



CHALMERS
UNIVERSITY OF TECHNOLOGY

Bidirectional initiation of dissipative solitons in photonic molecules

Downloaded from: <https://research.chalmers.se>, 2024-03-13 08:51 UTC

Citation for the original published paper (version of record):

Helgason, Ò., Ye, Z., Schröder, J. et al (2021). Bidirectional initiation of dissipative solitons in photonic molecules. 2021 Conference on Lasers and Electro-Optics Europe and European Quantum Electronics Conference, CLEO/Europe-EQEC 2021, June 2021.
<http://dx.doi.org/10.1109/CLEO/Europe-EQEC52157.2021.9542193>

N.B. When citing this work, cite the original published paper.

Bidirectional initiation of dissipative solitons in photonic molecules

Óskar B. Helgason, Zhichao Ye, Jochen Schröder, Victor Torres-Company

Department of Microtechnology and Nanoscience, Chalmers University of Technology, SE-41296 Gothenburg, Sweden

Dissipative solitons (DSs) can be generated in microresonators featuring Kerr nonlinearities via continuous wave (CW) pumping, forming a frequency comb in the spectral domain [1]. While single cavity DSs have been thoroughly investigated in the last years, recent efforts have moved towards photonic molecules (linearly coupled cavities). These arrangements give rise to exotic physical phenomena [2,3] and practical improvements in terms of conversion efficiency and tuneable comb dynamics [4,5]. In a recent study of normal dispersion photonic molecules [3], we found that DSs can be generated in absence of intracavity CW bistability. Here, we show that this feature enables the CW initiation of DSs, tuning the laser into resonance either from the blue side or the red side. While DS initiation from the red side has been demonstrated with the photorefractive effect [6], this is the first demonstration of bidirectional initiation that only requires a Kerr nonlinear medium.

For our experiments we apply 10 mW laser power to the photonic molecule from [3] (Fig. 1a), also adapting a similar numerical analysis. Using the parameters measured from our photonic molecule, we show the simulated evolution of intracavity peak power of the main cavity (Fig. 1b). Tuning the laser into resonance from the blue side (blue trace), the intracavity power matches the CW steady state at low powers. Tuning further into resonance, power builds up inside the cavity enabling the generation of a DS, with the soliton branch stretching into the CW bistability regime. The red trace shows the peak power evolution for the case when the laser approaches the resonance from the red side. It follows the lower branch of the CW steady state towards the edge of the bistability region, where the intracavity power jumps towards the upper CW branch. This increase in power results in a DS being generated, reaching the same soliton branch as with the blue side initiation. In Fig. 1c, we show experimental results for this bidirectional operation. The converted comb power (conversion) is measured in the 1580-1590nm span. Tuning from the blue side, the laser first pushes through the auxiliary resonance before reaching the soliton branch in the main resonance (227.3 GHz FSR). The laser frequency is tuned further until the comb state drops. At this point, the laser is set to tune backwards and initiates a DS from the red side, as indicated by the conversion trace. We find that these DSs belong to the same soliton branch as the DSs initiated from the blue side. This is illustrated in Fig. 1d, where spectrum “1” was initiated from the blue side. For comparison, the spectrum in “2” is acquired by first initiating from the red side, then decreasing the laser frequency until the comb state matches spectrum “1”.

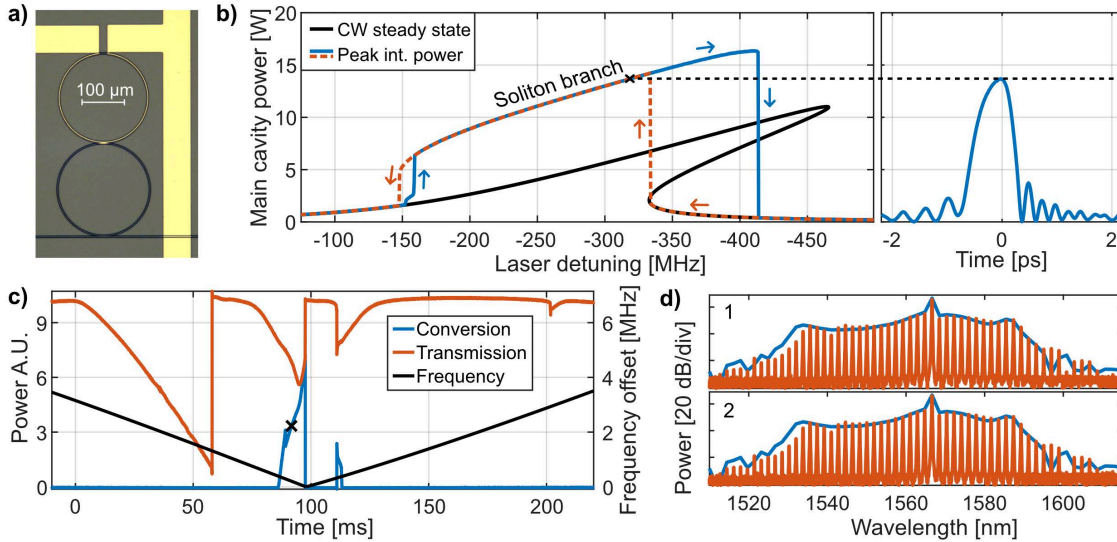


Fig. 1 a) Photonic molecule used to generate our DSs [3]. b) The CW steady state and intracavity peak power in the main cavity as a function of laser detuning, with an example of a DS shown on the right. c) The process of initiating the DS, first by decreasing laser frequency, then by increasing laser frequency, where the conversion marks the location of comb generation. d) The measured spectrum (red) of point depicted in c), after initiation from the blue side (1) and the red side (2), with the simulated spectral envelope (blue) corresponding to the DS in b).

References

- [1] T. J. Kippenberg, et al., “Dissipative Kerr solitons in optical microresonators,” *Science* **361**, 567 (2018)
- [2] A. Tikan, et al., “Emergent Nonlinear Phenomena in Driven Dissipative Photonic Dimer,” <https://arxiv.org/pdf/2005.06470.pdf> (2020)
- [3] Ó. B. Helgason, et al., “Dissipative solitons in photonic molecules,” *Nat. Photonics* (2021)
- [4] B. Y. Kim, et al., “Turn-key, high-efficiency Kerr comb source,” *Opt. Lett.* **44**, 4475-4478 (2019)
- [5] X. Xue, et al., “Normal-dispersion microcombs enabled by controllable mode interactions,” *Laser Photon. Rev.* **9**, L23-L28 (2015).
- [6] Y. He, et al., “Self-starting bi-chromatic LiNbO₃ soliton microcomb,” *Optica* **6**, 1138-1144 (2019)