

Ultrastable dual frequency comb generation using whispering gallery resonators

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A frequency comb generator produces coherent light with a spectrum comprising equally spaced lines. Frequency combs have many uses, including frequency multiplexing of telecoms signals, optical frequency atomic clocks, and low noise generation of microwave frequencies.

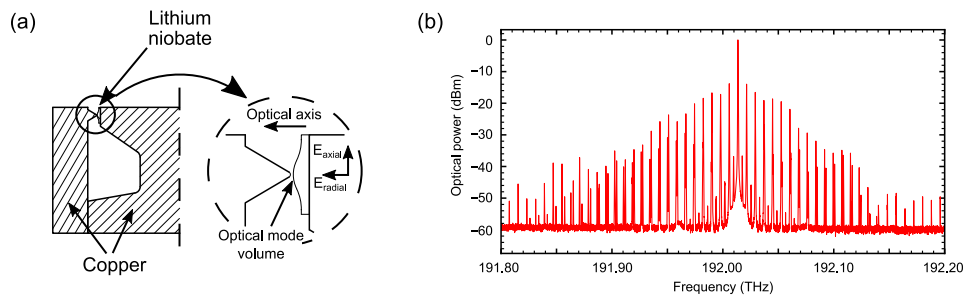


Figure 1: Dual comb generation. (a) Device architecture, comprising a prism-coupled LiNbO₃ WGM resonator embedded in a metallic microwave cavity. (b) The dual comb spectrum resulting when the microwave cavity is pumped with microwave tones at 7.814 GHz and 7.934 GHz.

By combining two combs with different line spacing, a dual frequency comb results. Applications of dual combs often require a high level of mutual coherence between combs [1], but achieving this can be demanding, and often requires elaborate feedback methods. We demonstrate a dual frequency comb [2] in which electro-optic modulation of the refractive index of lithium niobate (LiNbO₃) creates comb lines as sidebands around an optical pump. To enhance the non-linear effects in the LiNbO₃, we fabricate a whispering gallery mode (WGM) resonator with Q-factor $\sim 10^8$, and embed it in a metallic microwave cavity. This leads to resonant enhancement of the optical and microwave fields, and an effective increase in the electro-optic coefficient. The resulting combs are efficiently generated and ultrastable. Our combs have a relative linewidth of $\sim 500\mu\text{Hz}$, and require no stabilisation or post-processing methods.

- [1] P. Trocha, M. Karpov, D. Ganin, M. H. P. Pfeiffer, A. Kordts, S. Wolf, J. Krockenberger, P. Marin-Palomo, C. Weimann, S. Randel, W. Freude, T. J. Kippenberg, C. Koos, “Ultrafast optical ranging using microresonator soliton frequency combs,” *Science* **359**, 887 (2018).
- [2] Alfredo Rueda, Florian Sedlmeir, Madhuri Kumari, Gerd Leuchs and Harald G. L. Schwefel, “Resonant electro-optic frequency comb” *Nature* **568**, 378 (2019)