Phase-predictable tuning of single-frequency optical synthesizers

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Single-frequency optical synthesizers (SFOS) provide an optical field with arbitrarily adjustable frequency and phase which is phase-coherently linked to a reference signal. Ideally, they combine the spectral resolution of narrow linewidth frequency stabilized continuous wave lasers with the broad spectral coverage of frequency combs[1] in a tunable fashion.

In previous implementations of SFOSs[2,3,4], a dedicated comb line order switching is needed when tuning over more than one repetition frequency of the employed mode-locked laser. This imposes technical overhead, leads to forbidden frequency gaps and limits the tuning agility of the SFOS.

Here, we present the characterization of a novel type of SFOS which relies on serrodyne-shifting[5] of the frequency comb and subsequent selection of a single line. We investigate the tuning behavior of two identical SFOSs sharing a common frequency comb generator, by comparing the phases of their output signals as they are tuned while having a fixed frequency offset. We achieve phase-stable and cycle slip free frequency tuning over 28.1 GHz (>500 comb lines) with a short term rms phase deviation of 55 mrad (see Fig1). The tuning range using this approach can be extended to the full bandwidth of the frequency comb.

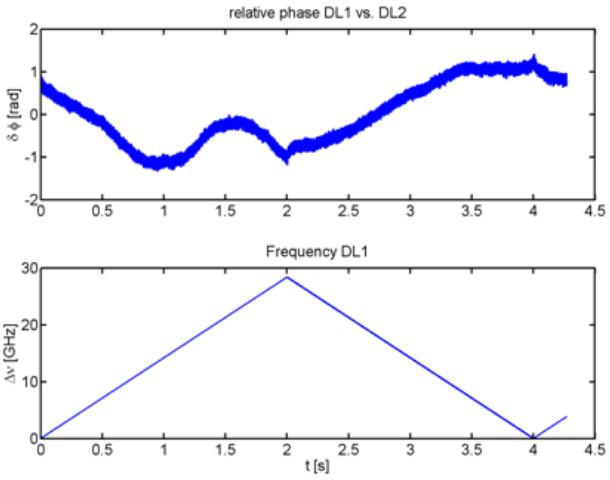

Fig. 1: Upper: Relative phase deviation of two SFOS during a triangular absolute frequency detuning across about 500 comb lines (28.1 GHz). Below: Independently frequency detuning of one of the SFOS monitored with an uncertainty of ± 100 MHz.

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