

FIBERED AND INTEGRATED APPROACHES FOR ULTRA HIGH Q OPTICAL RESONATORS AND COMB GENERATION APPLICATION TO MICROWAVE AND MMW SOURCES

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Keywords : optical resonator, WGM resonator, fiber resonator, optoelectronic oscillator, microwave optics, phase noise

Thanks to the availability of ultra high Q factors in the optical domain, optics is today a powerful technique to generate frequency reference signals in the whole electromagnetic spectrum. Microwave (1 to 30 GHz) and millimeter wave (30 to 300 GHz) sources can take benefit of this advantage when they are locked to ultra high Q optical resonances, using at least two modes of a resonator whose frequency separation corresponds to the microwave frequency to be generated. In the optical domain, frequency stabilized combs based on active or passive resonators are powerful tools for spectroscopy or time-frequency applications.

Over the last years, we have developed at LAAS a high spectral purity microwave oscillator referenced to a fiber ring resonator (featuring a Q factor higher than 10^9). In this system, the single-frequency laser is first stabilized to the resonator using the Pound Drever Hall technique, and the resonator lateral modes are used to stabilize the microwave oscillation. The measured phase noise of this system is as low as -128 dBc/Hz at 10 kHz offset from the 10.2 GHz frequency [1]. To obtain this result, we have developed a detailed understanding of the noise origin and properties of this system, including the conversion of the laser noise (FM and AM) into microwave noise and the generation of excess noise in the high Q resonator itself due to the ultra-high intra-cavity power enhancement factor and associated nonlinear behaviors.

Our goal is now to reduce the system size, to reach higher operating frequencies but also to explore other system topologies, such as the combination of a mode locked fiber laser and a microwave oscillator.

For size reduction, we investigated the use of mini-disks resonators (CaF_2 disks) evanescently coupled to tapered fibers in place of the fiber ring resonator [2]. In this solution, the resonator coupling was mechanically too sensitive, and further size reduction will require a more robust approach for resonator coupling, together with the use of direct optical locking between laser and resonator. However, because of the ultra high Q of such resonators, the onset of some nonlinear effects was reached for relatively low power levels. Therefore, optical combs can be directly generated inside the resonator using four wave mixing processes and could lead to further size reduction and simpler systems.

To address the mechanical stability issue, we are currently working on various approaches to integrate these resonators. Small size resonators ($\sim 100 \mu\text{m}$) will be dedicated to optical applications, while large size resonators ($> 500 \mu\text{m}$) will be used to stabilize millimeter wave sources. The resonators under study at LAAS are mainly based on GaAs disks and Si_3N_4 rings.

References:

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