Abstract
We present temperature dependent integrated Brillouin measurements inside a fully sealed, CS_2-filled liquid-core optical fiber. We demonstrate the influence of the temperature and pressure on two acoustic modes at temperatures up to 136 °C.

Strong optoacoustic interaction in hot CS_2-filled liquid-core optical fiber

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Optical fibers with a liquid core provide a versatile platform for nonlinear optics [1]. Filled with carbon disulfide (CS_2), the high linear refractive index of 1.59 at 1549 nm and low speed of sound 1250 $\mathrm{m\,s^{-1}}$ compared to silica ensures guidance of optical and acoustic waves inside the fiber core. This type of fiber also provides a large optoacoustic interaction via stimulated Brillouin scattering (SBS) [2] due to the high optical nonlinearity of CS_2, the long interaction length and the low optical loss.
In this work, the temperature dependence of the optoacoustic properties of a sealed CS_2-filled liquid-core fiber is investigated by backward Brillouin backscattering [3]. The complete sealing by spliced patch-chords enables heating far above the boiling point of CS2 at 46.3 °C [1] and low coupling losses which allows investigation at low input powers.
For our analysis, 50 ns-long optical pulses at 1549 nm with an average power of 10 mW are send into the liquid-core fiber with 1.25 µm core diameter and 60 cm length. The backscattered Stokes light, seeded by thermal phonons, is recorded by a heterodyne detection technique with the pump laser as coherent local oscillator. The integrated Brillouin spectra are recorded at different temperatures of the fiber, ranging from 20 °C to 136 °C. In Fig. 1a the spectrum at room temperature (20 °C) is shown, revealing two acoustic modes at 2.15 GHz and 2.47 GHz. For comparison, also the Brillouin scattering spectrum at 52 °C is depicted. With increasing temperature, an overall increase of the Brillouin resonance frequency is observed (Fig. 1b), despite the negative thermo-optic coefficient of CS_2. The splitting of each of the two Stokes modes originates in the influence of global pressure (positive piezo-optic coefficient) and local temperature (negative thermo-optic coefficient). While the non-heated part of the fiber is exposed to the pressure only (upper split off modes), the heated part of the fiber is influenced by both temperature and pressure (lower split of modes).
In conclusion, with their strong and tunable Brillouin response, sealed CS_2-filled liquid-core fibers provide a versatile platform for fundamental optoacoustic investigations and SBS-based applications, such as signal processing and sensing.

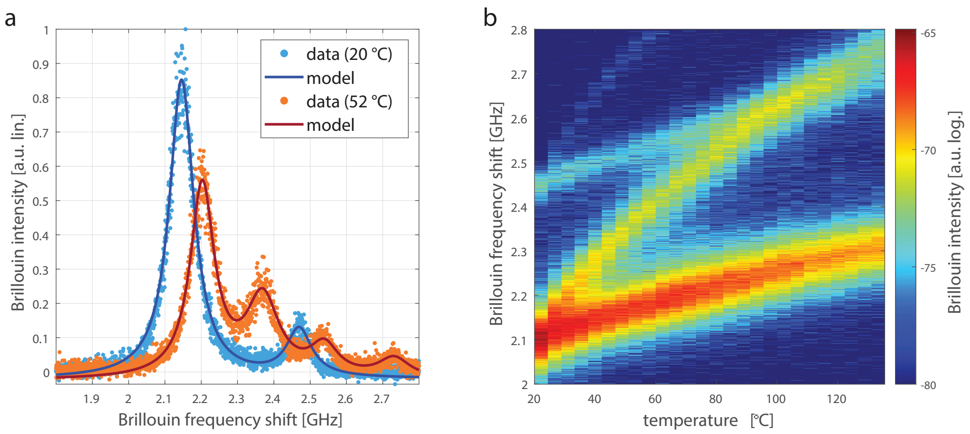

Fig. 1 Brillouin gain spectrum analysis of CS_2-filled liquid-core fiber. a) Normalized Spectrum at 20 °C, Brillouin intensity over Brillouin frequency shift with multi-Lorentzian fit. b) Brillouin gain spectrum for increasing fiber temperature. Brillouin frequency shift (BFS) over temperature, Brillouin intensity is color coded.

Example References

[1] S. Pumpe, M. Chemnitz, J. Kobelke, and M. A. Schmidt, “Monolithic optofluidic modecoupler for broadband thermo- and piezo-optical characterization of liquids.”, Optics express, 25(19):22932–22946 (2017).
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