TUESDAY 25th OCTOBER

SESSION 1 – Fiber Lasers and Systems	
14:00	**Sergei Turitsyn** (Aston University) *Nonlinear dynamics in fibre lasers with semiconductor optical amplifier*
	I will discuss nonlinear dynamics of radiation in the pulsed fiber lasers using the semiconductor optical amplifier (SOA) as the gain medium.
14:25	**Regina Gumenyuk** (Tampere University) *Design guidelines for ultrashort pulse generation by a Mamyshev regenerator*
	Fiber based Mamyshev regenerators provide potentiality for a low cost, pulse-on-demand source development with pulse durations down to the hundred femtosecond scale. Based on nonlinear broadening of gain switched diode laser pulses in fiber and consequent pulse shaping methods, these sources can provide an alternative for mode-locked systems. We study numerically and experimentally the properties and limitations of such sources and build up the roadmap for the optimum design.
14:50	**Arnaud Mussot** (ULille) *All-fiber frequency agile triple-frequency comb light source*
	We experimentally demonstrate a novel approach to generate an all fiber, frequency agile tri-comb light source with a high mutual coherence, by propagating the pulses within a multicore nonlinear fiber.
15:15	**Maria Chernysheva** (Leibniz Institute of Photonic Technology) *Ultrashort pulse interaction dynamics in a free-running bidirectional mode-locked fibre laser and applications in rotation sensing*
	The fundamental study of the ultrafast phenomena in fibre laser cavities can provide a basis for further improvement of the generation performance and improve cost-metric factors, stability and versatility of laser-based tools and, therefore, resulting applications. In this context, relying on a pair of synchronised pulse trains, ultrafast metrology and dual-comb spectroscopy have not obtained their full force and effect due overall immaturity of the field of prominent bidirectional ultrafast lasers and unexplored properties of counter-propagating pulse generation. Importantly, theoretical and experimental investigations rarely focus on the bidirectional ultrafast generation and, therefore, do not provide an understanding of the nature of the nonlinear collision and interaction processes in bidirectional fibre laser cavities. In my presentation, I will

	discuss the observed pulse formation dynamics through pulse collision in bidirectional lasers and the variety of generation regimes regarding the intracavity nonlinear interaction of counter-propagating pulses. This observation indicates the different mechanisms of colliding mode-locking and synchronisation of counter-propagating channels. Finally, I will show that the real-time analysis of bidirectional pulse dynamics in the intensity and single-shot spectral domains allows high-sensitive and high-resolution measurements of slow angular rotation: down to 0.1 mrad/sec in an active laser gyroscope; and 5.8 µdeg/s in a passive Mach-Zender interferometer scheme.
15:40	**Thibaut Sylvestre** (CNRS FEMTO-ST Institute) *Recent progress in supercontinuum fiber lasers: Challenges and Perspectives*
	Supercontinuum fiber technology and its industrial applications have matured considerably these last few years. The scientific challenges faced in recent years were to overcome the current shortcomings of SC sources in terms of wavelength coverage, noise, power density, and robustness to offer a truly unique and disruptive technology for societal and industrial challenges, such as pollution and food quality monitoring, bio-imaging, molecular spectroscopy, detection and monitoring of key diseases, such as cancer and glaucoma. We review our recent work on supercontinuum generation in specialized optical fibers. Significant progress has been made in the emerging mid-UV and IR wavelength ranges for OCT applications and molecular spectroscopy, as well as in ultra-low noise coherent sources using fully normal scatter fibers. As a result, supercontinuum technology and its industrial applications have matured considerably.
	SESSION 2 – Multimode and Hollow Core Fibers
16:35	**Stefan Wabnitz** (Sapienza University of Rome) *Statistical mechanics of multimode fiber beams*
	We describe theory and experiments of multimode beam propagation and interactions in multimode graded index optical fibers. Statistical mechanics permits to describe and forecast the evolution of complex nonlinear multimode light.
17:00	**Günter Steinmeyer** (Max Born Institut) *Entropy loopholes in multimode fiber self-cleaning*
	Nonlinear optical effects have been experimentally shown to give rise to remarkable beam self-cleaning in multimode fibers. With increasing optical power, linear-optical speckle patterns eventually condense into a few low-order modes. Recently, a thermodynamic theory emerged which explains self-cleaning as a thermalization process, giving rise to a Rayleigh-Jeans distribution. While this theory correctly explains several aspects of this condensation process it fails to explain a decrease of entropy seen in several experiments. This apparent violation of the second law of thermodynamics is indicative for a previously unrecognized dissipation channel, which will be unveiled in this talk.
17:25	**Francesco Tani** (Max Planck Institute for the Science of Light) *Gas-based nonlinear optics in hollow-core fibres*
	Gas-filled fibres allow for combining nonlinear fibre optics and high-field laser science. In this talk, I will discuss the properties of hollow-core PCFs, give an overview of soliton dynamics in such a system, present a few key results and then discuss photoionization-

