SESSION 1: Channel Modeling for Nonlinear Propagation		
Title	Author(s)	Abstract
P1.1 (9:20) On the Nonlinear Reference Phase in Regular Perturbation Models	P. Serena A. Bononi	We provide an analytical expression of the nonlinear phase induced by the Kerr effect that highlights its dependence on the modulation format and on the link parameters. We show that such a nonlinear phase must be used in regular-perturbation models in order to minimize their modeling error. We detail the case of dispersion-managed systems as an application example.
P1.2 (9:40) Propagation Effects in Optical Fibers for Space-Division Multiplexed Transmission	C. Antonelli	In this talk we review the major propagation effects involved in Space-Division Multiplexed transmission based on multi-mode fiber optic structures (MMFs). These include random mode coupling, modal dispersion, and nonlinearities. We show that in the regime of strong coupling between modes the equations describing nonlinear propagation in MMFs assume the form of coupled generalized Manakov equations and discuss their implications.
P1.3 (10:00) Numerical Solution of the Direct Scattering Problem for the Nonlinear Schrödinger Equation	L. Fermo C. van der Mee S. Seatzu	We illustrate a numerical method to compute the scattering data for the Zhakarov-Shabat system associated to the initial value problem for the nonlinear Schrödinger equation. This numerical method which, to our best knowledge, is the first method proposed to compute all scattering data under general assumptions, is based on the version of the Inverse Scattering Transform method proposed by one of the authors.
P1.4 (10:15) Nonlinear Noise Characterization in Highly Dispersive Optical Transmission Systems	F. Matera	This paper reports an analytical investigation, confirmed by numerical simulations, about the nonlinear noise impact on the performance of single-channel systems adopting generic modulation-detection formats and operating in long links with both managed and unmanaged dispersion compensation. Such a noise contribution is analyzed in terms of a pulse nonlinear interaction length, that depends on the link dispersion characteristics and on the modulation-detection format.
P1.5 (10:30) Numerical Methods for the Inverse Nonlinear Fourier Transform	S. Civelli L. Barletti M. Secondini	We introduce a new numerical method for the computation of the inverse nonlinear Fourier transform and compare its computational complexity and accuracy to those of other methods available in the literature. For a given accuracy, the proposed method requires the lowest number of operations.

SESSION 2: Transmission and Detection Strategies		
Title	Author(s)	Abstract
P2.1 (11:20) Nonlinear Fourier Transform and Eigenvalue Communications	S. Turitsyn	Many of the current optical transmission techniques were developed for linear communication channels and are constrained by the fibre nonlinearity. Recently ressurected nonlinear Fourier method offers radically different approaches to signal coding, transmission and processing. I will overview recent progress in application of the powerful method of the inverse scattering transform, also known as the nonlinear Fourier transform, to fibre communication systems.
P2.2 (11:40) Receiver-Based Strategies for Mitigating Nonlinear Distortion in High-Speed Optical Communication Systems	T. Xu G. Liga N. A. Shevchenko R. I. Killey P. Bayvel	Transmission rate and spectral efficiency of optical communication systems can be enhanced using higher modulation formats and closer channel spacing. However, such systems are significantly affected by intra-channel and inter-channel fibre nonlinearities. By using multi-channel digital back-propagation, nonlinear signal-signal interactions can be, in principle, fully removed within the bandwidth of the nonlinear compensation. Alternatively, detection strategies tailored to the optical fibre channel can also effectively mitigate nonlinear transmission impairments and in some case achieve the optimal performance. Analysis and discussion on the influence of fibre nonlinearities and the performance of receiver-side techniques (multi-channel digital back-propagation and optimum detection) for counteracting the nonlinear distortions in optical communication systems will be described.
P2.3 (12:00) Inter-Band Nonlinear Interference Canceler for Long-Haul Coherent Optical OFDM Transmission	A. Amari P. Ciblat Y. Jaouën	In the context of long-haul multi-band coherent OFDM transmission (at 400 Gbps), we propose an inter-band nonlinear interference canceler based on Volterra series. This new type of receiver significantly improves the BER performance compared to the standard third-order inverse Volterra series nonlinear equalizer.
