MASTER INTERNSHIP M2 PPN (5 months)

2023-2024

Title of the project: High Saturation Power Erbium-Doped Fiber Amplifier (EDFA) for Kerr Comb Generation

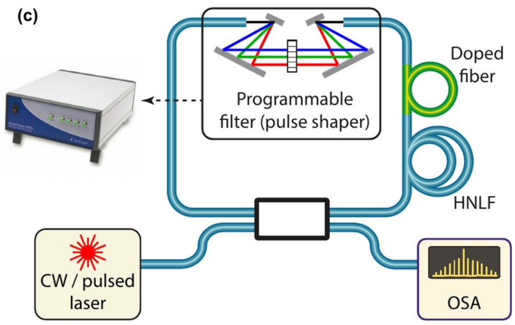
Supervisor(s): Dr. Erwan Lucas

Laboratory / Department / Team : **ICB / Photonics / SAFIR**

Summary:

Optical frequency combs (OFCs) are precise arrays of evenly spaced optical frequencies, serving as a light ruler with applications spanning high-precision spectroscopy to telecommunications [1]. A notable breakthrough in OFCs involves the creation of soliton pulses within Kerr resonators [2], [3], yielding robust, short, and bright temporal structures termed dissipative cavity solitons. These innovations have opened doors to diverse applications, particularly in microresonators [4]. However, inherent limitations, such as fixed spectral shapes and low conversion efficiency of solitons, pose challenges in practical applications.

The objective of this Master's thesis is to lay the groundwork for the development of highly optimized comb sources that can be customized on-demand [5]. The primary focus will be on the design, assembly, and testing of an Erbium-Doped Fiber Amplifier (EDFA) with a high saturation power [6]. This amplifier plays a pivotal role within the envisioned cavity system, counteracting losses introduced by additional components [7], including filters, which will be instrumental in shaping the Kerr combs.



Your responsibilities during this educational and research-oriented internship will encompass both theoretical and experimental aspects. This will include tasks such as simulating optical gain and saturation power, integrating gain into nonlinear equations simulations, assembling, testing, and fine-tuning the amplifier, and exploring Kerr comb generation in a non-lasing active cavity. Proficiency in coding is imperative for this project, and an affinity for experimental science is also highly valued. This internship opportunity will be hosted within the specialized team in nonlinear photonics at the ICB laboratory in Dijon, offering an exceptional platform to expand your knowledge.

References

[1] S. A. Diddams, K. Vahala, and T. Udem, "Optical frequency combs: Coherently uniting the electromagnetic spectrum," *Science*, vol. 369, no. 6501, p. eaay3676, Jul. 2020, doi: 10.1126/science.aay3676.

[2] F. Leo, S. Coen, P. Kockaert, S.-P. Gorza, P. Emplit, and M. Haelterman, "Temporal cavity solitons in one-dimensional Kerr media as bits in an all-optical buffer," *Nature Photonics*, vol. 4, no. 7, pp. 471–476, Jul. 2010, doi: 10.1038/nphoton.2010.120.

[3] T. Herr *et al.*, "Temporal solitons in optical microresonators," *Nature Photonics*, vol. 8, no. 2, pp. 145–152, Dec. 2013, doi: 10.1038/nphoton.2013.343.

[4] T. J. Kippenberg, A. L. Gaeta, M. Lipson, and M. L. Gorodetsky, "Dissipative Kerr solitons in optical microresonators," *Science*, vol. 361, no. 6402, p. eaan8083, Aug. 2018, doi: 10.1126/science.aan8083.

[5] E. Lucas, S.-P. Yu, T. C. Briles, D. R. Carlson, and S. B. Papp, "Tailoring microcombs with inverse-designed, meta-dispersion microresonators," *Nature Photonics*, pp. 1–8, Jul. 2023, doi: 10.1038/s41566-023-01252-7.

[6] C. R. Giles and E. Desurvire, "Modeling erbium-doped fiber amplifiers," *Journal of Lightwave Technology*, vol. 9, no. 2, pp. 271–283, 1991, doi: 10.1109/50.65886.

[7] N. Englebert, C. Mas Arabí, P. Parra-Rivas, S.-P. Gorza, and F. Leo, "Temporal solitons in a coherently driven active resonator," *Nature Photonics*, vol. 15, no. 7, pp. 536–541, Jul. 2021, doi: 10.1038/s41566-021-00807-w.

Type of project (theory / experiment): Numerical and experimental

Required skills: Good knowledge in nonlinear fibre optics, Coding (Python/MATLAB)