

Advance Program

Nonlinear Fiber Optics

Monday, 19 July 2010

ALL SESSIONS TO BE HELD IN RIVIERA 1

09.00 - 10.00

Session MC1: NONLINEAR PROCESSING I

Session Chair: Masayuki Matsumoto, *Osaka University, Suita, Osaka, Japan*

MC1.1 09.00 - 09.30 (Invited)

Optics versus Electronics for High-Speed Switching and Signal Processing, R. S. Tucker, *University of Melbourne, Melbourne, Australia*

We compare the relative merits of nonlinear optics and electronics for high-speed switching and signal processing, with a focus on three key practical considerations: energy consumption, device footprint, and data throughput.

MC1.2 09.30 - 10.00 (Invited)

All-Optical Regeneration: The Holy Grail or Cold Fusion?, G. Raybon, *Alcatel-Lucent, Holmdel, NJ, USA*

All-optical regeneration, once believed to be the Holy Grail of optical communications for extending reach and mitigating transmission impairments, is now being challenged by the progress in electronic processing and advanced modulation techniques.

10.00 – 10.30

COFFEE BREAK

10.30 - 12.00

Session MC2: FIBERS

Session Chair: Masaaki Hirano, *Sumitomo Electric Industries Ltd., Yokohama, Japan*

MC2.1 10.30 - 11.00 (Invited)

Photonic Bandgap Fibres for Nonlinear Optics, S. Fevrier, D. D. Gaponov, N. Ducros, B. Beaudou, R. Jamier, P. Roy, M. Hanna, *University of Limoges, Limoges, France*, D. N. Papadopoulos, F. Druon, L. Daniault, *Institut d'Optique, Orsay, France*, P. Georges, *Institut d'Optique, Palaiseau, France*, M. E. Likhachev, M. Salganskii and M. Yashkov, *Russian Academy of Sciences, Moscow, Russia*

Nonlinear chirped pulse amplification at high average power and supercontinuum generation are demonstrated in bandgap fibres. A hollow-core fibre is proposed as a host for nonlinear frequency conversion in gas.

MC2.2 11.00 - 11.30 (Invited)

Recent Advances in Very Highly Nonlinear Chalcogenide Photonic Crystal Fibers and Their Applications, D. Mechin, L. Brilland, *PERFOS, Lannion, France*, J. Troles, Q. Coulombier, P. Houizot, *Universite Europeenne de Bretagne, Rennes, France*, A. Monteville, *PERFOS, Lannion, France*, T. N. Nguyen, D. M. Nguyen, S. D. Le, M. Thual, T. Chartier, *Universite Europeenne de Bretagne, Lannion, France* and J.-L. Adam, *Universite Europeenne de Bretagne, Rennes, France*

Using a new method based on casting glass to fabricate chalcogenide preforms, we have manufactured a single mode AsSe Chalcogenide Photonic Crystal Fibers exhibiting a record high nonlinear coefficient γ greater than $30000 \text{ W}^{-1}\text{km}^{-1}$.

MC2.3 11.30 - 12.00 (Invited)

Chirped Photonic Crystal Fibers Break Pulse-Duration Limits in Femtosecond Beam Delivery, G. Steinmeyer, *Max Born Institute, Berlin, Germany*

We demonstrate a novel photonic-crystal fiber architecture that breaks with the paradigm of lattice homogeneity and enables a new degree of freedom in photonic-crystal-fiber design. We experimentally demonstrate guiding of <20 fs pulses over meter distance.

12.00 – 13.30

LUNCH BREAK

13.30 - 15.00**Session MC3: TELECOMMUNICATIONS I****Session Chair:** Robert M. Jopson, *Alcatel-Lucent, Holmdel, NJ, USA***MC3.1 13.30 - 14.00 (Invited)****Ultrafast Optical Technologies for Large-Capacity TDM/WDM Photonic Networks**, T. Morioka, *NTT Corporation, Kanagawa, Japan*

Research efforts of developing new generation optical communication technologies for the next few decades and beyond are described which enable well over Peta bit/s per fiber link capacity and Exa-class network throughput.

