PhD Thesis Proposal

Title: Nonlinear dynamics in multi-component fibre Kerr resonators
Laboratory: Laboratoire ICB – UMR 6303
PhD Supervisor(s): J. Fatome jfatome@u-bourgogne.fr et E. Lucas erwan.lucas@u-bourgogne.fr
Research fields: Nonlinear fibre optics

Context:
This Phd thesis takes place in the framework of an international project funded by the CNRS: Wall-IN project established in collaboration between the ICB laboratory and the University of Auckland (NZ). The aim of this project in to study the nonlinear dynamics of lightwave circulating in multi-component Kerr resonators (isotropic or few mode fibres). https://cnrssingapore.cnrs.fr/project/irp-wall-in/

Scientific project:
Optical frequency combs (OFCs) are coherent light sources which emit a broad and coherent spectrum made of discrete and evenly spaced frequency lines. They are widely used as optical frequency rulers and have led to major advances in numerous fields of science such as spectroscopy, metrology, astronomy or high-capacity optical communications. The generation of such OFCs in nonlinear Kerr resonators is mostly based on the emergence of robust, short and bright temporal structures, called dissipative cavity solitons (CSs). First observed in a macroscale optical fibre ring in 2010, CSs have attracted growing interest over the past decade after being identified as key elements for OFCs generation in integrated microresonators. However, CSs are mostly restricted to optical platforms characterized by anomalous group velocity dispersion (GVD), which dramatically limits the range of available spectral bands and thus potential applications. Indeed, recalling that numerous materials are characterized by strong normal dispersion, in particular in the mid-infrared where molecules provide strong absorptions, there is a growing interest in the generation of short temporal and robust structures in normally dispersive Kerr resonators. In this thesis, we will extend the applications of OFCs and associated dissipative temporal structures in normal GVD Kerr resonators around 1.55µm. Our strategy is first based on the investigation of novel vectorial as well as multimode nonlinear dynamics in fibre based macroresonators, which are known to be governed by the same equations than microresonators, whist providing much easier and versatile experimental implementation. Subsequently, our findings will be investigating within mesoresonators (Fabry-Pérot cavities) and active-fibre loops and finally in integrated Kerr microresonators.

References:

G. Xu,..., J. Fatome *et al.* "Spontaneous symmetry breaking of dissipative optical solitons in a two-component Kerr resonator," Nat. Commun. **12**, 4023 (2021).
N. Englebert,..., and J. Fatome. "Bloch oscillations of coherently driven dissipative solitons in a synthetic dimension," Nat. Phys. **19**, 1014 (2023).
S. Coen,... and J. Fatome. "Nonlinear topological symmetry protection in a dissipative system," Nat Commun **15**, 1398 (2024).
E. Lucas,..., and J. Fatome. "Polarization faticons: Chiral localized structures in self-defocusing Kerr resonators," arXiv:2412.05116 (2025).

Required skills:
The candidate must have a Master's degree in physics or a related discipline. Good knowledges in nonlinear optics and optical fibres are required. Good skills in numerical simulations will be appreciated as well as an advanced English level. Scientific rigor, autonomy and intellectual curiosity are some of the essential skills required for this project.