University of Pavia

Ph.D. School of Electrical and Electronics Engineering and Computer Science

SEMINAR

NONLINEAR PHENOMENA IN GAS-FILLED HOLLOW-CORE FIBERS

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Abstract: High-energy ultrashort optical pulses have opened new avenues in the investigation of ultrafast and strong-field-driven phenomena including generation of high-energy isolated attosecond pulses, probing and driving dynamics in matter, and ultrabroadband terahertz (THz) generation. However, the direct generation of such pulses, potentially down to the single-cycle duration, is still very challenging and requires extremely broadband spectra not directly available from common laser gain media. Therefore, for operation in the few-cycle regime, the spectra of laser pulses have to be further extended by means of nonlinear effects and, in most cases, recompressed afterwards. In addition, systems based on optical-parametric amplification or four-wave mixing can be used to tune the central frequency of the laser in the infrared or visible regions at the expenses of the overall efficiency and system complexity required to manage dispersion and nonlinearities over broad amplification bandwidths. Originally introduced for pulse compression by Nisoli et al. in 1996, nowadays, gas-filled hollow-core fibers (HCFs) represent a unique platform to explore a variety of nonlinear phenomena. On one side, despite their lower nonlinearity with respect to their bulk counterparts, gases offer a (almost) dispersionless environment while, on the other, HCFs ensure extended propagation distances in the order of meters. Therefore, meters-long gas-filled HCFs allows to moderately drive nonlinear pulse propagation, avoiding detrimental nonlinear effects that distort the spectral phase and thus achieving a well-defined output. In this seminar, we show that gas-filled HCFs can be successfully employed in a vast variety of situations including extreme pulse broadening and compression, ultrabroadband THz generation, extreme Raman red-shift, and supercontinuum generation.

Bio: **Riccardo Piccoli** received his Bachelor (2009), Master (2011), and PhD (2014) Degrees in Electronics Engineering from University of Pavia on the design and characterization of laser sources under the supervision of Prof. A. Agnesi and Prof. G. Reali. He also spent a period abroad at Swansea University (Wales, UK) with Prof. S. Taccheo, where he studied Photodarkening effect in Yb-doped fibers as a part of the European project: Leadership in Fiber Technology (LIFT). In February 2015, he joined the INRS-EMT Research Center (Canada) as Postdoctoral Fellow under the supervision of Prof. R. Morandotti and Prof. L. Razzari. Since then, he has been investigating different fields including THz science (detectors, waveguides, imaging), metamaterials and plasmonic nanostructures from visible to THz frequencies, as well as nonlinear phenomena in gas-filled hollow-core fibers. These projects are carried out in collaboration with prestigious institutions such as MIT (USA), Institut Polytechnique de Paris (France), Heriot-Watt University (UK), TU Wien (Austria), and IIT (Italy). Soon after a brief visiting period at the Max-Planck-Institut für Kernphysik (Germany), he joined in October 2020 the Weizmann Institute of Science (Israel) as a Senior Researcher, where he is investigating strong-field and attosecond processes in solids with Prof. N. Dudovich. To date, Dr. Piccoli has published 28 papers in international journals (including *Nature Communications* and *Optica*), more than 70 conference contributions and seminar talks, and filed 4 patent applications.

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