P2.4 (12:15) Digital Back Propagation in Soliton Coherent Transmission	O. Yushko A. Redyuk M. Fedoruk S. Turitsyn K. Blow N. Doran A. Ellis	We have revised soliton transmission in the new context of coherent optical detection optimizing and comparing digital backward propagation and in-line optical filtering as a means to suppress soliton timing and phase jitter. We find that in-line optical filtering allows one to improve the reach of the soliton system by up to the factor of two. We compared jitter suppression for transmission links using different types of fiber. We showed that with launch power growth jitter suppression is less efficient. However, our results show that nonlinear propagation can lead to enhanced performance of the fiber network systems.
P2.5 (12:30) Nonlinearity Compensation: Is the Knowledge of Absolute Amplitude and Phase Really Necessary?	N. Alic E. Temprana E. Myslivets S. Radic	We discuss necessary and sufficient conditions conducive to the reversal of nonlinear interaction in fiber optic transmission. While the complete information about complex amplitude and phase of the electric field certainly allows reversal of the nonlinear interaction, it is shown that knowledge about carriers' frequencies in WDM represents a sufficient condition for a successful compensation of the nonlinear impairment.
P2.6 (12:45) Experimental Demonstration of Long Haul Transmission of Eigenvalue Modulated Signals	A. Maruta A. Toyota Y. Matsuda Y. Ikeda	Eigenvalues of the associated equation of the nonlinear Schrödinger equation are mathematically invariable. We experimentally demonstrate the eigenvalues can be almost conserved for longer than 1,500km in wavelength division multiplexed optical fiber transmission line for the first time.

SESSION 3: System Aspects of Non-Linear Transmission		
Title	Author(s)	Abstract
P3.1 (14:25) Theoretical and Experimental Assessment of Nonlinearity Mitigation through Symbol Rate Optimization	P. Poggiolini G. Bosco A. Carena V. Curri Y. Jiang S. M. Bilal A. Nespola L. Bertignono S. Abrate F. Forghieri	We investigated the reach increase obtained through non-linearity mitigation by means of transmission symbol rate optimization (SRO). First, we did this theoretically and simulatively. We found that for PM-QPSK systems at full-C-band the reach increase may be substantial, on the order of 10%-25%, with optimum symbol rates on the order of 2-to-6 GBaud. We extended the investigation to PM-16QAM, where we found a qualitatively similar effect, although the potential reach increase is typically only about half that of PM-QPSK. We then set up an experiment to obtain confirmation of the theoretical and simulative predictions. We demonstrated a reach increase of 11% in a 19-channel, 128 Gbit/s per channel, PM-QPSK experiment, when going from single-carrier to multi-subcarrier (up to 16 subcarriers per channel) transmission. The experiment reached 14,100 km over PSCF, with 110 km spans and EDFA- only amplification. The results matched well the EGN model predictions.
P3.2 (14:45) On the Impact of Carrier Phase Estimation on Phase Correlations in Coherent Fiber Transmission	T. Fehenberger N. Hanik T. A. Eriksson P. Johannisson M. Karlsson	Carrier phase estimation (CPE) is an integral part of the digital signal processing (DSP) of coherent optical communication systems as it compensates laser phase noise (LPN) introduced by free-running transmitter and local oscillating (LO) lasers. Nonlinear interactions during propagation are another source of correlated phase noise. In this paper, we show through simulations and in experiments that blind decision-directed (DD) CPE with regular block lengths removes a large portion of the memory. This makes it virtually impossible in practice to quantify correlations that come from propagation effects, or to obtain rate gains by exploiting the nonlinear phase noise (NLPN). Larger CPE block lengths leave the memory partly intact. This, however, comes at the expense of reduced information rates. We are able to fully recover this rate loss in simulations by using idealized processing of phase distortions. In experiments with full DSP, an almost full rate recovery is reported.
P3.3 (15:00) On the Performance of Digital Back-Propagation for Imperfect Knowledge of Link Design	R. Rath W. Rosenkranz	Digital back-propagation (DBP) was shown to have the potential to become the most promising method for compensation of fiber nonlinearities. However, apart from its high computational effort, the performance of DBP is dependent on the knowledge of the transmission link, i.e. the link's dispersion map as well as its power profile. In this contribution, we investigate the performance of DBP under the assumption of an imperfect link-design knowledge, and discuss its implications in an optical network scenario.