MC3.2 14.00 - 14.15**Fiber Optical Parametric Amplifier in High-Speed WDM Networks**, N. El Dahdah, D. S. Govan, M. Jamshidifar, N. J. Doran and M. E. Marhic, *Swansea University, Swansea, Wales, UK*

We report high-capacity (> 1 Tb/s) amplification by a fiber optical parametric amplifier in different roles displaying compatibility and versatility in future WDM networks with phase-shift keying modulation format.

MC3.3 14.15 - 14.30**Optically Powered WDM Signal Transmission System with Distributed Parametric Amplification**, X. Xu, C. Zhang, S. Yang, T. I. Yuk and K. K.-Y. Y. Wong, *University of Hong Kong, Hong Kong*

We report an optically-powered WDM communication system with distributed parametric amplification in dispersion-shifted fiber. The parametric pump also supplies power for the receiver. Power penalties less than 2-dB for each channel at the BER of 10^{-9} are demonstrated with 10-dB gain.

MC3.4 14.30 - 15.00 (Invited)**Impact of Cross-Phase Modulation in Coherent Transmission Systems**, M. Karlsson, *Chalmers University of Technology, Göteborg, Sweden*

We analyze analytically how four-dimensional coherent constellations are influenced by cross-phase modulation (XPM) from adjacent wavelengths. The XPM-induced rotation angle of the constellation can be used to estimate transmission penalties, accounting for both cross-phase and cross-polarization modulation simultaneously.

15.00 – 15.30**COFFEE BREAK****15.30 - 17.00****Session MC4: LIGHT SOURCES I****Session Chair:** Siddharth Ramachandran, *OFS Laboratories, Somerset, NJ, USA***MC4.1 15.30 - 16.00 (Invited)****Fiber-Based Frequency Combs and Optical Lattice Clocks**, F.-L. Hong, H. Inaba, Y. Nakajima, K. Hosaka, T. Kohno, *National Institute of Advanced Industrial Science and Technology, Tsukuba, Ibaraki, Japan*, M. Yasuda, *National Metrology Institute of Japan, Tsukuba, Ibaraki, Japan*, D. Akamatsu and A. Onae, *National Institute of Advanced Industrial Science and Technology, Tsukuba, Ibaraki, Japan*

We have been developing optical frequency combs, especially fiber-based frequency combs, for laser frequency measurement and laser frequency control. We are also working on Yb and Sr optical lattice clocks for precision frequency metrology.

MC4.2 16.00 - 16.15**Tunable U-Band Raman Fiber Source with 3 W CW Output Power**, M. E. Marhic and R. Malik, *Swansea University, Swansea, Wales, UK*

We have generated 3 W of output power from a fiber Raman amplifier, tunable over a bandwidth of nearly 30 nm around 1.65 μm . We used a fiber optical parametric oscillator for providing a large seed in the U-band.

MC4.3 16.15 - 16.30**Tunable Repetition Rate Multiplier Based on Fiber Optical Parametric Oscillator**, Y. Zhou, E. Zhou, Q. Li, S. Yang, P. C. Chui and K. K.-Y. Y. Wong, *University of Hong Kong, Hong Kong*

We demonstrate a tunable repetition rate multiplier based on fiber optical parametric oscillator. 2-6 times repetition rate multiplication of a 10-GHz pulse source is achieved with a tuning range of 20 nm in the L-band.

MC4.4 16.30 - 17.00 (Invited)**Short Pulse Generation using Nonlinear Fiber Optics for Biomedical Imaging Applications**, C. Xu, *Cornell University, Ithaca, NY, USA*

We discuss soliton-self frequency shift and soliton Cherenkov radiation generation in higher-order-mode (HOM) fibers below 1300 nm. Tunable, energetic femtosecond sources enabled by the HOM fibers are promising for biomedical imaging applications such as deep tissue multiphoton microscopy.

