Athermal forward stimulated Brillouin scattering

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Forward stimulated Brillouin scattering (FSBS) in optical waveguides enables acousto-optic interactions between co-propagating light and guided acoustic waves, offering promising applications in integrated photonics and sensing. However, in conventional optical fibers, FSBS encounters challenges such as temperature-induced sensitivity of the acoustic resonance frequency, significant acoustic wave transmission loss in coated layer. In this work, we propose the use of aluminum-coated optical fibers to address these challenges simultaneously via two innovative mechanisms. First, we propose a novel mechanism to achieve "athermal FSBS". By optimizing the ratio of the radius and thickness of silica to aluminum to approximately 2.21, the temperature dependence of the acoustic velocity in the aluminum coating compensates for that in silica cladding, thereby achieving temperature insensitivity of the FSBS resonance spectrum, as verified through both simulation and experimental validation. Second, we propose the concept of quasi-acoustic impedance matching for enhanced sensing performance. The acoustic impedance between the silica cladding and the aluminum coating is nearly matched, minimizing acoustic field reflection at the interface and enabling high signal-to-noise ratio discrimination of air and water with a spatial resolution of 2 meters. The aluminum-coated optical fiber simultaneously exhibits a temperature-insensitive FSBS and superior optical force sensing capability, offering a significant impetus for the transition of FSBS technology from laboratory research to engineering applications.

Short Bio:

Yongkang Dong received the bachelor's and Ph.D. degrees from the Harbin Institute of Technology (HIT), Harbin, China, in 2003 and 2008, respectively. During 2008–2011, he was a Postdoctoral Fellow with the Physics Department, University of Ottawa, Canada. In 2012, he re-joined HIT as a Full Professor.

He is currently the Chief Scientist of the National Key Scientific Instrument and Equipment Development Project of China. He has authored and coauthored more than 110 international journal papers. His current research interests involve nonlinear fiber optics and Brillouin scattering based optical fiber sensor and its applications in structural health monitoring. He was the recipient of the First Prize in Provincial Natural Science Award in 2013, the First Prize in Provincial Science and Technology Progress Award in 2017, and the Innovation Award of Chinese Society for Optical Engineering in 2021.