

Phd Thesis Defense: Engineered optical fiber structures for communication and quantum applications

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December 09, 2026
15:00 to 16:00
ICFO Auditorium

Loss is one of the main limitations in optical systems. Classical applications are generally relatively tolerant to it: attenuation can often be compensated through amplification or post-processing, at the cost of increased complexity and cost. Quantum applications are fundamentally more sensitive because information is often encoded in single photons and is lost with them. Multi-photon states can be even more vulnerable, making system scalability exponentially sensitive to loss.
Current optical systems combine active and passive components. Active devices are generally based on highly nonlinear materials, such as silicon, indium phosphide, or lithium

niobate, which are not ideal for low-loss propagation. Light is therefore typically coupled to silica optical fibers, the standard medium for passive transmission and interconnection between devices. Interfacing different material platforms, however, inevitably introduces additional coupling loss. This thesis aims to reduce this contribution by following an alternative approach: using optical fibers themselves as the active material minimizing the need to interface different platforms. The work focuses on two main devices, which eventually could even be combined.

The first project explores a novel fused fiber-bundle-like device containing embedded electrodes for active signal modulation. By relying on standard components and post-processing techniques similar to those used for fused fiber bundles, the structure can provide a low-loss interface between standard fibers and complex multi-material cross sections. I fabricated devices with a total insertion loss below 0.5 dB. Separately, I demonstrated light modulation through the DC-Kerr effect with a half-wave voltage below 20 kV. I then analyzed how these results could be combined and further improved toward an ultra-low-loss, electrically controlled fiber modulator.

The second project investigates silicon core fibers (SCFs), a type of fiber that consists of a crystalline silicon core surrounded by a pure silica cladding. To the best of my knowledge, I present the first experimental study of their use for quantum applications, specifically as a photon-pair source in the C-band based on intramodal four-wave mixing. A measured intrinsic brightness of 570 kHz/nm/mW^2, a coincidence-to-accidental ratio of 133±2, and propagation loss of ?0.3 dB/cm showed that SCFs can support room-temperature quantu sources with performance comparable to, and potentially better than, existing sources base on similar technologies. Coupling to SCFs was identified as the current main practica limitation of this platform, and I therefore proposed an alternative coupling strategy. Th strategy is based on an adiabatic transition through fiber tapering between core-modes an cladding-modes, exploiting the fact that the cladding of both SCFs and standard fibers ar made of the same material, namely pure silica. Simulations suggest that the coupler los could ultimately be limited by propagation loss in the SCF section, while preliminar experiments reached a loss of 8.6 dB/coupler.

The results obtained during my PhD show that optical fiber-based devices represent a promising platform when minimizing loss is the primary performance objective. I envision quantum applications, specifically communication and memories, and reconfigurable classical networks to be the main fields of interests of ultra-low-loss active devices.

Wednesday December 9, 15:00 h. ICFO Auditorium

Thesis Director: Prof. Dr. Valerio Pruneri and Dr. Stefano Signorini

Hosted by: Prof. Dr. Valerio Pruneri