17.30 – 18.30

Welcome Reception

Tuesday, 20 July 2010

09.00 - 10.00

Session TuC1: PARAMETRIC AMPLIFICATION**Session Chair:** John D. Harvey, *University of Auckland, Auckland, New Zealand***TuC1.1 09.00 - 09.30 (Invited)****Noise Properties of in Phase-Sensitive Optical Parametric Amplifiers**, C. J. McKinstrie, *Alcatel-Lucent, Holmdel, NJ, USA* and Z. Tong, *Chalmers University of Technology, Gothenburg, Sweden*

One- and two-mode phase-sensitive parametric amplifiers, based on the inverse and direct modulation instability, respectively, were demonstrated recently. The quantum noise properties of these devices will be described in detail, and the consequences of these properties for phase-sensitive communication links will be discussed.

TuC1.2 09.30 - 09.45**All-Fiber Optical Parametric Amplifier at 1 μm using a Microstructured Fiber**, M. W. Lee, T. Sylvestre, M. Delqué, *University of Franche-Comte, Besançon, France*, A. Kudlinski, A. Mussot, *University of Sciences and Technologies of Lille 1, Villeneuve d'Ascq, France*, J.-F. Gleyze, A. Jolly, *Commissariat à l'Énergie Atomique, Le Barp, Aquitaine, France* and H. Maillotte, *University of Franche-Comte, Besançon, France*

We demonstrate experimentally an all-fiber optical parametric amplifier and wavelength converter at 1 μm using a microstructured fiber and an electro-optical intensity modulator. A gain of 40dB is obtained for a signal at 1053nm. The experimental gain bandwidth agrees well with the theoretical one including Raman.

TuC1.3 09.45 - 10.00**Spectral Dependence of Nonlinear Phase Noise in One-Pump Fiber-Optic Parametric Amplifiers**, S. Moro, A. Peric, N. Alic, *University of California - San Diego, La Jolla, CA, USA*, B. Stossel, *Lockheed Martin, Goodyear, AZ, USA* and S. Radic, *University of California - San Diego, La Jolla, CA, USA*

We present a comprehensive theory on the spectral dependence of nonlinear phase noise in a single-pumped fiber parametric amplifier, which is subsequently validated by stringent simulation.

10.00 – 10.30

COFFEE BREAK

10.30 - 12.00

Session TuC2: NONLINEAR PROCESSING II**Session Chair:** Shu Namiki, *National Institute of Advanced Industrial Science and Technology, Tsukuba, Ibaraki, Japan***TuC2.1 10.30 - 11.00 (Invited)****Nonlinear Processing with Bismuth Oxide Nonlinear Fibers**, J. H. Lee, *University of Seoul, Seoul, Korea*

The ultimate potential of Bismuth oxide-based nonlinear optical fibers for all-optical signal processing is reviewed.

TuC2.2 11.00 - 11.30 (Invited)**Real-time Polychromatic Parametric Processing**, A. O. Wiberg, C.-S. Bres, B. P. P. Kuo, N. Alic and S. Radic, *University of California - San Diego, La Jolla, CA, USA*

The recent demonstrations of parametric wavelength multicasting and polychromatic sampling have opened new possibilities of real-time processing of ultrafast signals. We present the latest results of processing 320 Gb/s providing access to "all-the-data-all-the-time".

TuC2.3 11.30 - 12.00 (Invited)**Nonlinear Fiber Based Processing for High Speed Optical Communication and Sensor Systems**, C. Yu, J. Yang and J. Hu, *National University of Singapore, Singapore*

We give a review of our recent research on nonlinear fiber based processing, including: multi-channel 80-GHz pulse train generation; suppression of polarization sensitivity in SBS sensor; and long distance sensing system based on Raman amplification.

