Seminar at FOTON Laboratory

Mathematical Foundations of Optical Fiber Communication

Dr. Mansoor I. Yousefi

Communications and Electronics Department

Télécom ParisTech

Paris, France

Tuesday 29 November 2016

14:00-16:00

ENSSAT, Lannion

Lecture Hall 138C

Abstract:

Motivated by the looming "capacity crunch" in global fiber-optic networks, information transmission over such systems is revisited. Pulse propagation in optical fibers is governed by the stochastic nonlinear Schrödinger (NLS) equation. The NLS equation describes the interplay between dispersion, Kerr nonlinearity and noise, providing a challenging, yet commercially important, channel model for communication engineers and information theorists.

In this tutorial presentation we explore the mathematical underpinning of optical fiber communication. In the first part of the presentation, we discuss the data communication applications of the nonlinear Fourier transform (NFT), a signal analysis technique that simplifies the complicated nonlinear spatio-temporal signal evolution in the lossless and noiseless NLS equation and certain other types of models. The NFT decorrelates signal degrees-of-freedom in (an ideal model of) optical fiber, in much the same way that the Fourier transform does for linear systems. Just as the (ordinary) Fourier transform converts a convolution into a multiplication operator in the frequency domain, the nonlinear Fourier transform converts a nonlinear dispersive equation described by a *Lax convolution* into a multiplication operator (a filter) in the nonlinear spectral domain. We propose a nonlinear frequency-division multiplexing (NFDM) based on the NFT, which is the analogue of the orthogonal frequency-division multiplexing in linear channels. In this approach, information is encoded in the generalized frequencies (complex numbers) and their spectral amplitudes. We review NFDM and summarize past results. In particular, we show that the NFDM rate increases monotonically with transmit power in simulations, in contrast to the WDM rate which characteristically vanishes as the transmit power is increased more than an optimal value.

In the second part of the presentation we discuss the implications of the information theory in optical communication. We unfold the origin of the capacity limitations in fiber and present the asymptotic capacity when the input power tends to infinity.

Part of this talk is joint work with Frank Kschischang at the University of Toronto and Xianhe Yangzhang at University College London.

Mansoor I. Yousefi is Assistant Professor in the Communications and Electronics Department at Télécom ParisTech, Paris, France. He received his Ph.D. from the University of Toronto, Canada, in Electrical Engineering in 2013. From 2013 to 2016, he was a Post-doctoral Fellow at the Institute for Advanced Study, and the Institute for Communications Engineering, at the Technical University of Munich, Germany. His research interests include information theory, optical fiber and applied mathematics. He is a recipient of a number of awards and scholarships.

References

Mansoor I. Yousefi and Frank R. Kschischang, "Information transmission using the nonlinear Fourier transform, Part I – Part II – Part III," IEEE Trans. Inf. Theory, vol. 60, no. 7, pp. 4312–4369, Jul. 2014.

Mansoor I. Yousefi and Xianhe Yangzhang, "Linear and nonlinear frequency-division multiplexing," arXiv:1603.04389v2, May 2016.

Mansoor I. Yousefi, "The asymptotic capacity of the optical fiber," arXiv:1610.06458, Oct 2016.

Contact FOTON : Christophe Peucheret (christophe.peucheret@univ-rennes1.fr)