Capacity of Nonlinear Fibre Channels

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An interplay between effects of dispersion and nonlinearity is a fundamental and very general physical phenomenon of high practical importance that occurs in diverse areas of physics and engineering. In particular, for many years it has been a focus of research in fiber-optic communications, responsible for transporting of a major fraction of global data traffic. The evolution of fiber transmission concepts in the past decades with regard of fiber dispersion was quite remarkable - from initial attempts to use zero-dispersion regimes (e.g. in dispersion-shifted fiber) to fibers with moderate dispersion and dispersion-management techniques (with high local dispersion and low overall dispersion value) [1-3]. The recent surge in development of coherent optical communication systems resulted in the dramatic change of the way in which optical fiber channels are operated. In recent concepts of coherent transmission the dispersion is not compensated at all in the optical domain and signal is recovered through digital signal processing using high speed electronics at the receiver [4,5].

The evolution of the treatment of optical fiber nonlinearity, that occurs due to the Kerr effect, was not less salient than in the case of fiber dispersion. From initial disparagement of the importance of Kerr nonlinearity for long-haul fiber communication through building systems making positive use of a partial balance between dispersion and nonlinearity [2,3], the optical transmission community has arrived to modern concepts of coherent signal transmission where high non-compensated (in optical domain) fiber dispersion is used to minimize impact of nonlinearity. Indeed, in systems with large non-compensated dispersion propagation of signal at conventional powers is effectively quasi-linear. However, nonlinear propagation effects are still critically affect the capacity of optical fiber channels [3-15]. The reason is rather transparent - increase of input signal power to improve signal-to-noise ratio at some power level inevitably leads to observable nonlinear signal interactions. Dominating fiber dispersion does not remove nonlinearity, but it can increase the power threshold for onset of nonlinear effects. Therefore, nonlinearity is still critically important and the significance of an accurate evaluation of nonlinear transmission effects for analysis of nonlinear fiber channel capacity cannot be overestimated.

In general, signal transmission in fiber channels is described by nonlinear partial differential evolution(s) that makes analysis of capacity of such channels a very complex problem, indeed. Therefore, there is a strong demand on analytical approximate models of nonlinear fiber channel even if they can be applied only in some limits.

I will overview our recent works in this field [16]. Our findings agree with recent mathematical result [17] (see also [13]), proving that despite the prevalent paradigm, the Shannon channel capacity [18] cannot decrease with increasing transmitted power. An analytical description of a specific nonlinear fibre channels with non-compensated dispersion will be presented. Information theory analysis shows that capacity of such nonlinear fibre channel does not deccrease with growing signal power.

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