for modes of the same symmetry, when the radii are different, plasmonic coupling can exist between different higher order modes.

Effect of Oscillation Frequency Shift on Photorefractive Phase-Shift in Single Photorefractive Ring Resonators

M.K. Maurya, T.K. Yadav, R.A. Yadav; Banaras Hindu University, India

66, Poster

Amplification of the light beam due to two beam coupling in photorefractive materials has been analyzed in the strong nonlinear regime. The signal beam can be amplified in the presence of material absorption, provided the gain due to the beam coupling is large enough to overcome the cavity losses. Such amplification is responsible for the oscillations. The gain bandwidth is only a few Hz. In spite of such an extremely narrow bandwidth, unidirectional oscillation can be observed easily at any cavity length in ring resonators by using photorefractive crystals as the medium and this can be explained in terms of the photorefractive phase-shift.

Transport and Stability of Two-Dimensional Matter-Wave Solitons in a Driven Optical Lattice

Jasur A. Abdullaev [1], Dario Poletti [2], Elena A. Ostrovskaya [1], Yuri S. Kivshar [1]; [1]Australian National University, Australia; [2]National University of Singapore, Singapore

67, Poster

We study the transport of quasi-two-dimensional matter-wave solitons in a Bose-Einstein condensate with attractive atomic interactions in a two-dimensional driven optical lattice potential. In order to describe the dynamics of 2D matter-wave soliton analytically we use the effective Hamiltonian theory. We also present numerical studies of the soliton evolution in the system.

The BCS-BEC Crossover and the Single Impurity Anderson Model

S.F. Caballero Benítez [1], Joel Corney [2], M. Gulácsí [3]; [1]Australian National University, Australia; [2]University of Queensland, Australia; [3]MPI-PKS, Germany

68, Poster

In this paper we relate the BCS-BEC crossover problem with the single impurity Anderson model. We establish the equivalence of the models in certain parameter regime and consider the physical parameters for the ultracold ^{6}Li to determine the equivalent magnetic regime of the impurity problem. We propose that the unitary limit can be studied in terms of the single impurity Anderson model in the valence fluctuation regime.

Getting the Most Out of Your Atom Laser: What is the Best Way to Squeeze an Atom Laser for Precision Measurement?

S.A. Haine [1], Mattias Johnsson [2]; [1]University of Queensland, Australia; [2]Australian National University, Australia

69, Poster

We examine various schemes for creating a squeezed atom laser, and compare the amount of squeezing which can be obtained for realistic experimental parameters. The technical challenges of each scheme are discussed. Finally, we investigate the ability of each scheme to increase the sensitivity of a measurement made with an atom interferometer.

Matter-Wave Soliton Tunneling in Driven Potentials

Kimberley Heenan [1], Mario Salerno [2], Tristram J. Alexander [1], Elena A. Ostrovskaya [1]; [1]Australian National University, Australia; [2]Università di Salerno, Italy

70, Poster

We study the dynamics of a Bose-Einstein condensate, with an attractive interatomic interaction, trapped in an anharmonic cubic and double-well potential, in the presence of weak periodic driving. We investigate, numerically and analytically, the dependence the tunneling behaviour of a bright soliton on the frequency of the driving. Regions of trapping and transport are observed for different driving frequencies.

Correlation Measurements in a Bose-Einstein Condensate of Metastable Helium

Sean S. Hodgman, Andrew G. Manning, Robert G. Dall, Mattias Johnsson, Andrew G. Truscott; Australian National University, Australia

71, Poster

We report on recent changes to our metastable helium Bose-Einstein condensate experiment, with the installation of a new microchannel plate and delay-line detector providing the opportunity to measure single atoms with high temporal and spatial resolution. This will allow us to observe quantum correlation effects such as the Hanbury Brown-Twiss effect with massive particles. We present measurements characterising the new detection system and preliminary results for a correlation function describing the quantum statistics of the atoms.

Efficient Stochastic Simulations Using a Novel Number-Phase Wigner Representation and Non-Classical Probability Distribution Sampling Technique

M.R. Hush, André R.R. Carvalho, Joseph J. Hope; Australian National University, Australia

72, Poster

Coherent state based phase space representations (P, Q, Wigner)

have been successful in the creation of C-number equations for the efficient stochastic simulation of high dimensional quantum systems. However many problems using these techniques remain intractable over long integrations times. We present a new Number-Phase Wigner representation that can be unraveled into stochastic equations, these converge to the correct solution for an anharmonic oscillator with small dampening for significantly longer than other phase space representations. Sampling of a non-classical probability distribution was required, we show this can be achieved using stochastic weights. This novel method is applicable outside the simulations performed in this paper.