	induced long-lived effects and the challenges faced by light sources based on such a system.
17:50	**John Travers** (Heriot-Watt University) *Some peculiar nonlinear dynamics in gas-filled hollow-core fibres*
	A multitude of nonlinear dynamics in gas-filled hollow-core fibres have now been widely studied. In this talk, I will discuss some more peculiar results that we have observed over the last few years, which have more complex explanations. Some are difficult to explain at all. While deep ultraviolet generation through resonant dispersive-wave emission from solitons is very well explored in noble gases, here I will discuss how these dynamics become periodic, over slow timescales, when using air as the filling gas. I will also discuss a new route to supercontinuum formation through a beautiful interplay between different molecular oscillations. Finally, I will show evidence that gas can be (semi) permanently removed from the core of the fibre through the use of very intense laser pulses. In all three cases, the explanations we have developed are non-trivial and incomplete. I hope we can have some interesting discussions as a result.
18:15	**Francesca Gallazzi** (Tampere University) *Full-field real-time measurements with sub-30 fs resolution*
	In recent years the study of ultrafast dynamics, which requires real-time measurement techniques, has been really active. We present here a method to characterize in real-time the full-field of broadband complex optical pulses, such as the soliton fission induced by noise-seeded modulation instability. The measurement technique is inspired by Fourier Transform spectral interferometry, which, in this case, is combined with a phase-stable broadband reference field generated through self-phase modulation. Such a broadband reference is combined with our test field, that presents significant shot-to-shot variations, and it allows us to measure the full-field in real-time over a temporal window of 20 ps and with a resolution of 25 fs. The single-shot spectral interference between reference and test fields is recorded with high dynamic range using a real-time spectrometer and finally the full-field (intensity and phase) is reconstructed from numerical post-processing. Given the resolution below 30 fs, we are able to observe soliton-like pulses emerging from the noise-seeded fission.
	STUDENTS SESSION 1
18:40	**Dennis Kirsch** (Leibniz Institute of Photonic Technology) *Self-mode-locking in Thulium-doped fibres via nonlinear ion pairs excited-state absorption*
	Over the last decade, the ultrafast short-wave infrared (SWIR: 1600 – 2500 nm) laser market has been promisingly growing, with Thulium-doped fibre systems as key players. An advantageous low-loss atmospheric transmission, a deep biological tissue penetration, and various absorption lines of gases and biomolecules drive the demand for efficient light sources operating at this wavelength band. To unleash the potential for expanding applications, the laser system must present highly integrated, cost-effective, rugged, compact turn-key solutions. Broadband wavelength tuneability can ensure one more level of versatility for laser systems and extend areas of their applications. To implement self-mode-locking, a heavily-doped active fibre enriched

