Optical Rogue Waves Detection Through Spectral Measurements

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Passive mode-locked fiber lasers have attracted interest for decades mainly for their capacity to produce stable trains of ultrashort pulses, which are attractive for applications. However, in recent years, the study of non-stationary pulses produced by these lasers began to generate a lot of interest due to the many disconcerting dynamics they present. Among these regimes, we can find noise-like pulses (NLPs), and their interaction with solitons and optical rogue waves (ORWs) [1–3]. By adjusting the polarization of the laser cavity and the dispersion of the fibres that compose it, quite stable NLPs can be produced, which are useful for applications such as supercontinuum generation (SCG) [4]; but also, less stationary pulses can be produced which exhibit fascinating dynamics involving, in particular, the manifestation of ORWs [2,3].

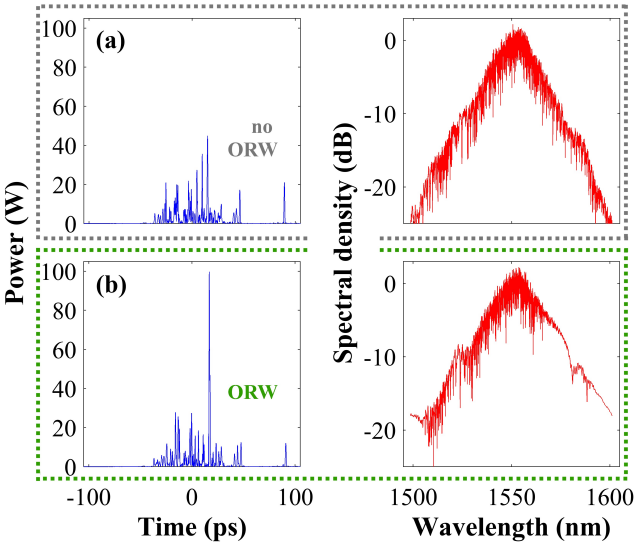

Figure 1: Correspondence between the temporal profile and the instantaneous spectrum of two consecutive roundtrips, showing the alteration that the spectrum undergoes around an ORW: (a) no ORWs are present; (b) an ORW is manifested

In this work, we present the development of a simple method to detect ORWs through spectral measurements. Using the numerical model of a figure-eight laser (F8L) [3], we produce hundreds of roundtrips of NLPs. Calculating the spectrum with the FFT of each temporal single-shot pulse, changes were observed in the flanks of the optical spectrum when an ORW manifests temporally. We believe that by exploiting this idea, it is possible to experimentally identify the presence of ORWs that, in general, cannot be observed in the time domain due to bandwidth limitations of the measurement setup. In Figure 1, two consecutive single-shot measurements (blue) and their respective optical spectra (red) are shown. While in Figure 1(a), there is no manifestation of ORWs, and the spectrum presents its typical profile, in Figure 1(b), the presence of an ORW clearly causes a deformation in the instantaneous spectrum. In practice, single-shot spectra can be readily measured using, in particular, the dispersive Fourier transform technique [5].

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