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Photonic Crystal Ring Resonators for Tailored Microcombs

Nonlinear-wave mixing in optical microresonators offers new perspectives to generate compact optical-frequency microcombs [1], which enable an ever-growing number of applications. Microcombs exhibit a spectral profile that is primarily determined by their microresonator's dispersion; an example is the $sech^2$ spectrum of dissipative Kerr solitons under anomalous group-velocity dispersion.
Photonic crystal ring resonators (PhCR) constitute an important step toward flexible tailoring of optical cavities [2]. They consist in a ring resonator in which a corrugation is added to the inner wall of the waveguide. This allows a targeted and independent control of the resonance frequencies of a cavity mode, while maintaining the ring's high quality factor (Q). This approach provides programmable mode-by-mode frequency splitting and thus greatly increases the design space for controlling the nonlinear dynamics of optical states such as Kerr solitons.
We investigate the benefits of this added control for the control and generation of microcombs in the normal dispersion regime and to implement a 'meta-dispersion' resonator by selectively controlling the resonance of multiple modes. Along with their modeling, we present some newly observed dynamics in these cavities.
By pairing the system's governing equation into a genetic algorithm, we are able to efficiently identify a dispersion profile that produces a microcomb closely matching a user-defined target spectrum [3].

References

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[2] S.-P. Yu et al. “Spontaneous pulse formation in edgeless photonic crystal resonators”. Nat. Phot. 15.6 (2021).
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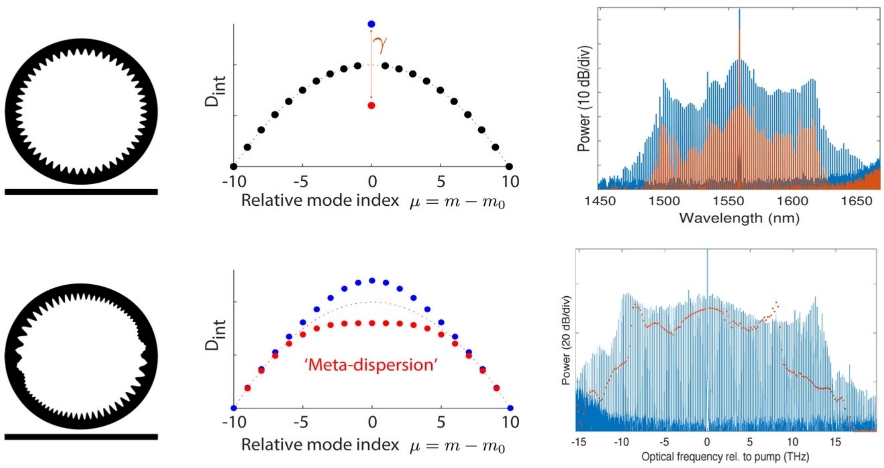

Figure 1: Comb generation in photonic crystal ring resonator. Top: single mode manipulation in normal dispersion. Bottom: meta dispersion for comb flattening.