PhD GRANT 2024 (Funded)

PhD project title: Nonlinear optics in gas-filled hollow core antiresonant fibers

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Laboratory: PhLAM, University of Lille

Application deadline: May 17th 2024.

PhD project summary

Gas-filled hollow-core waveguides bring together nonlinear fibre optics and high-field laser science [1], thus providing access to novel nonlinear dynamics, new powerful tools for manipulating ultrashort light pulses, and enhanced light-matter interaction. The optical properties of these waveguides, such as the broadband transmission, the weak dispersion and the high-damage threshold, allow guiding of extremely short and intense laser pulses and excellent control over their nonlinear propagation dynamics. Harnessing these enables the development of new efficient and broadband light sources in spectral regions otherwise not easily accessible [2–4]. Most experimental and theoretical works with these platforms investigated single-mode dynamics in straight fibres (with a few exceptions, e.g., [5,6]). Our project is about exploring new dimensions and dynamics involving few and many spatial modes. We will use single- and multi-mode anti-resonant hollow-core fibres with constant longitudinal profiles and optical properties varying along their length. In this fashion, we will ensure long interaction lengths in a highly controllable environment. In these platforms, we want to study and exploit nonlinear dynamics to develop new flexible light sources (e.g., for dual-comb spectroscopy, multiphoton imaging, THz generation, etc.), to investigate unexplored fundamental nonlinear phenomena and study the properties of matter. The fibres will be designed, manufactured and characterized at the FiberTech platform, and the nonlinear optics experiments will involve working with high-power ultrashort pulses over a wide spectral range spanning from the ultraviolet to the mid-infrared. The design of the experiment and analysis of the data will rely on advanced and verified numerical codes and the further development of those.

We seek highly motivated candidates with a strong academic performance record in photonics, physics or engineering, a good command of English and hands-on experience. Laboratory experience and familiarity with programming (e.g., Python, Matlab) will be highly valued. Candidates should be creative and have the will to learn. The gross salary will be 2100 € /month minimum.

[1] P. St. J. Russell, P. Hölzer, W. Chang, A. Abdolvand, & J. C. Travers, *Hollow-Core Photonic Crystal Fibres for Gas-Based Nonlinear Optics*, Nat. Photonics **8**, 278 (2014).
[2] F. Köttig, F. Tani, C. M. Biersach, J. C. Travers, & P. St. J. Russell, *Generation of Microjoule Pulses in the Deep Ultraviolet at Megahertz Repetition Rates*, Optica **4**, 1272 (2017).
[3] U. Elu et al., *Seven-Octave High-Brightness and Carrier-Envelope-Phase-Stable Light Source*, Nat. Photonics **15**, 4 (2021).
[4] F. Tani, J. Lampen, M. Butryn, M. H. Frosz, J. Jiang, M. E. Fermann, P. St. J. Russell, *Temporal Self-Compression and Self-Frequency Shift of Submicrojoule Pulses at a Repetition Rate of 8 MHz*, Phys. Rev. Applied **18**, 064069 (2022).
[5] F. Tani, J. C. Travers, and P. St.J. Russell, *Multimode Ultrafast Nonlinear Optics in Optical Waveguides: Numerical Modeling and Experiments in Kagomé Photonic-Crystal Fiber*, J. Opt. Soc. Am. B **31**, 311 (2014).
[6] M. I. Suresh, J. Hammer, N. Y. Joly, P. St. J. Russell, and F. Tani, *Deep-UV-Enhanced Supercontinuum Generated in a Tapered Gas-Filled Photonic Crystal Fiber*, Opt. Lett. **46**, 4526 (2021).