Complex Noise-Like Pulse Dynamics in Passively Mode-Locked Fiber Lasers

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Passively mode-locked fibre lasers are versatile sources that are mostly known for their ability to produce stable trains of optical solitons. However, a radically different mode of operation of these sources has also been recognized, namely the noise-like pulsing regime [1]. Although in general they still manifest themselves as a periodic pulse train at the laser output, the properties of these unconventional pulses (optical spectrum and autocorrelation, among others) differ completely from those of solitons. Noise-like pulses (NLPs) are long (ns) bunches of radiation with a complex, chaotic internal dynamics. Their outstanding properties, like high pulse energy, which now reaches a fraction of a microJ [2], and their very wide, supercontinuum-like optical spectrum [3], makes them attractive for applications like micromachining [4] or medical imaging [5], among others. NLPs are also attracting a growing interest due to their connection with optical rogue waves [6]. However, knowledge of their mechanisms of formation and dynamics is still incomplete and, due to their extremely complex and volatile nature, a precise characterization of these objects remains extremely challenging. Although in most cases a single, compact NLP forms in the laser cavity, under some circumstances the NLP splits into multiple pulses, leading to harmonic mode locking [2] or to more complex, cuasi-stationary behaviors, such as the rain of NLPs (figure 1(a)) [7]. In this work, we report the experimental observation of several puzzling NLP dynamics and try to understand, using numerical simulations, the conditions that favor the breaking of a NLP into multiple substructures (figure 1(b)).

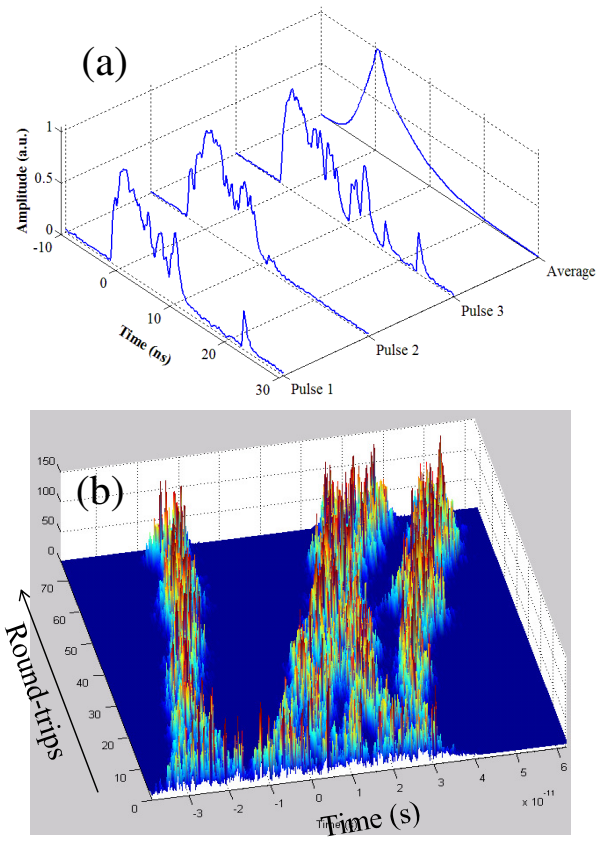

Figure 1: (a) Scope measurement of sub-pulses emerging from a main NLP and (b) Simulated evolution of a NLP splitting into multiple bunches

This work is supported by CONACyT/Fronteras de la Ciencia program (grant 471).

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