12.00 – 13.30

LUNCH BREAK

13.30 - 15.00

Session TuC3: STIMULATED BRILLOUIN SCATTERING**Session Chair:** J. R. Taylor, *Imperial College London, London, UK***TuC3.1 13.30 - 14.00 (Invited)****SBS Suppression Techniques in Highly Nonlinear Fibers**, M. Takahashi, M. Tadakuma, R. Sugizaki and T. Yagi, *Furukawa Electric Co. Ltd, Ichihara, Chiba, Japan*

We summarize the state of the art SBS suppression techniques in HNLFs. Novel design for SBS suppression of HNLFs are discussed, and the impact of an efficient SBS suppression is introduced.

TuC3.2 14.00 - 14.30 (Invited)**Brillouin Suppression by Fiber Design**, P. D. Dragic, *Neolight Labs LLC, Chicago, IL, USA*

The design of Brillouin scattering suppressed optical fibers is described, including optimization of the acoustic index profile, designs for acoustic anti-guidance, and materials considerations for both design implementation and further reductions in Brillouin gain.

TuC3.3 14.30 - 15.00 (Invited)**Optical Fiber Sensors Based On Brillouin Scattering**, X. Bao and L. Chen, *University of Ottawa, Ottawa, Canada*

The Brillouin scattering in fiber can be used as point sensors or distributed sensors for measuring temperature, strain, birefringence and vibration over centimeters (Brillouin grating length) or over 50km length with sub-meter spatial resolution.

15.00 – 15.30

COFFEE BREAK

15.30 - 17.00

Session TuC4: THEORY**Session Chair:** Michel E. Marhic, *Swansea University, Swansea, Wales, UK***TuC4.1 15.30 - 16.00 (Invited)****Emergence of Extreme Events in Fiber Based Nonlinear Devices**, B. Kibler, K. Hammani, C. Finot, A. Picozzi and G. Millot, *Université de Bourgogne, Dijon, France*

We review our experimental and theoretical results showing the emergence of rogue events during light propagation in fiber-based nonlinear systems. Distinct statistical properties are underlined through parametric and Raman amplifications, supercontinuum generation and optical turbulence.

TuC4.2 16.00 - 16.15**Robust Dissipative Soliton Molecules with Nonlinearly Evolving Phase in Mode-Locked Fiber Lasers**, A. Zaviyalov, R. Iliev, O. A. Egorov and F. Lederer, *Friedrich-Schiller University- Jena, Jena, Germany*

We numerically obtain novel two-soliton molecules with nonlinearly evolving phase in mode-locked fiber lasers. They represent robust oscillating solutions with independently evolving phase difference or flipping phase difference, alternating between zero and π .

TuC4.3 16.15 - 16.45 (Invited)**Supercontinuum Instabilities and Rogue Waves in Optics**, G. N. Genty, *Tampere University of Technology, Tampere, Finland* and J. M. Dudley, *University of Franche-Comte, Besancon, France*

We will discuss the precise nature of "optical rogue wave" statistics and examine in detail the dynamics leading to the formation of extreme events in the context of noise-driven supercontinuum generation in highly nonlinear fibers.

TuC4.4 16.45 - 17.00**Efficient pre-Compensation Algorithm for Self Phase Modulation (SPM)**, A. Awadalla, M. S. O'Sullivan, *Ciena Corporation, Ottawa, Canada* and D. O. Yevick, *University of Waterloo, Waterloo, Canada*

We present an efficient estimation algorithm for the pre-compensation of SPM in direct detection systems and test this under many link conditions. A 3dB improvement in single channel launched power is demonstrated.

Wednesday, 21 July 2010

09.00 - 10.00

Session WC1: FIBER PROPERTIES

Session Chair: David J. Richardson, *University of Southampton, Southampton, UK*

WC1.1 09.00 - 09.15

Measurement of Ultra-Low Fourth Order Dispersion Coefficient of Nonlinear Fiber by Distant Low-Power FWM, F. Gholami, J. M. Chavez Boggio, S. Moro, N. Alic and S. Radic, *University of California - San Diego, La Jolla, CA, USA*

We demonstrate accurate measurement of ultra-low fourth-order dispersion coefficient in as short as 2m-long highly nonlinear fibers using phase matched four-wave-mixing between a laser at 1260nm and a noise 'pump' at 1550nm band.

