Toward SI-Traceable Photonic Thermometry using Dual-Comb Spectroscopy

Precise measurements of temperature are an important requirement in many fields, with functions ranging from process control in manufacturing, to disease treatment in medicine, to military applications. Whereas the Standard Platinum Resistance Thermometer (SPRT) is a robust and simple method to measure temperature to uncertainties less than 10mK, their sensitivity to mechanical shock and need for routine calibration has motivated research to establish platforms based on photonic thermometry [1]. A photonic thermometer is composed of an element highly sensitive to temperature (a photonic thermistor), and a means to reference the device to a primary standard. For example, a prominent platform is the silicon photonic thermometer (SPoT), which uses the narrow resonance of a photonic crystal cavity that can be calibrated against the thermal Brownian motion of its nanomechanical resonator [2]. Here, we propose a platform based on dual-comb spectroscopy (DCS), where the absolute frequency axis retrieved in DCS is used to provide a primary standard. In particular, by leveraging developments in low SWaP and compact fully self-referenced frequency combs, we aim to employ a high resolution 50MHz dual-comb spectrometer covering 30nm of optical bandwidth in the C-band. This spectrometer can be paired with a fiber Bragg grating [3] or a NIST standard reference gas-cell [4] to resolve temperature-dependent frequency shifts below 100MHz with direct SI traceability. Its high resolution targets the 10 mK sensitivity range, while SI traceability can be provided either in the RF by locking the repetition rate to a reference oscillator, or in the optical domain by locking a comb line to an optical standard. Together, these capabilities point toward a compact and fieldable thermometry platform relevant to precision metrology in demanding environments.

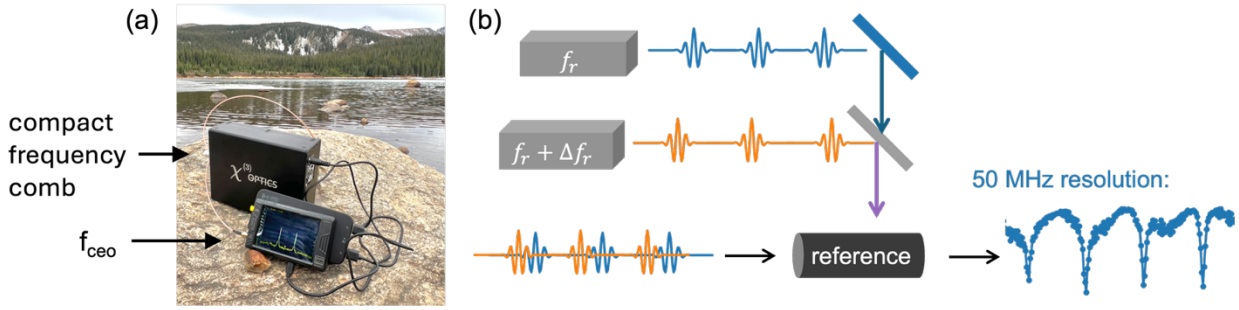

Figure 1: (a) Chi3 Optics frequency comb: developments in fully self-referenced, compact and rugged frequency combs make DCS in the telecom C-band a simple platform. (b) Concept of DCS: a dual-comb spectrometer can cover absorption features with high resolution and an absolute frequency axis.

References

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