	with Tm ion clusters has been explored to reinforce its saturable absorption mechanism with 23% modulation depth. I will also discuss intriguing implications of the saturation level, gain, and glass matrix observed both experimentally and numerically. In this presentation, I will demonstrate nearly 90 nm tuneability in ultrafast Tm-doped fibre laser spanning from 1873 to 1962 nm by implementing variable feedback for efficient control of the excitation level of the active medium. The highest laser efficiency is observed with 20% feedback, generating 580-fs soliton pulses at 1877 nm central wavelength with 1.5 nJ output pulse energy. A numerical model combining the nonlinear Shroedinger and population inversion rate equations for the gain medium helps to unveil nonlinear pulse evolution under the influence of a dynamically varying gain spectrum.
18:50	**Mikko Närhi** (Tampere University) *Design on all-fiber, single-cavity dual-comb laser*
	Single-cavity dual-comb lasers provide a turn-key and cost-efficient path for dual-comb spectroscopy that can provide spectra with sub-GHz resolution in milliseconds. Compared to traditional dual-comb systems, consisting of two separate frequency combs locked to each other with complex electronic feedback, the single-cavity system provides two mutually coherent combs with no active stabilization requirements. We present an experimental and numerical study on a SESAM-based single-cavity dual-comb system in an all-all fiber configuration at 1035 nm. It is shown that gain coupling of the two combs in the cavity leads to extreme sensitivity in the cavity parameters compared to traditional single-comb mode-locked lasers.
19:00	**Mathilde Hary** (Tampere University) *Machine Learning Control of Nonlinear Fiber Supercontinuum Generation*
	The propagation of short and intense pulses of light in optical fibers exhibits a very rich landscape of nonlinear dynamics leading to dramatic changes in the pulse temporal profile and spectrum. With the development of fibers with tailored characteristics and the availability of advanced optical components, there has been in the past decade significant research efforts to harness the propagation dynamics and optimize the spectral broadening mechanisms for particular applications. Here, we combine a programmable spectral phase modulator and a genetic algorithm to optimize the nonlinear propagation dynamics to generate an on-demand target spectrum. Our approach is generic and can be adapted to a wide range of optical fibers and pump pulses.

WEDNESDAY 26th OCTOBER

SESSION 3 - Integrated Photonics	
9:00	**Alessia Pasquazi** (Loughborough University) *Self-emerging laser cavity solitons as dominant attractors of a microcomb system*
	Optical frequency comb in microresonators, or 'microcombs', are optical sources composed of a set of equally spaces frequency lines obtained in nonlinear microcavities usually by Kerr nonlinearity. The discovery of dissipative temporal cavity solitons has been a fundamental breakthrough and allowed to achieve a broad, smooth spectrum particularly suitable for metrological comb applications. More recently, we demonstrated that it is possible to generate localized pulses in a configuration where the micro-cavity is inserted in a fiber laser loop. We reported the observation of laser cavity-solitons [1], which have previously attracted large attention, especially in spatial configurations. By merging their properties with the physics of both micro-resonators and multi-mode systems, this scheme represents a fundamentally new paradigm for the generation, stabilization, and control of solitary optical pulses in micro-cavities. In this framework, it is important to discuss the main physical features of these types of waves, including the energy efficiency and their dynamical properties, which are key for the initiation and recovery of the system. Moreover, we recently demonstrated that they can self-emerge and robustly recover [2]. Here we discuss the fundamental mechanism that transforms the laser cavity solitons in the dominant attractors of a microcomb system based on a Kerr microresonator nested in an amplifying cavity. Particularly, we discuss the effect of the slow nonlinearities of the system and how they allow the robust emergence of solitary waves in our system.
9:25	**Christelle Monat** (Ecole Central de Lyon, INL) *Hybrid nonlinear integrated waveguides with 2D materials*
	The recent development of silicon photonics, namely based on Si and Si derivative materials (e.g. Si3N4) has enabled the successful integration of a wide range of optical devices onto the same chip. However, due to the silicon indirect bandgap, and its high two-photon absorption at telecom wavelengths, light-emitting diodes, lasers or all-optical signal processing devices cannot be efficiently integrated in silicon monolithic architectures. III-V/ Si wafer bonding and LiNBO3 thin film technologies have already provided a successful path to increase the number of functionalities that can be heterogeneously integrated onto silicon chips, which turned hybrid. Two-dimensional materials represent another viable route to complement the properties of silicon and create very compact hybrid architectures with functionalities that silicon alone cannot achieve. I will here discuss some of these developments, in particular the demonstration of graphene/ Si3N4 nonlinear waveguides for chip-based saturable absorbers. I will also present our results on the exploitation of the graphene Kerr nonlinear response for four-wave mixing processes, which turn out to be limited, practically speaking, par the very large graphene absorption coefficient. Finally, I will also discuss the potential use of alternative 2D materials for hybrid nonlinear chip-based devices.