Asymmetric Steering: When Alice and Bob Disagree

Sarah L.W. Midgley, Andy Ferris, Murray K. Olsen; University of Queensland, Australia

73, Poster

Asymmetric steering is an effect whereby an inseparable bipartite system can be found to be either described by quantum mechanics or local hidden variable theories depending on which one of the famous Alice or Bob makes the required measurements. We show that, even with an inseparable bipartite system, situations can arise where measurements on one half are not sufficient to answer the fundamental question of which theory gives an adequate description, but that the whole system must be considered. This is possible because of an asymmetry in the definition of the original Einstein-Podolsky-Rosen paradox and we demonstrate this theoretically using the intracavity nonlinear coupler.

Vortex Decay in High Temperature Bose-Einstein Condensates

Samuel Rooney, Ashton S. Bradley, P. Blair Blakie; University of Otago, New Zealand

74, Poster

We use the Stochastic Projected Gross-Pitaevskii (SPGPE) theory to determine the lifetime of a quantized vortex in a Bose-Einstein condensate held in an oblate trap. We devise a simple scheme to estimate input parameters of the theory, allowing a system of fixed atom number to be investigated over a range of temperatures both above and below the phase transition. We use this approach to determine the lifetime of a vortex over a range of temperatures, and investigate the role of fluctuations in setting the timescales involved.

Metastable Helium on an Atom Chip

RuGway Wu [1], Brenton Hall [2], Robert Evans [1], Robert G. Dall [1], Andrew G. Truscott [1]; [1] Australian National University, Australia; [2] Swinburne University of Technology, Australia

75, Poster

In our work with the atom chip, metastable helium will for the first time be trapped in a magnetic trap formed by electric currents on an atom chip. Further, in this trap we will produce a Bose-Einstein condensate. The unique features of helium and an atom chip offer a rich variety of exciting experiments that can be done, including surface probing using Auger electrons, quantum feedback control, real time, high bandwidth density probe for the atom cloud, with a resolution limit of 50 nm.

Magnetic Lattices for Ultracold Atoms and Quantum Degenerate Gases

M. Singh, S. Jose, Andrei Sidorov, Russell McLean, Peter Hannaford; Swinburne University of Technology, Australia

76, Poster

We describe the trapping of ultracold rubidium atoms in a 1D magnetic lattice constructed from TbGdFeCo magnetic film on a 10 μm-period grooved structure on an atom chip. Progress towards the trapping of arrays of Bose-Einstein condensates in the individual sites of the magnetic lattice is reported. Extension to the case of a 2D magnetic lattice and possible applications as a large-scale storage register for quantum information processing are discussed.

Entanglement Generated by Jump Based Feedback with Raman Transitions

R.N. Stevenson, André R.R. Carvalho, Joseph J. Hope; Australian National University, Australia

77, Poster

We follow on from work in Ref. [1] and investigate a feedback scheme to generate entanglement in systems with a vacuum stimulated Raman transition. These systems have excited states with long spontaneous emission lifetimes, allowing entanglement to be maintained after feedback is turned off for longer than an equivalent two level system. We take experimental data from Ref. [3] to analyse the effect of experimental imperfections, in particular the effect of ion delocalisation within the cavity standing wave on the final entanglement.

Optical Characterization of a Phase Fresnel Lens for Trapped Ion Quantum Computing

Benjamin Norton, Erik W. Streed, Justin J. Chapman, D. Kielpinski; Griffith University, Australia

78, Poster

To efficiently collect light from ions in a trapped ion quantum computer, a lens with a high numerical aperture is advantageous. Using phase Fresnel lenses with large working distances and high numerical apertures, we can couple a large fraction of the fluorescence from an ion into a single optical propagation mode (TEM00). We have optically profiled a phase Fresnel lens with a numerical aperture of 0.64 and a focal length of 3 mm. A 350±15 nm beam waist and a beam quality M^2 of 1.08±0.05 was measured, near the diffraction limit.

