Direct measurement of correlations of amplitude and phase noise in optical frequency combs

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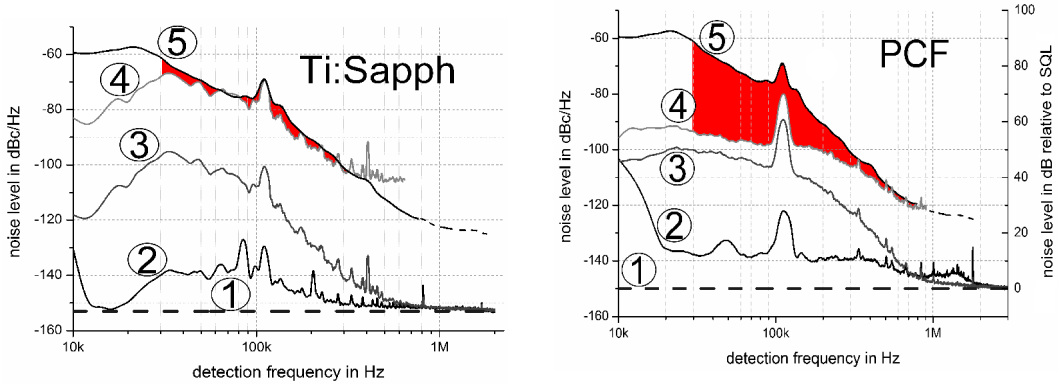
Amplitude and phase noise of optical frequency combs have been studied extensively for Ti:Sapph[1] and fiber based oscillators[2]. Although the correlations of amplitude and phase noise can be obtained from theory[3] they have not yet been accessed directly. We report a ready to use method that can do so. It is based on the comparison of the input- and output amplitude noise of a passive cavity used in transmission and relating it to data of an f-2f measurement. The method is subsequently applied to a photonic crystal fiber (PCF) generating a supercontinuum.



The left figure considers a 45nm FWHM Ti:Sapph oscillator, the right one 80nm of an octave spanning PCF output. For both (1) is the shot noise limit, (2) the intensity noise before – (3) the same after transmission through a passive cavity, (4) contains both the phase noise and amplitude-phase correlations obtained from (2) and (3). The correlation term can be obtained from the difference to an f-2f measurement (5) and is plotted in red. The data show that for a Ti:Sapph oscillator the CEO-phase noise is not correlated to the remaining amplitude noise and thus driven by spontaneous emission in the oscillator[3]. Seeded with such a comb, the output of the PCF has different properties. Amplitude and phase noise are significantly correlated.

In conclusion, the method presented here underlines the recently reported[4] versatility of broadband passive cavities for the analysis of noise structures in any type of coherent optical frequency combs. The data presented here can help to identify suitable pathways to reduce amplitude driven phase noise of oscillators down to the quantum limit.

1 D.V. Sutyrin, et. al., Frequency noise performances of a Ti:sapphire optical frequency comb stabilized to an optical reference, Optics Communications, (2012)

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3 H. A. Haus, A. Mecozzi, Noise of Mode-Locked Lasers, IEEE J.Quant.Electron., **1993**, *29*, 983-996

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