Dispersive time stretching measurements of real-time spectra and statistics for supercontinuum generation around 1550 nm

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Fiber supercontinuum (SC) generation is a well-known process widely studied over the last decade [1]. Recently, the particular case of noise-driven SC has received increasing attention because of novel instability properties and links with other systems in the formation of extreme events [2]. SC fluctuations have been investigated experimentally typically through RF measurements technique [3] or considering only a specific region of the SC spectrum with filtering [2]. Recently, the development of the dispersive time-stretch Fourier transform technique has been applied to map spectral fluctuations of modulation instability sidebands into temporal fluctuations that could be measured using a real time oscilloscope [4]. In this study, we apply the technique of dispersive time-stretching to implement the first complete study of real-time fluctuations across the full bandwidth of a supercontinuum generated around 1550 nm.

Our experiments use 70 W peak power 3.5 ps pulses power to excite SC in 20 m of highly nonlinear fiber (HNLF) with anomalous dispersion. We characterize SC intensity noise over the full bandwidth using a dispersive time stretch system, with 1 nm equivalent spectral resolution using a 12 GHz real-time detection system [4]. The SC generation arises from noise-driven modulation instability (MI) associated with high shot to shot spectral fluctuations [1,2]. Fig. 1(i) is a false color plot of 500 spectral measurements showing the significant variation in spectral width and structure. Fig. 1(ii) plots the spectra on a logarithmic scale, and also plots the mean spectrum to highlight the significant noise at each wavelength in the SC. We can readily extract from this data intensity histograms at different wavelengths as shown, allowing us to identify regions of Gaussian fluctuations (around the pump) and long-tailed rogue-wave like fluctuations (in the wings). We can also readily calculate from the data higher-order statistical moments of coefficient of variation, skew and kurtosis, and these are shown in Fig. 1(iii). Summary statistics such as these are especially useful to quantify the wavelength variation of the SC statistics, and can be readily compared with the predictions from stochastic numerical simulations. Simulation results are also presented in Fig. 1(iii) showing very good agreement.

These results confirm the power of dispersive time stretching as a technique for SC spectral noise characterization. The ability to determine SC statistics at arbitrary wavelengths and to calculate metrics of higher-order moments reveals effects that are not apparent in averaged measurements, and is highly complementary to other techniques such as RF spectral analysis.

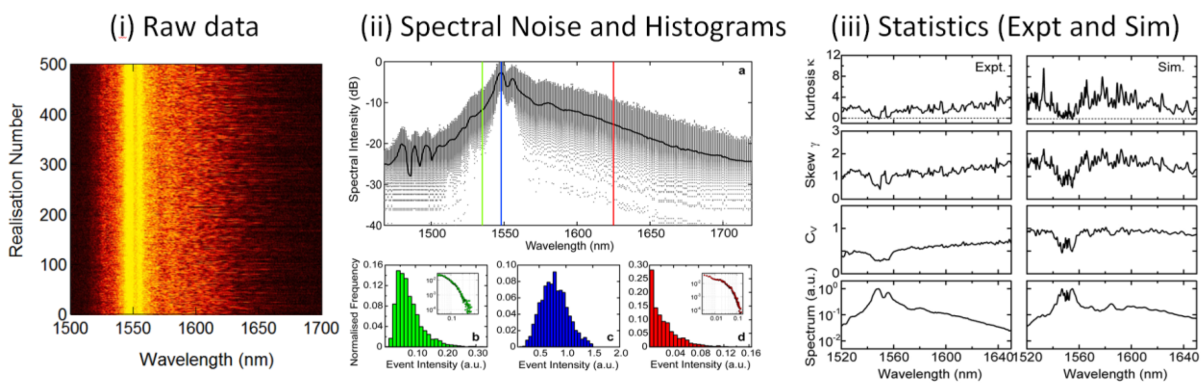

Fig. 1 SC spectral fluctuations are presented in (i) and (ii). In subfigure (ii) the shot to shot realisations are shown in grey; the mean spectrum is the black line. Histogram data is plotted for the wavelengths shown. (iii) Calculated mean spectra and statistics from these experiments (left) and from numerical modeling (right).

References

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978-1-4799-0594-2/13/$31.00 ©2013 IEEE