Time-Averaged Optical Potentials for Bose-Einstein Condensates

E.D. van Ooijen, S.K. Schnelle, K.J. Weegink, Leif Humbert, Matthew J. Davis, Norman R. Heckenberg, Halina Rubinsztein-Dunlop; University of Queensland, Australia

79, Poster

Since the first experimental realization of a Bose-Einstein condensate (BEC), many of its properties have been thoroughly investigated. Specifically tailored potentials are helpful tools when investigating properties of ultra-cold gases. Here we demonstrate the loading of ultra-cold atoms into two-dimensional, time-averaged optical potentials. The time-averaging scheme allows us to make arbitrary, two dimensional trapping potentials, where the potential shape and depth can be dynamically controlled.

Single-Plane Phase Imaging of Cold Atoms

Andrew McCulloch, David Sheludko, Harry Morris Quiney, Robert Scholten; University of Melbourne, Australia

81, Poster

We demonstrate a new technique for imaging cold atom clouds based on phase retrieval from a single diffraction measurement. Single-shot diffractive imaging methods for cold atoms have previously assumed a monomorphic object. The method presented here allows quantitative imaging of an inhomogeneous cloud. Using ideas borrowed from density functional theory, we calculate the approximate paraxial diffracted intensity derivative from the measured diffracted intensity distribution and use it to solve the transport of intensity equation for the phase of the wave at the detector plane. Back-propagation to the object plane yields the object exit surface wave and then provides a quantitative measurement of the atomic column density.

Non-Linear Faraday Rotation in an Optical Dipole Trap

Leszek Krzemien, Krzysztof Brzozowski, Jerzy Zachorowski, Wojciech Gawlik; Jagiellonian University in Krakow, Poland

82, Poster

Non linear Faraday rotation can be used to make precise measure-

ments of magnetic field [1]. Here we report the observation of non-linear Faraday rotation in an optical dipole trap which we hope can be utilised to build a precision magnetometer with high spatial resolution. Continuous wave as well as amplitude modulated optical rotation [2] signals were obtained in a sample of rubidium atoms cooled to about 40 μK. Measurements were conducted in a volume determined by the overlapping region of the CO_2 dipole trap and probe beams, which was as small as 0.007mm^3.

Two-Level Atoms Macroscopic Quantum Trapping in an Optical Cavity

S.C. Lei [1], M.K. Soi [2], C.H. Lee [1], R.K. Lee [3], Yuri S. Kivshar [1]; [1]Australian National University, Australia; [2]Macao Labour Affairs Bureau, China; [3]National Tsing-Hua University, Taiwan

83, Poster

We consider a gaseous Bose-Einstein condensate of bosonic atoms which populate two hyperfine levels coupled by a cavity mode. The system can be well described by a Dicke model in addition to an atom-atom nonlinear quadratic interaction which arises from the mean-field inter-atomic interaction within a single-mode approximation. The equations of motion can be obtained for applying the mean-field treatment to the full quantum Hamiltonian of the system. System variables are related via the conservation law. Three stationary states existing in both Rabi and Josephson regimes are found. The necessary condition from Rabi enters to Josephson regime is the average atomic interaction energy larger than the photon-atom coupling energy in this system. The characters of stationary states depend both on the nonlinearity interactions strength and the excitation number. In the limit of large excitation number, the mean-field results are consistent with the ones for classical Bose-Josephson Junctions.

DS2009 Posters

Union Building Eclipse/Equinox, 17:20, Wednesday

Transformations of Continuously Self-Focusing Dissipative Solitons

C. Mejía-Cortés [1], J.M. Soto-Crespo [1], N. Akhmediev [2], N. Devine [2]; [1]CSIC, Spain; [2]Australian National University, Australia

85, Poster

Self-focusing dissipative media admit the existence of localized beams and them are stable inside of a certain region of its existence. Beyond these region, beams loose their stability, and new dynamical behaviors appear. We present several types of instabilities and give examples of beam dynamics in the area adjacent to the region. We observed that the beams loose the radial symmetry.

Light Bullets in Nonlinear Curved Waveguide Arrays

Michal Matuszewski, Ivan L. Garanovich, Andrey A. Sukhorukov; Australian National University, Australia

86, Poster

We predict that stable spatio-temporal solitons can exist in arrays of periodically curved optical waveguides. We combine approximate variational methods and direct numerical simulations to describe two-dimensional light bullets in one-dimensional arrays with harmonic in-plane bending profile, and three-dimensional bullets in square lattices with helical bending profile. We show that light bullets can freely move across the arrays with optimized bending, and this mobility property is a distinguishing characteristic compared to previously considered discrete light bullets which were trapped to a specific lattice location. These results suggest new possibilities for flexible spatio-temporal manipulation of optical pulses.

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