Lab project M1 PPN & QuanTEEM

12/05/2025 – 20/06/2025

Title of the project: Intermodal nonlinear interactions in multimode and birefringent optical fibers

Supervisor(s): Guy Millot

Laboratory / Department / Team: ICB/Photonics/SAFIR

Collaborations: Théo Thorres, Bertrand Kibler

Summary:

The study of intermodal nonlinear interactions in multimode optical fibers is a very active field of research due to the observation of spectacular physical phenomena, such as self-beam cleaning, multimode solitons or supercontinuum generation over several octaves ranging from the visible to the near-infrared wavelengths [1-3]. These fibers also open up new applications in imaging, optical communications and high-power lasers. Experiments have been carried out for excitations of these fibers mainly in the near infrared at 1.06 µm and 1.55 µm.

In this internship, we propose to couple laser pulses into graded-index or microstructured multimode fibers in the visible range at 532 nm. The aim is to observe the generation of new frequencies extending into the near ultraviolet. Interpretation of the experimental data will be based on the phase-matching conditions of intermodal four-wave mixing phenomena.

A second objective of the internship will be to exploit polarization effects in highly birefringent multimode optical fibers. Special fibers with appropriate dispersion and birefringence parameters will be supplied by the XLIM laboratory in Limoges. Our aim is to observe novel effects linked to the birefringence properties of multimode optical fibers, a topic that has not been studied to date.

Main references which can be supplied on request:

[1] K. Krupa, A. Tonello, A. Barthélémy, T. Mansuryan, V. Couderc, G. Millot, P. Grelu, D. Modotto, S. Babin, S. Wabnitz. Multimode Nonlinear Fibre Optics, a spatiotemporal avenue. APL Photonics **4** (110901), 1-42, 2019. https://doi.org/10.1063/1.5119434

[2] L. G. Wright, W. H. Renninger, D. N. Christodoulides, F.W. Wise. Nonlinear multimode photonics: nonlinear optics with many degrees of freedom, Optica **9**, 824-841, 2022. https://doi.org/10.1364/OPTICA.461981

[3] Y. Sun, P. Parra-Rivas, G. P. Agrawal, T. Hansson, C. Antonelli, A. Mecozzi, F. Mangini, S. Wabnitz. Multimode solitons in optical fibers: a review, Photon. Res. **12**, 2581-2632, 2024. https://doi.org/10.1364/PRJ.531393

Type of project (theory/experiment): Mainly experimental with numerical simulations using Matlab

Required skills: A keen interest in optical experiments with different types of lasers and optical fibers. Theoretical interpretation of experimental results with the help of numerical simulations. High motivation and personal commitment.