Ultrastable Photonic-microwave Oscillator for a cold Rb Atomic Clock

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The current realizations of the primary frequency standards (PFS) are constructed with local oscillators (LO) based on frequency synthesis that up-scales OCXOs RF sources[1–3] (5-200 MHz with ~10^{-13} level stability at 1 s, steered with Hydrogen Masers at longer time scales), and in some cases based on synthesis starting from cryogenic sapphire oscillators (CSO) microwave (MW) sources[4,5] (<5×10^{-15} level stability at 1-10 s). In the first case, the resulting phase noise of the MW probe signal is indeed degraded by the multiplication factor, in some cases limiting the atomic fountain stability. In the second case, Quantum Projection Noise (QPN) limited operation of the atomic fountains[6] is now reached at the infrastructural level[4]. The use of CSOs comes with an increased level of required maintenance that cryogenic cooling requires, rendering such approach cumbersome, impractical and energy-intensive. A third and superior option is to use optical frequency division via frequency combs of reference optical signals. This Nobel-prize winning approach, also permits to phase-coherently inter-link optical frequency standards[7]. In some National Metrology Institutes this is currently becoming the leading approach for daily operation of the PFS[4,8,9]. In fact, photonic microwave synthesis via frequency combs permits to yield the lowermost phase noise and the highest stability demonstrated today, and this technology has transitioned from table-top experimental setups[10], to robust and cycle-slip-free transportable systems[11]. Here we present the engineering of a compact and transportable system with an absolute stability in the 10^{-15} level for the Microwave and for the RF synthesized outputs. We employ the ultrastable signal to construct the frequency chain utilized in a cold Rb clock[12], and we will present the interface between the two systems. We outline the system details and the measurement campaign envisioned to demonstrate a 10-fold frequency stability enhancement of the atomic clock. The aim is to reach QPN-limited operation, hence permitting the synthesis of arbitrary MW carriers inheriting such phase stability.

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