Erasmus Mundus Master QuanTEEM
Master Internship

TITLE	Topological localized structures in pocket-size Kerr resonators
SUPERVISOR	Julien Fatome - jfatome@u-bourgogne.fr
INSTITUTION	Université de Bourgogne-CNRS
LAB / DEPARTMENT / TEAM	ICB, team Safir
COLLABORATIONS	University of Auckland, ULB Brussels, Max Planck Erlangen
TYPE OF PROJECT (theory / experiment)	Numerical and experimental

Summary

Optical frequency combs (OFCs) are light sources which emit a broad and coherent spectrum made of discrete and evenly spaced frequency lines. They can act as “spectral optical rulers” that enable to measure unknown optical frequencies with extraordinarily high precision. Frequency comb systems commercially available mainly rely on bulky ultrashort-pulse lasers and supercontinuum technologies. However, a fundamentally different approach was demonstrated in 2007, when continuous laser light was shown to be transformed into an evenly-spaced comb when confined into a nonlinear Kerr microresonator. It is now well understood that such OFC generation in nonlinear Kerr resonators is mostly based on the emergence of robust, localized temporal structures, called dissipative cavity solitons (CSs). First observed in a macroscale optical fibre ring and demonstrated subsequently in microresonators, CSs have attracted growing interest over the past decade and have led to major advances in numerous fields of science such as optical communications, astrocombs, topology, and spectroscopy. Complementary to these ring architectures, Fabry–Perot (FP) Kerr mesoresonators made of few cms of optical fibre encapsulated between dispersive mirrors represent a promising and versatile approach for advanced OFCs generation. First, their native repetition rates range from hundreds of MHz to tens of GHz, thus bridging the gap between fibre loops and microresonators. Furthermore, they combine the flexibility and stability of fibre-based systems as well as dispersion engineering of integrated platforms, whilst preserving interestingly high-Quality factors. FP Kerr resonators have nowadays gained a boost of interest with a plethora of opportunities for dispersion engineering and system scalability. In this project, we will develop versatile and pocket-size GHz-FP Kerr resonators for advanced OFCs generation. In particular, we will investigate the vectorial nature of light and quantum walk applications in normal GVD FP resonators. We will show that the circulating light can spontaneously break its symmetry between the two polarization modes of the cavity and forms topological vectorial localized structures which can propagate endlessly in the resonator.

References:
B. Garbin, J. Fatome et al. Phys. Rev. Lett. 126, 023904 (2021)
G. Xu, J. Fatome et al. Nature Communications 12, 4023 (2021)
N. Englebert, J. Fatome et al. Nature Physics, 19, 1014, (2023)
J. Fatome et al. arXiv:2106.07642 (2021).

Additional Information

Required skills: Good knowledge in nonlinear fibre optics & Matlab