Phase noise measurement of optical amplifiers

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Unlike RF/microwave amplifiers[1], phase noise of optical amplifiers is little studied. The literature reports on RIN[2] or on optically carried microwaves[3], or is unsatisfactory[4] for different reasons. The measurement of laser noise with/without amplifier[5] is a common misconception.

We introduce a novel measurement method (Figure 1), topologically similar to the self-heterodyne but governed by different principles.

Our scheme is a MZ interferometer with the amplifier under test (DUT) in one arm and an AOM in the other arm to shift the optical frequency. The beat between the two optical beams results in a RF signal ν_b at the photodetector output, whose phase noise is equal to the DUT phase noise $S_\varphi(f)$. The scheme differs from the literature in that it does a true differential measurement, comparing the instantaneous input-output phase of the DUT to the 190 MHz RF oscillator. This is made possible by modern digital phase noise analyzers, which work with arbitrary input phase relationships, and accept multiple-cycle phase shift during the measurement.

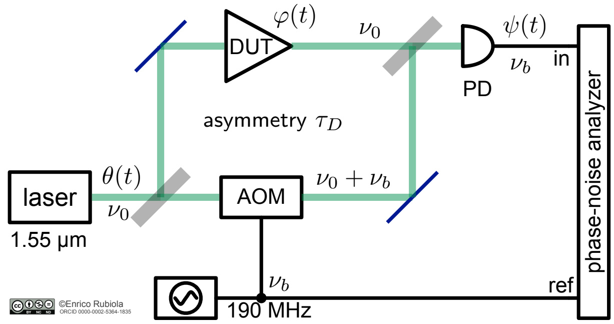

Figure 1. Measurement principle.

We show the phase noise of an optical amplifier (Thorlabs BOA1550S) at different values of pump current and of input power, below saturation. Figure 2 shows an example of our results, compared to the literature[6].

The white noise is consistent with the shot-noise model down to -126 dBrad^2/Hz. The $1/f$ noise is < -32 dBrad^2/Hz at 1 Hz (upper bound), equivalent to a fractional frequency stability ADEV of $5.2 \times 10^{-17}/\tau$.

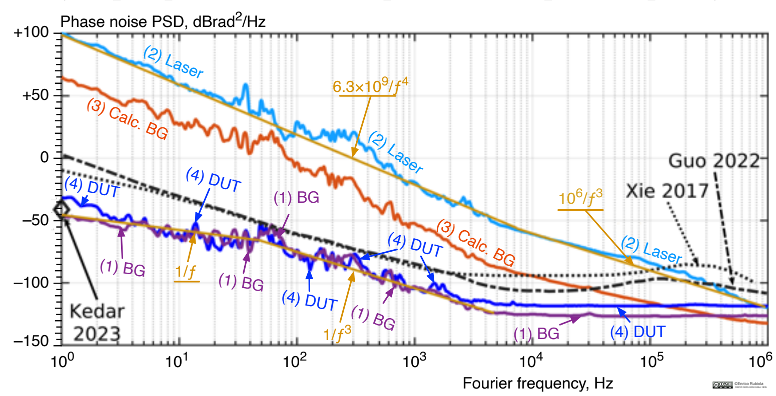

Figure 2. Curve (1): background, with no DUT and symmetric MZ. (2): laser noise, with no DUT and 460 ns MZ asymmetry. (3): Background of the laser-noise measurement, calculated from curve (1) with 460 ns asymmetry. (4) DUT plus background. Guo, Kedar and Xie are from the references.

The details on principle, setup, background noise model, and results are available in Ref 7 (Figure 2 is from Ref 7 too).

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