

Locating Auxiliary Elastic Resonances in Silica Microwires

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Different classes of auxiliary elastic resonances along a microwire are generated and detected using a phase-correlation distributed Brillouin measurement method. Experimental results reveal the diverse acoustic spatio-spectral dynamics inside a microscale structurally-varied optical waveguide.

The existence of multiple auxiliary elastic resonances in silica microwires have been experimentally verified by detecting the spontaneous Brillouin backscattering generated by thermally-excited acoustic waves [1]. Although such measurements indicate the existence of multiple elastic resonances in the entire sample, applied techniques so far have not resolved the exact longitudinal location of each resonance mode inside the microwire. Indeed, the existence of each acoustic mode highly depends on the diameter of the microwire, and therefore inside a tapered fibre section, different resonance frequencies are expected to be found at different longitudinal positions of the taper. Here, we propose a method to stimulate and probe different classes of acoustic waves at specific locations inside a microwire, thus pinpointing precisely their respective locations and amplitude. We demonstrate that, by using a distributed Brillouin measurement method based on phase correlation, the Brillouin frequencies associated to the different acoustic modes can be fully mapped along a tapered fibre with a spatial resolution of a few centimetres [2, 3], as shown in Fig. 1. This approach can open up a previously-unexplored way to better understand the fundamental physical behaviours of guided acoustic waves with changing structural dimensions.

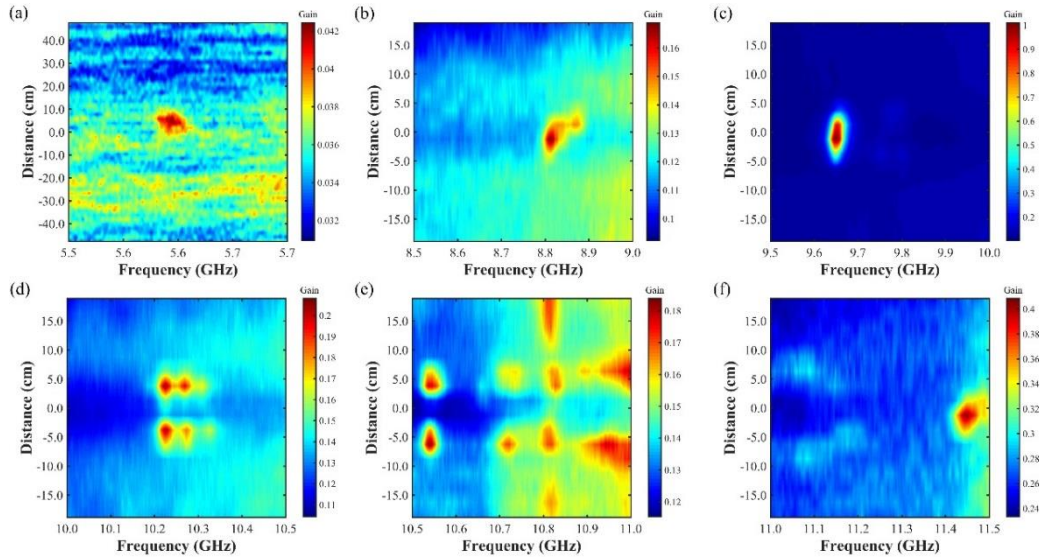


Fig. 1: Distributed Brillouin gain spectra measured at different positions of a silica microwire, for different frequency ranges: (a) 5.5 – 5.7 GHz, (b) 8.5 – 9.0 GHz, (c) 9.5 – 10.0 GHz, (d) 10.0 – 10.5 GHz, (e) 10.5 – 11.0 GHz and (f) 11.0 – 11.5 GHz. The centre of the tapered waist (diameter = 1 μ m, length = 4 cm) corresponds to the position set as 0 cm.

References

- [1] J.-C. Beugnot, S. Lebrun, G. Pauliat, H. Maillotte, V. Laude, and T. Sylvestre, “Brillouin light scattering from surface acoustic waves in a subwavelength-diameter optical fibre,” *Nat. Commun.*, vol. 5, p. 5242, 2014.
- [2] A. Zadok, Y. Antman, N. Primerov, A. Denisov, J. Sancho, and L. Thevenaz, “Random-access distributed fiber sensing,” *Laser Photonics Rev.*, vol. 6, no. 5, pp. L1–L5, 2012.
- [3] A. Denisov, M. A. Soto, and L. Thévenaz, “Going beyond 1000000 resolved points in a Brillouin distributed fiber sensor: theoretical analysis and experimental demonstration,” *Light Sci. Appl.*, vol. 5, no. 5, p. e16074, 2016.