WC1.2 09.15 - 09.30

Rayleigh-Backscattering Impact on Performance of NOLM-Based Phase-Preserving Optical Limiters, G. Onishchukov, K. Sponsel, C. Stephan, T. Roethlingshoefer, *Max Planck Institute for the Science of Light, Erlangen, Germany*, B. Schmauss, *University of Erlangen-Nuremberg, Erlangen, Germany* and G. Leuchs, *Max Planck Institute for the Science of Light, Erlangen, Germany*

An additional four-fold increase of DPSK transmission distance was obtained by optimization of the regenerator design, especially of the highly nonlinear fiber used. Numerical simulations show that further improvement can be achieved by additional dispersion imbalance.

WC1.3 09.30 - 09.45

Distributed Measurement of Modulation Instability Along Optical Fibers, G. Ravet, *University of Mons-Hainaut, Mons, Hainaut, Belgium*, A. Mussot, *University of Sciences and Technologies of Lille 1, Villeneuve d'Ascq, France*, M. Wuilpart, *University of Mons-Hainaut, Mons, Belgium*, A. Kudlinski, *University of Sciences and Technologies of Lille 1, Villeneuve d'Ascq, France*, C. Caucheteur and P. Megret, *Faculté Polytechnique de Mons, Mons, Belgium*

We present an optical time domain reflectometry technique that allows characterizing the modulation instability along optical fibers. We can examine where the different frequencies are generated when high power pulses are launched in the fiber.

WC1.4 09.45 - 10.00

Observation of Brillouin Linewidth Broadening and Decay Time in Photonic Crystal Fiber, T. Sylvestre, B. Stiller, *University of Franche-Comte, Besançon, France*, J. C. Beugnot, S. Foaleng Mafang, *École Polytechnique Fédérale de Lausanne, Lausanne, Switzerland*, M. W. Lee, M. Delqué, *University of Franche-Comte, Besançon, France*, A. Kudlinski, *University of Sciences and Technologies of Lille 1, Villeneuve d'Ascq, France*, V. Laude, *University of Franche-Comte, Besançon, France*, L. Thevenaz, *École Polytechnique Fédérale de Lausanne, Lausanne, Switzerland* and H. Maillotte, *University of Franche-Comte, Besançon, France*

We present a novel distributed sensing technique that allows for the observation of Brillouin gain spectral distribution and acoustic decay time in photonic crystal fiber as well as in standard single-mode fiber.

10.00 – 10.30

COFFEE BREAK

10.30 - 12.00

Session WC2: NONLINEAR PROCESSING III

Session Chair: Stojan Radic, *University of California - San Diego, La Jolla, CA, USA*

WC2.1 10.30 - 11.00 (Invited)

Optical Signal Processing for Advanced Optical Modulation Formats, G.-W. Lu, *National Institute of Information and Communications Technology, Tokyo, Japan*

We review several FWM-based optical signal processing schemes for advanced optical modulation formats, including optical phase and intensity multiplexing for traffic grooming and optical phase erasure for extraction of a binary tributary from multi-level signals.

WC2.2 11.00 - 11.30 (Invited)

Multichannel All-Optical Regeneration, P. G. Patki, M. Vasilyev, *University of Texas at Arlington, Arlington, TX, USA* and T. Lakoba, *University of Vermont, Burlington, VT, USA*

We present our experimental results on 12x10 Gb/s all-optical 2R regeneration, enabled by the group-delay management scheme in Mamyshev regenerator, and discuss extension of this approach beyond 2R regeneration.

WC2.3 11.30 - 12.00 (Invited)

All-Optical Modulation Format Conversion Using Highly Nonlinear Fibers, A. Maruta, *Osaka University, Osaka, Japan*

We review all-optical modulation format conversion schemes from non-return-to-zero on-off-keying (NRZ-OOK) signals to return-to-zero (RZ) M-ary phase-shift-keying (PSK) or multilevel amplitude-phase-shift-keying (APSK) signal based on parametric amplification and/or cross-phase modulation in optical fibers.

