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Noise Reduction of High-power Supercontinuum sources by Back Seeding

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Ultra-broadband high-power supercontinuum (SC) light sources are currently being applied to a wide range of biooptical applications, in which noise is a severely limiting factor. With picosecond pumping, as we consider here, noise is inherent in the SC generation process, because the generation is initiated by modulation instability (MI), which amplifies random fluctuations in the pump pulse. Above a certain threshold power the original pulse breaks up into a train of solitons, which evolves into a supercontinuum [1]. Recently it has been shown that by seeding the four-wave mixing (FWM) gain wavelengths, SC generation close to the threshold can be accelerated and the noise can be greatly reduced [2,3]. The noise is reduced because the seed initiates the MI in a controlled manner, thereby removing a great deal of the randomness in the SC generation process [3]. The theory behind it builds on the recent discovery of Rogue waves in SC [4,5].

However, for most applications a high power SC is desired, such as the 4.5W SC generated by the superK source from Koheras. In this case the pump power is significantly higher than the SC generation threshold. Here we show that seeding of the SC can also be used to reduce the noise in the continuum above the threshold although the reduction is less than what is achieved close to the threshold. We have demonstrated this experimentally using a simple back seeding method in which the seeding signal is part of the generated SC, which is coupled back, time matched with the pump pulse, and recycled in the SC generation process. This ensures that the seed is always matched to the repetition rate of the pump, avoids the need for a separate seed generation system, and allows a positive feedback process, in which a reduction in the SC noise reduces the noise of the seed, which in turn reduces the noise of the SC, etc.

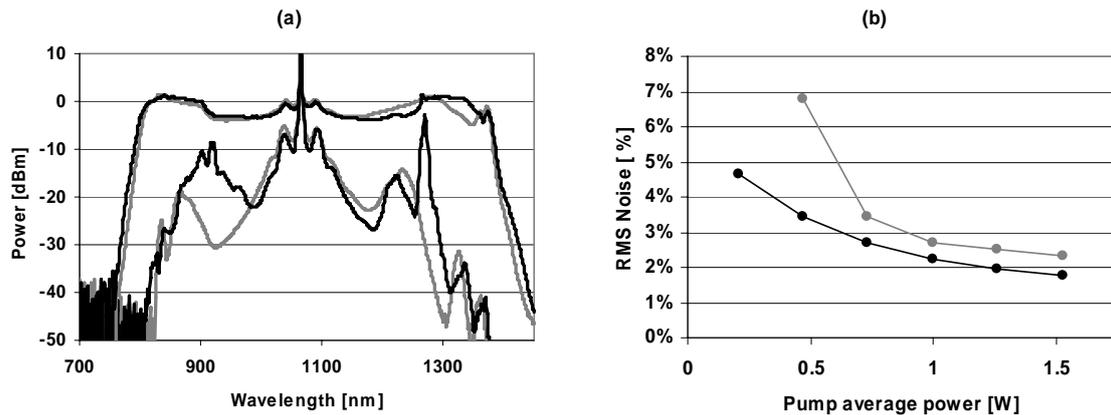


Fig. 1 (a) The SC generated with (black) and without (gray) back seeding at the threshold 0.2 W average power and significantly above at 1.5 W. (b) The 7.5 kHz-10MHz RMS noise of the power above 1250 nm as a function of average pump power with (black) and without (grey) back seeding. The SC was generated using a 70 MHz 14 picosecond pump at 1064 nm in 4 m of NL-1050-Zero-2 photonic crystal fibre (Crystal Fibre A/S, Denmark). The zero dispersion wavelengths of this fibre are at 950 and 1150 nm.

Previously seeding has only been investigated at pump powers around the SC generation threshold. Here we show that it is also of interest for supercontinuum generation at higher powers where we here found that it can reduce the noise even in a part of the spectrum with relatively low noise.

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