

Non-linear optics for quantum applications

Abstract: Non-linear optical processes play a central role in quantum photonics, enabling the generation, manipulation, and interconnection of non-classical states of light. In particular, spontaneous parametric down-conversion and four-wave mixing have become standard approaches for the generation of entangled photon pairs and other quantum resources. Beyond these conventional two-photon states, current research also explores more complex non-linear interactions capable of producing multipartite entangled states or exploiting effective photon-photon interactions at the single-photon level, opening the way toward richer quantum networks and advanced quantum information protocols. In parallel, non-linear frequency conversion has emerged as an essential tool for quantum technologies. Indeed, many quantum systems of interest, such as quantum memories, solid-state emitters, or molecular transitions, operate at wavelengths that are incompatible with low-loss optical fiber communication. Quantum frequency conversion provides a coherent and noise-controlled interface between these spectral domains, bridging, for example, the mid-infrared or visible ranges with the telecom bands. Such interfaces are crucial for the development of scalable hybrid quantum networks, where heterogeneous quantum systems must efficiently exchange quantum information. Together, quantum light generation and quantum frequency conversion illustrate how non-linear optics constitutes a foundational toolbox for future quantum communication, sensing, and networking technologies.



Lecturer: L. Labonté is Professor at Université Côte d'Azur and a researcher at INPHYNI. He received his PhD from the University of Limoges (2002–2005), where he worked at XLIM on the advanced characterization of microstructured optical fibers. In 2006, he joined INPHYNI as an associate professor to investigate the applications of specialty optical fibers for fiber lasers and nonlinear photonics. Building on his expertise in both linear and nonlinear optics, he progressively expanded his research activities toward quantum photonics and quantum optical interfaces. His current research focuses on quantum and nonlinear photonics, optical metrology, quantum frequency conversion, and integrated quantum technologies. He is particularly involved in the development of photonic interfaces for quantum networks and quantum sensing applications. He has coordinated and participated in 16 national and international research projects, supervised 7 PhD students and 4 postdoctoral researchers. He is the author of 40 journal publications and one patent. As founder and academic coordinator of the OPTIQ Master program, he actively promotes strong interactions between research, higher education, and industry in the fields of photonics and quantum engineering.