Characterization of supercontinuum generation along a silica tapered optical fiber using a confocal micro-spectrometer

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ABSTRACT FOR TECHNICAL REVIEW (200-300 WORDS; TEXT ONLY)

While supercontinuum (SC) light has been carefully analyzed in both the time and frequency domains, allowing close comparison to numerical simulations, its longitudinal dynamics along the waveguide remains difficult to access experimentally. There is therefore a particular need for high-sensitive distributed measurement to analyze SC build up inside the nonlinear waveguide, in order to allow optimization of simulation parameters. Mapping the longitudinal SC generation along the waveguide, especially those that are non-uniform and have defects, therefore represents a valuable tool for improving multi-parameter nonlinear models, in combination with neural network algorithms. Even if a few distributed measurement techniques dedicated to SC analysis have already been demonstrated so far [1,2], none are suitable for centimeter-long nonlinear waveguides for instance for fiber taper or long-spiral integrated waveguides.
We apply a novel method based on a confocal micro-spectrometer, allowing distributed frequency-resolved Rayleigh scattering measurements along an optical waveguide in operando with both micrometer spatial resolution and sub-nanometer spectral resolution [3], to characterize SC generation along a highly tapered silica optical fiber with longitudinally varying dispersion and nonlinearity. We observed specific spectral features not seen with standard spectral analysis, in particular, the gradual generation of a multi-order Raman cascade in the first taper section enhanced by four-wave mixing, and followed by the generation of dispersive waves in the taper. All experimental observations are successfully compared to numerical simulations. From a general point of view, this technique opens new pathways for observing nonlinear phenomena localized inside photonic waveguides. It could also be exploited to map nonlinear effects in other photonic platforms such as photonic integrated circuits.

[1] R. Hontinfnde, *et al.*, Opt. letters 42, 1716 (2017).
[2] A. Coillet, *et al.*, Nanophotonics VII, SPIE, p. 106720L (2018).
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SUMMARY OF ABSTRACT FOR DISPLAY IN THE PROGRAM (50-150 WORDS; TEXT ONLY)

A novel highly-sensitive distributed measurement technique is developed, allowing for supercontinuum generation characterization along a tapered silica optical fiber. Based on a confocal Raman microscope, this technique relies on a far-field point-by-point Rayleigh scattering analysis along the waveguide with micrometer spatial resolution and high spectral resolution. This non-destructive, non-invasive technique allows each step of supercontinuum generation to be observed along the fiber taper, including cascaded Raman scattering, four-wave mixing, and dispersive wave generation, thus revealing unique spatial nonlinear dynamics not accessible with standard spectral analyzers.

Keywords: Nonlinear fiber optics, Supercontinuum generation, fiber taper, distributed optical measurement, confocal microscopy.