

## **Eigenvalue communication in optical transmission lines**

In the recent years optical fibre channels have become the backbone of the global telecommunication systems [1, 2]. Mathematically the problem of signal transmission through a typical line involves nonlinear mapping through a segment of optical fibre. The signal propagation inside such a segment is well described by the scalar Nonlinear Schrodinger Equation (NLSE). This system is completely integrable by means of Inverse Scattering Transform technique [3,4] and supports both localized particle-like solutions (solitons) and quasilinear radiation waves. In this technique the solution of the nonlinear problem is obtained via the solution of the auxiliary *linear* spectral problem (called Zakharov-Shabat eigenvalue problem). The complex eigenvalues of this spectral problem are integrals of motion, i.e. they are the same both at the beginning and at the end of the transmission segment. This constitutes the general idea of *eigenvalue communication* [5,6] which is to use these invariant eigenvalues to encode and transmit information without distortions from source to destination.

The **goal** of the project will be to study different input waveforms as most suitable candidates for eigenvalue communication in the noiseless channels and then consider the impact of noise on the quality of transmission. A few **key stages** can be singled out:

1. The first stage is preliminary and is dedicated to the thorough study of the background of the IST technique [3,4].
2. At the next stage one must apply the existing code for analyzing the Zakharov-Shabat spectral content of a given input pulse. Different wave forms (including purely random ones) should be tried and the number and the distribution of the discrete eigenvalues must be studied.
3. At the final stage noise is introduced into the system which makes it no longer integrable by IST. Therefore one will need to use the existing NLSE solver code to simulate signal propagation and then analyze the spectral content of the output pulse.

**Required skills:** The prospective applicant must have a solid background in mathematics (PDEs, spectral theory of linear operators, complex analysis) and some basic knowledge of the numerical methods. The knowledge of at least one of the programming languages (C/C++/Fortan) is desirable but not necessary.

### **References:**

- [1] G.P. Agrawal, "Fiber-Optic Communication Systems" (Wiley, 2002).
- [2] E. Iannone, F. Matera, A. Mecozzi, and M. Settembre, "Nonlinear Optical Communication Networks", (Wiley, 1998).
- [3] S.V. Manakov, S.P. Novikov, L.P. Pitaevskii, and V.E. Zakharov, "Theory of Solitons" (Consultants Bureau, NewYork, 1984).

- [4] V.E. Zakharov, A.B. Shabat, Sov. Phys. JETP **34**, 62 (1971).
- [5] A. Hasegawa and Y. Kodama, "Solitons in Optical Communications", (Clarendon Press, Oxford, 1995).
- [6] A. Hasegawa and T. Nyu, J. Lightwave Technol. **11**, 395 (1993)