

# Phase Measurements of Optical Frequency Comb Modes in Microresonators

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One of the main research topics in the field of microresonator-based optical frequency combs (“microcombs”) is related to the question about the mechanism that locks the different comb frequencies together. Independent four-wave mixing processes during the comb generation process do not necessarily lead to the generation of continuous combs. Thus, there must be additional mechanisms that force the different comb modes to be equidistant in frequency. There have been several explanations for such locking mechanisms in the last year, including soliton mode locking [1, 2] and self-injection locking of microcombs [3]. An important pre-requisite to understand the locking mechanism in microcombs is the knowledge of the relative phases of the different comb modes. For example, a peak-power-maximizing mode locking mechanism would force all comb phases to be zero.

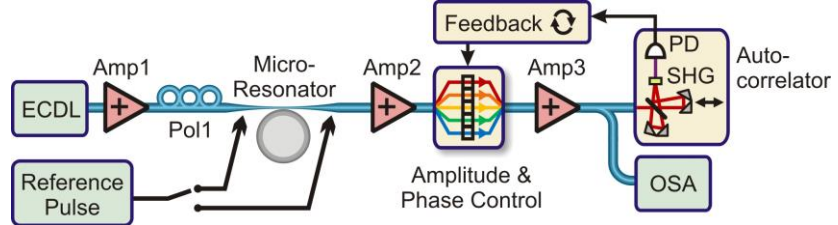


Fig 1. Experimental setup for microcomb phase measurements. Amp=optical amplifier; Pol=polarization controller; PD=photo diode; SHG=second harmonic generation; OSA=optical spectrum analyzer.

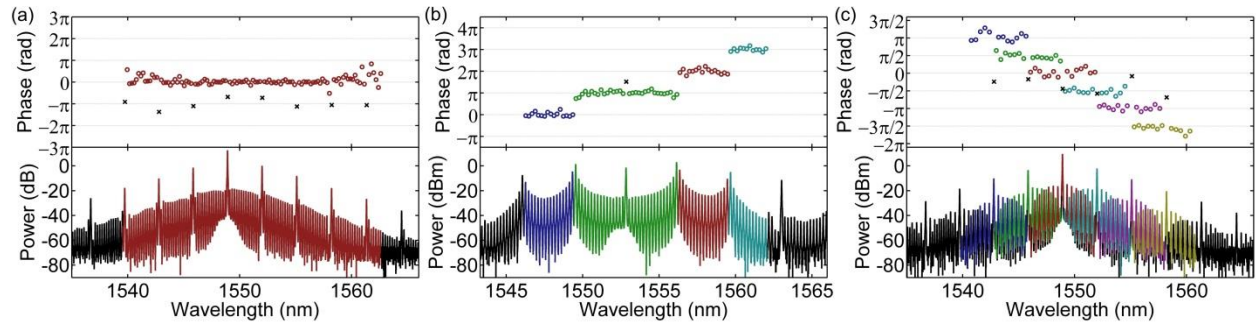


Fig 2. Phases of microcomb modes in different phase locked states.

Here, we present a novel type of simultaneous phase measurement of individual optical frequency comb modes that are emitted by optical microresonators. The comb phases are retrieved by adding additional phase delay to each individual comb mode (cf. Fig 1) until the shortest possible pulse (“zero” phases) is measured with an autocorrelator. The microcomb phases shown in Fig. 2 are derived from the inverse of the applied phases (taking setup dispersion into account).

[1] T. Herr et al, Temporal solitons in optical microresonators, *Nature Photonics* (2013).

[2] K. Saha et al, Modelocking and femtosecond pulse generation in chip-based frequency combs, *Optics Express* **21**, 1335–1343 (2013).

[3] P. Del’Haye et al, Self-Injection Locking and Phase-Locked States in Microresonator-Based Optical Frequency Combs, *Physical Review Letters* **112**, 043905 (2014).