12.00 – 13.30

LUNCH BREAK

13.30 - 15.00

Session WC3: TELECOMMUNICATIONS II**Session Chair:** Peter A. Andrekson, *Chalmers University of Technology, Gothenburg, Sweden***WC3.1 13.30 - 14.00 (Invited)****Nonlinear Impairments in Coherent Communication Systems**, S. Bigo, *Alcatel-Lucent, Marcoussis, France*, O. Bertran-Pardo, J. Renaudier and G. Charlet, *Alcatel-Lucent, Nozay, France*

We measure the impact of nonlinearities when upgrading a 10Gb/s system with 40Gb/s and 100Gb/s coherent QPSK channels. The results suggest that the dominant impairment is specific to polarization multiplexed coherent systems, namely cross-polarization modulation.

WC3.2 14.00 - 14.30 (Invited)**All-Optical Regeneration of Phase-Encoded Signals in Transmission Systems**, M. Matsumoto, *Osaka University, Osaka, Japan*

Recent studies on all-optical regeneration of (D)BPSK and (D)QPSK signals, especially those using fiber nonlinearities, are reviewed. Issues in using the regenerators in real systems are also discussed.

WC3.3 14.30 - 15.00 (Invited)**Nonlinear Fiber-Optic Signal Processing for Future Photonic Networks**, S. Watanabe, T. Kato and R. Okabe, *Fujitsu Laboratories Ltd., Kawasaki, Japan*

Ultra-fast all-optical signal processing using nonlinear fibers is described. Recent development of our research on optical parametrically amplified fiber switch/limiter and all optical data combination by cross-phase modulation for high speed network is introduced.

15.00 – 15.30

COFFEE BREAK

15.30 - 17.00

Session WC4: LIGHT SOURCES II**Session Chair:** Michel E. Marhic, *Swansea University, Swansea, Wales, UK***WC4.1 15.30 - 16.00 (Invited)****White Light Continuous Wave Supercontinuum Source**, A. Kudlinski, B. Barviau and A. Mussot, *University of Sciences and Technologies of Lille 1, Villeneuve d'Ascq, France*

We demonstrate white-light supercontinuum generation with a CW pump and a GeO₂-doped core microstructured fiber. We numerically show that the GeO₂-doping allows a significantly enhanced soliton self-frequency shift.

WC4.2 16.00 - 16.15**Generation of Ultra-High Repetition Rate Pulses in a Highly Nonlinear Dispersion-Tailored Compound Glass Fibre**, A. Camerlingo, F. Parmagiani, *University of Southampton, Southampton, UK*, R. Slavic, X. Feng, *Tampere University of Technology, Southampton, UK*, F. Poletti, P. Horak, W. H. Loh, P. Petropoulos and D. J. Richardson, *University of Southampton, Southampton, UK*

The generation of ultrastable optical pulses beyond 160GHz is demonstrated based on two injection-locked CW lasers through nonlinear temporal compression in a high SBS-threshold highly nonlinear dispersion tailored compound glass W-type fibre.

WC4.3 16.15 - 16.30**Fourier Domain Mode Locking Laser Based On Two-Pump Optical Parametric Amplification**, K. Y. K. Y. Cheung, *University of Hong Kong, Kowloon City, Hong Kong*

We present a Fourier domain mode locked (FDML) laser scanning from 1540 to 1570 using two-pump optical parametric amplifier (OPA) as the gain medium. The sweep rate of 39.683 kHz is achieved.

WC4.4 16.30 - 17.00 (Invited)**High Power and High Repetition Rate Fiber Frequency Combs**, I. Hartl, *IMRA America, Inc., Ann Arbor, MI, USA*

ABSTRACT NOT AVAILABLE

END OF PROGRAM