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Opto-acoustic Coupling and Brillouin Phenomena in Microstructure Optical Fibers

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Abstract

Like photonic crystals have revolutionized the way of manipulating optical waves at the sub-micron scale, phononic crystals have more recently played similar decisive role for sound waves, or more generally elastic waves. Then, the idea of coupling light and sound in purposely designed microstructures is now emerging. In this respect, the periodic, wavelength-scale (for both optic and high-frequency acoustic waves) transverse air-hole microstructure of photonic crystal fibers (PCFs) provides additional degrees of freedom for light-sound interactions. PCFs can indeed exhibit photonic and phononic bandgap effects, allowing for tight confinement and joint waveguiding of both types of waves [1]. Electrostriction-driven Brillouin phenomena, namely backward Stimulated Brillouin Scattering (SBS) and forward Guided Acoustic Wave Brillouin Scattering (GAWBS), constitute an important category of such opto-acoustic coupling. The geometry of PCFs can dramatically modify the Brillouin spectrum, the gain and the stimulated Brillouin threshold, globally yielding much richer opto-acoustic dynamics and spectral features than in conventional fibers [2-11]. Specific transverse or longitudinal guided acoustics modes in the 100 MHz - 10 GHz range can thus be selectively excited, resonantly enhanced and tightly confined within the microstructure, with an intimate dependence on its µm or sub-µm geometry. All these specific features have great potential for developing novel PCF-based distributed Brillouin sensors [6,7,12-14], for high-resolution longitudinal mapping of the intrinsic fluctuations of the fiber microstructure [15], and more generally for developing original tools of optical signal processing [1-4,9,16,17]. This talk will give a comprehensive overview of these original behaviors in a range of PCFs.

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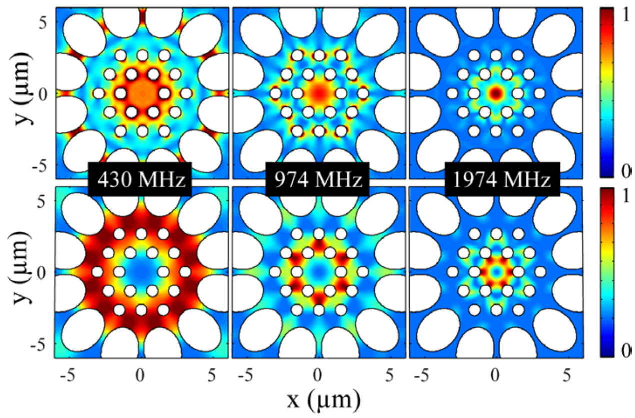

Fig. 1. (Up): strain energy density and (bottom): kinetic energy distributions calculated by full vector finite element method, showing the frequency-selective excitation of guided acoustic transverse modes in a multi-scale microstructure fiber.

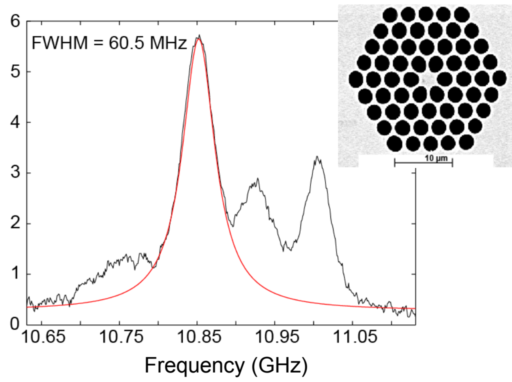

Fig. 2. Multi-peaked stimulated backward Brillouin scattering spectrum in a solid core photonic crystal fiber.

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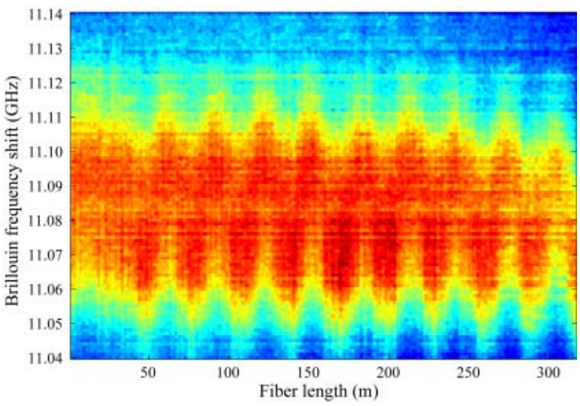

Fig. 3. Brillouin Echo Distributed Sensing measurement: Longitudinal mapping of the Brillouin gain spectrum in a periodically-varying microstructure fiber for SBS mitigation.

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