9:50	**Camille Bres** (EPFL) *Field-induced nonlinearities in silicon nitride nanophotonics*
	In this talk, I will cover our recent results on all-optical poling of silicon nitride waveguides and microresonators, including a generalized model and the possibility of cascading the 2nd order nonlinear effects. I will also show recent experimental work on thermally assisted electric-field poling and how charge carrier concentration and waveguide dimension play an significant role in determining achievable effective nonlinearities, as an necessary background to further advance chi(2) based devices in SiN.
10:15	**Christian Grillet** (INL-CNRS) *Recent progress in Broadband Mid-Infrared Supercontinuum Generation on (Si)Ge-based chips*
	Mid-infrared (mid-IR) technologies are right now in high demand because of their wide application domains ranging from pollution detection, environmental monitoring, security and safety. An appealing approach is to create compact molecular sensing devices in the mid-IR exploiting a high brightness integrated broadband light source, such as an integrated supercontinuum source, that would allow the detection of several molecules in parallel. Ge-based waveguides (silicon germanium-on-silicon, Ge on silicon) platform, has emerged as an attractive platform for mid-IR photonics, with transparency window potentially extending up to 15µm depending on the Ge content. In this talk, I will give an overview on our recent results on broadband mid-IR supercontinuum (SC) generation obtained in SiGe and pure Ge waveguides. The low propagation loss combined with a low nonlinear loss allowed us to harness nonlinear effects in these waveguides, resulting in a very bright SC signal with more than 10mW on-chip power. I will also show that we can play with dispersion to achieve a high degree of coherence. This coherent and high brightness supercontinuum establishes silicon germanium-on-silicon as a promising platform for integrated nonlinear photonics in the mid-IR.
	SESSION 4 – Lasers and applications
17:00	**Maxime Jacquot** (Université Bourgogne Franche-Comté) *Computer microvision-based precision motion measurement by digital holographic microscopy and photonic neural networks*
	We review a selection of recent results based on the ability of light to perform control or computation operations in spatial or temporal domain, in order to be applied widely in areas such as computer micro-vision with digital holographic microscopy, and photonic neural networks implementation in hardware. Photonic systems have revolutionized the hardware implementation of Recurrent Neural Networks and Reservoir Computing, in particular. The fundamental principles of Reservoir Computing strongly facilitate a realization in such complex analog systems. Especially delay systems, which potentially provide large numbers of degrees of freedom even in simple architectures, can efficiently be exploited for information processing. We also demonstrated learning in large-scale neural networks with numerous nonlinear nodes in an architecture using SLM. We will also present another area of particular importance in our research institute that

