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► **To cite this version:**

Sonia Boscolo, J.M. Dudley, Christophe Finot. Modelling the spectro-temporal evolution of a frequency comb in a nonlinear optical fibre with a feedforward neural network. 4ièmes Journées GDR Elios, Sep 2024, Bordeaux, France. hal-04728410

HAL Id: hal-04728410

<https://hal.science/hal-04728410v1>

Submitted on 9 Oct 2024

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Modelling the spectro-temporal evolution of a comb in a nonlinear optical fibre with a feedforward neural network

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Abstract: We deploy a feedforward neural network to predict the spectro-temporal evolution of a periodic waveform upon nonlinear fibre propagation and demonstrate efficient probing of the full input-parameter space for on-demand comb generation or significant spectral/temporal focusing occurrence. The computational speed is increased by more than 4 orders of magnitude.

Recent years have seen a growing interest in applying the techniques of machine learning to optical systems and, particularly, for the characterisation and control of ultrafast propagation dynamics [1]. We have successfully introduced the use of neural networks (NNs) as an efficient tool for substituting the nonlinear Schrödinger equation (NLSE) in the modelling of the shaping of ultrashort pulses that occurs upon nonlinear propagation in an optical fibre [2,3] or for predicting the generation of optical supercontinua [4]. The fibre nonlinearity does not only affect the propagation of ultrashort pulses, but also a continuous wave modulated at some frequency will experience an energy exchange between the spectral lines making up its spectrum along with a change in the relative phase between the frequency components. New equally spaced frequency components will emerge giving rise to a frequency comb, while significant reshaping will take place in the time domain, generally leading to very high repetition rate pulse trains [5]. In this paper, we implement a NN to predict the spectro-temporal evolution of a periodic waveform in a fibre [6]. Both the normal and anomalous second-order dispersion regimes of the fibre are studied, and the speed of the NN is leveraged to probe the space of input parameters for the generation of on-demand target combs or the occurrence of significant temporal or spectral focusing.

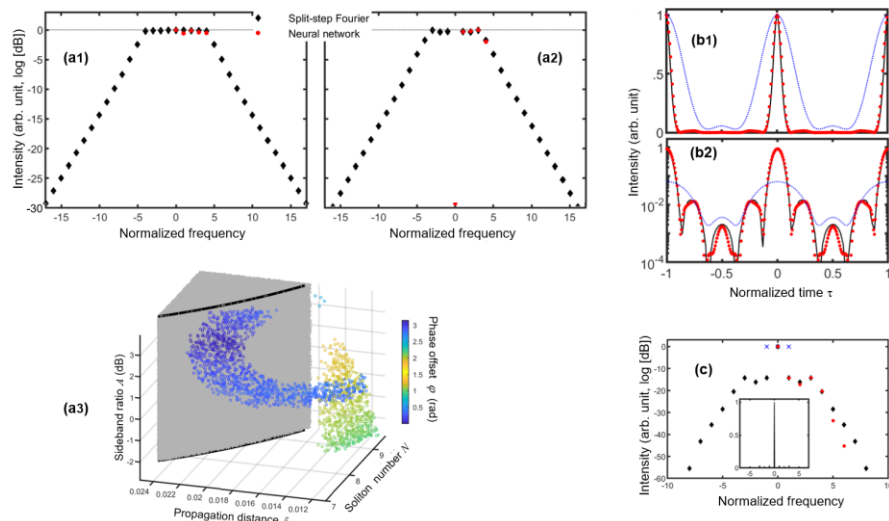


Figure 1 : (a) Generation of on-demand frequency combs in an anomalously dispersive fibre: (a1,a2) combs consisting of 9 spectral lines of equal amplitude and of 6 spectral lines of equal amplitude but with the central component cancelled, respectively; (a3) Regions in the input parameter space that enable the formation of high-flatness combs. (b) Temporal focusing in an anomalously dispersive fibre: generation of a pulse train with the highest pulse peak power relative to the average (c) Spectral focusing in a normally dispersive fibre: generated optical spectrum. The predictions from the NN (red circles) are compared with the results of NLSE numerical simulations (black diamonds or lines). Also shown are the initial conditions at the fibre input (blue crosses or lines).

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