

# Optical frequency combs induced by modulation instability in fiber Fabry-Pérot resonators: impact of the pump pulse duration

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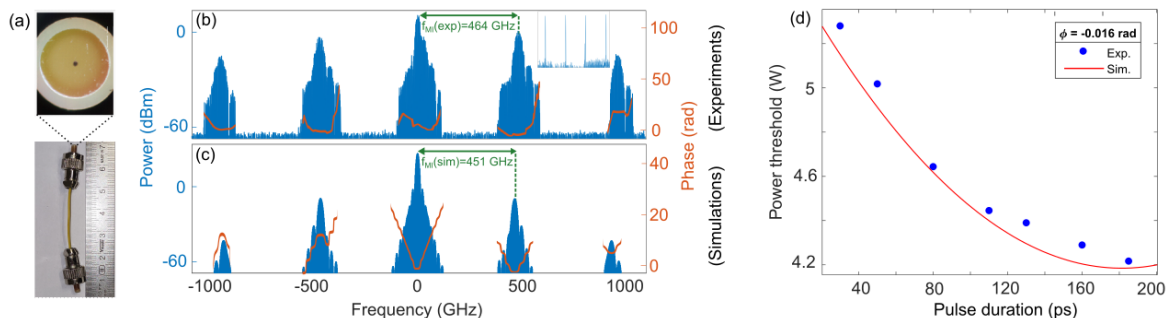
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Laser frequency combs, which consist of equidistant laser lines, have revolutionized time-keeping, metrology, and spectroscopy. In recent years, there has been progress in the development of optical frequency comb based on compact microresonators [1]. Fiber Fabry-Pérot resonators appeared as an interesting alternative of chip-scale microresonators combining their advantages with those of fiber ring cavities, namely, high quality factor, compact design, low energy consumption, and the capability to be easily implanted in fibered devices thanks to FC/PC connectors [2]. Interestingly, the nonlinear dynamics of these devices change compare to ring cavities due to the cross-phase modulation (XPM) effect between the temporal overlap of the forward and backward pulses.

Here, we focus on the impact of the XPM on MI Kerr frequency combs generation in FP resonators. We designed and fabricated an all-fiber Fabry-Pérot resonator made of a standard 6.51-centimeter SMF-28 mounted on FC/PC connectors. Highly reflective mirrors deposited on both connector ferrules lead to a quality factor of 38.5 million (Fig. 1. (a)). The cavity is implanted in a fiber setup and pumped with a 70 ps square pulse train with 4.5 W peak power, for which the repetition rate matches the cavity length. The pump laser is locked at a cavity detuning  $\Phi = -0.016$  rad thanks to a servo loop. The frequency comb is characterized in intensity and phase using a commercial 10 MHz resolution heterodyne detection system (BOSA) to analyse each tooth of the comb (Fig. 1. (b)). More than 125 comb teeth are observed in each MI side lobes and harmonics. The results are in good



**Fig. 1** Observation of modulation instability Kerr frequency combs in a fiber Fabry-Pérot resonator. (a) Pictures of the used fiber Fabry-Pérot resonator and one of its mirrors deposited at each extremity. (b) and (c) Observed and simulated MI comb spectrum at the resonator output. The box in (b) shows the resolution of the teeth of the measurement. (d) MI power threshold as a function of the input pulse duration for a given detuning (-0.016 rad); red line, numerics; blue dots, experiment.

agreement with numerical simulations based on the coupled mode theory [3] (Fig. 1. (c)). Then, we tuned the input pump pulse duration to investigate the impact on the MI process dynamics. Thus, the magnitude of the XPM between the forward and the backward waves is modified. We found the MI threshold significantly decreases with the pump pulse duration moving from 5.2 W to 4.2 W by increasing the duration from 37 ps to 180 ps. (Fig. 1. (d)).

We report the observation of modulation instability Kerr combs in an all-fiber high-quality factor Fabry-Pérot resonator. We show the pulse duration modifies the dynamics of the process by increasing the MI threshold at short durations in agreement with numerics. These works contribute to a better understanding of the dynamics of Kerr combs generation in resonators [4].

## References

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