	concerns the developing of advanced imaging techniques for 3D motion measurement in small-scale mechatronics and automated microscopy. This work explores extended computer micro-vision capabilities offered by combining digital holographic microscopy and last generation of deep learning algorithms such as Vision Transformer networks. In high-tech areas such as micro-robotics and photonics, measurement requirements are increasing in terms of high resolution and their controls are based on multi-scale and complex parameters. Increasingly real-time processing remains a big challenge for future applications, where next generation of systems will need to implement new hardware architectures, maybe based on photonic neural networks.
17:25	**Massimo Giudici** (Université Côte d'Azur) *Temporal Localized Patterns in Vertical External-Cavity Surface-Emitting Lasers (VECSELs).*
	We show that large aspect-ratio Vertical External-Cavity Surface-Emitting Lasers (VECSELs) with a saturable absorber can be operated in the regime of spatio-temporal mode-locking. The pulses emitted have a duration of about ten picosesconds and they exhibit a spatial profile resulting from the phase locking between an axial plane-wave with a set of tilted waves having a hexagonal arrangement in the Fourier space. We show that these pulsating patterns are temporally localized, i.e. they can be individually addressed by shining short pump pulses. The theoretical analysis shows that the emergence of these temporal localized patterns is a signature of a Turing instability whose critical wave vector depends on spherical aberrations of the optical elements. Our result reveals that large aspect-ratio VECSELs offer unique opportunities for studying fully developed spatio-temporal dynamics.
17:50	**Giovanna Tissoni** (Université Côte d'Azur, Insitut de Physique de Nice) *Spatiotemporal extreme events in a broad-area semiconductor laser with coherent injection*
	Spatiotemporal extreme events are interesting phenomena, both from a fundamental point of view, as manifestations of complexity in dynamical systems, and for their possible applications in different research fields. Here, we present some recent results about extreme events in spatially extended semiconductor laser systems (broad-area VCSELs) with coherent injection. We study the statistics of spatiotemporal intensity peaks occurring in the transverse (x,y) section of the field perpendicular to the light propagation direction and identify regions in the parameter space where extreme events are more likely to occur. Searching for precursors of these phenomena, we concentrate, on one hand, on the spatiotemporal dynamics of the field phase and in particular on the presence of optical vortices in the vicinity of an extreme event. On the other hand, we focus on the laser gain dynamics and the phase space trajectories of the system close to the occurrence of an extreme event. Both these complementary approaches are successful and allow us to shed some light on potential prediction strategies.
18:15	**Marco Ornigotti** (Tampere University) *Harmonic Generation in 2D Materials in the Presence of Magnetic Fields*
	In this talk, I will discuss how different topological and geometric features, such as the strain- or bend-induced magnetic fields, or tilted Dirac and Weyl cones, have

	on the nonlinear optical response of 2D materials. In particular, I will discuss the possibility to use Weyl semimetals as a possible platform to efficiently implement THz-to-visible and UV light.
	STUDENTS SESSION 2
18:40	**Antonio Cutrona** (Loughborough University) *Stability Property of Laser Cavity-Solitons for Metrological Applications*
	Laser cavity-solitons are optical states forming in systems where a microcavity is nested in a fibre loop providing gain. Being robust and self-emergent, they constitute an attractive class of states suitable for microcomb generation. With this simple topology, we can achieve free-running fractional stability performances on the repetition rate (48.9 GHz) better than 10^(-9) at one second gate time. While such performance is typical of a fibre laser, the much higher repetition rate can be quite advantageous for the metrological transfer of the reference. Our free running laser has comparable performance with maser-stabilised frequency combs.
18:50	**Boris Zabelich** (EPFL) *Linear electro-optic modulator based on electric-field poling of silicon nitride microring*
	Silicon nitride (SiN) is one of the most mature integrated photonic platforms for linear and nonlinear applications on-chip. However, second-order nonlinearity is not available in this material due to its centrosymmetric structure preventing its use for the three-wave-mixing and linear electro-optic modulation processes. Recently, it was shown that efficient second-harmonic generation can be achieved in SiN waveguides via the all-optical poling technique. The space-charge separation within the material leads to an electric field inscription and therefore introduces an effective second-order susceptibility $\chi_{eff}^{(2)}$. In this work, we implement thermally assisted electric-field poling to enable the linear electro-optic effect in SiN microring. An application of a high voltage at elevated temperature results in the formation of the depletion region and the inscription of a strong electric field reaching ~100 V/µm. A modulator based on poled SiN microring demonstrated a bandwidth of 1 MHz. Current findings establish a strong groundwork for further advancement of $\chi^{(2)}$ -based devices on SiN.
19:00	**Debayan Das** (Loughborough University) *High parametric efficiency in laser cavity-soliton microcombs*
	Laser cavity-soliton microcombs are robust optical pulsed sources, usually implemented with a microresonator-filtered fibre laser. In such a configuration, a nonlinear microcavity converts the narrowband pulse resulting from bandwidth-limited amplification to a background-free broadband microcomb. Here we theoretically and experimentally study the soliton conversion efficiency between the narrowband input pulse and the two outputs of a four-port integrated microcavity, namely the 'Drop' and 'Through' ports. We simultaneously measure on-chip, single-soliton conversion efficiencies of 45% and 25% for the two broadband comb outputs at the 'Drop' and 'Through' ports of a 48.9 GHz free-spectral range micro-ring resonator, obtaining a total conversion efficiency of 72%.