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Optical Frequency Division for Low Noise RF to W Band Signal Generation

FRANKLYN QUINLAN, National Institute of Standards and Technology

Modern optical frequency references have extraordinary spectral purity, with lasers stabilized to passive optical reference cavities reaching fractional frequency instabilities below 10^{-16} at 1 second, and optical atomic clocks approaching 10^{-18} at 10^4 seconds. Both the short- and long-term stability providing by ultrastable optical references can find new utility after high fidelity conversion to the electrical domain, including precision microwave spectroscopy, navigation and radar systems, and an optical clock-based redefinition of the SI second. Frequency division from an optical reference at 100s of THz to RF and microwave frequencies is performed by phase locking an optical frequency comb to the optical reference, followed by optical-to-electrical conversion with a high-speed photodetector. This process generates RF and microwave carriers at the harmonics of the repetition rate of the optical frequency comb, all of which ideally maintain the fractional stability of the optical reference. This talk will cover the performance of current and next-generation optical references, as well as the current and required performance of optical frequency combs and optical-to-electrical conversion needed to support the exquisite performance available in the optical domain. To date, 1 second instability $<10^{-15}$ at 10 GHz has been demonstrated, limited by the optical reference. Optical-to-electrical conversion has been shown to support state-of-the-art optical references, with added noise at a level of 10^{-17} at 1 second, and $<10^{-19}$ at 10^3 seconds. Techniques to extend the frequency range into the millimeter-wave domain while maintaining 10^{-15} fractional instability, as well as arbitrary frequency generation with sub-millihertz precision tuning, will also be discussed.