P3.4 (15:15) Wavelength Division Multiplexed Optical Eigenvalue Modulated System	A. Toyota A. Maruta	Wavelength division multiplexing is essential for achieving large capacity optical fiber transmission for any kind of modulation format. In this paper, we propose a wavelength division multiplexed optical eigenvalue modulated system and discuss its advantages and remaining issues for practical application.
P3.5 (15:30) Transmission Performances of 400 Gbps Coherent 16-QAM Multi-Band OFDM Adopting Nonlinear Mitigation Techniques	M. Song E. Pincemin V. Vgenopoulou I. Roudas	We experimentally study the transmission of a 400 Gbps coherent 16-QAM multi-band OFDM superchannel over a 10x100 km G.652 fibre-based WDM transmission line. We investigate the performance of Volterra-based and digital back- propagation-based nonlinear equalizers over three scenarios with different quantities of inter-channel nonlinearities.
P3.6 (15:45) Review on Phase Preserving Amplitude Regeneration for Phase-Coded Signals Exploiting FWM in a Saturated SOA	V. Vercesi G. Serafino A. Bogoni C. Porzi	All-optical phase-preserving amplitude regeneration is an effective method to reduce nonlinear phase noise in long-haul transmission of phase-modulated signals. Here we review the latest results on a proposed differential phase shift keying (DPSK) regeneration scheme exploiting a compact architecture based on a saturated semiconductor optical amplifier. The scheme allows for amplitude-only signal regeneration with limited excess phase-noise contribution. Both the pass-through (PT) and the four wave mixing (FWM) signals exhibit enhanced Q-factor and margin improvement in bit error rate vs receiver threshold measurements, making the configuration suitable for both wavelength-preserving optical regeneration and wavelength regenerative conversion. The regeneration through FWM has an higher resilience to noise than the PT and its polarization dependency can be eliminated with the implementation of a dual co-polarized pump scheme. Preliminary experiments of simultaneous regeneration of two DPSK data streams are also provided.

SESSION 4: Theoretical Limits in Fiber-Optic Communication		
Title	Author(s)	Abstract
P4.1 (16:30) Exploring the Limits of Receiver-Side Nonlinearity Mitigation	H. Wymeersch	Coherent optical communications is limited by nonlinear impairments, as transmission systems move towards higher-order modulation formats, which require higher input powers. Digital back-propagation and stochastic digital back-propagation can compensate for nonlinear impairments, but are both inherently suboptimal. In this talk, we describe several ongoing research directions towards the development of a truly optimal receiver.
P4.2 (16:50) Capacity Bounds for the Nonlinear Schrödinger Channel	M. Yousefi	We present bounds on the capacity of the stochastic nonlinear Schrödinger equation in one dimension, modeling signal propagation in single-mode optical fiber with amplification. Some generalizations to the Manakov system are discussed.
P4.3 (17:10) Spectral Efficiency Estimate for Non-linear Optical Fibers	P. Kazakopoulos A. Moustakas	Optical fiber communications can be analyzed using the non-linear Schroedinger equation, which is fully integrable. In this paper we show how this integrability can be exploited to communicate using solitonic pulses. Due to the presence of Gordon-Haus jitter, here we need to analyze the information content of point sets, rather than sequences. Based on a white Gaussian input signal distribution we use the known distribution of eigenvalues and distribution of scattering data to come up with an estimate for the spectral efficiency, taking into account the effects of noise due to amplification explicitly.
P4.4 (17:30) Information Theory Analysis of Regenerative Channels	M. Sorokina S. Sygletos S. Turitsyn	In this paper we summarize our recently proposed work on the information theory analysis of regenerative channels. We discuss how the design and the transfer function properties of the regenerator affect the noise statistics and enable Shannon capacities higher than that of the corresponding linear channels (in the absence of regeneration).
P4.5 (17:45) BICM Capacity Analysis of 8QAM-Alternative Modulation Formats in Nonlinear Fiber Transmission	K. Kojima T. Koike-Akino D. S. Millar K. Parsons	We investigate the nonlinear performance of 8QAM-alternative 4D modulation format using GMI to evaluate the BICM capacity. Due to its constant modulus feature, the 4D-2A8PSK modulation has higher nonlinear threshold than Star-8QAM and Circular-8QAM.