Polarization control of Brillouin scattering in silica nanofibers

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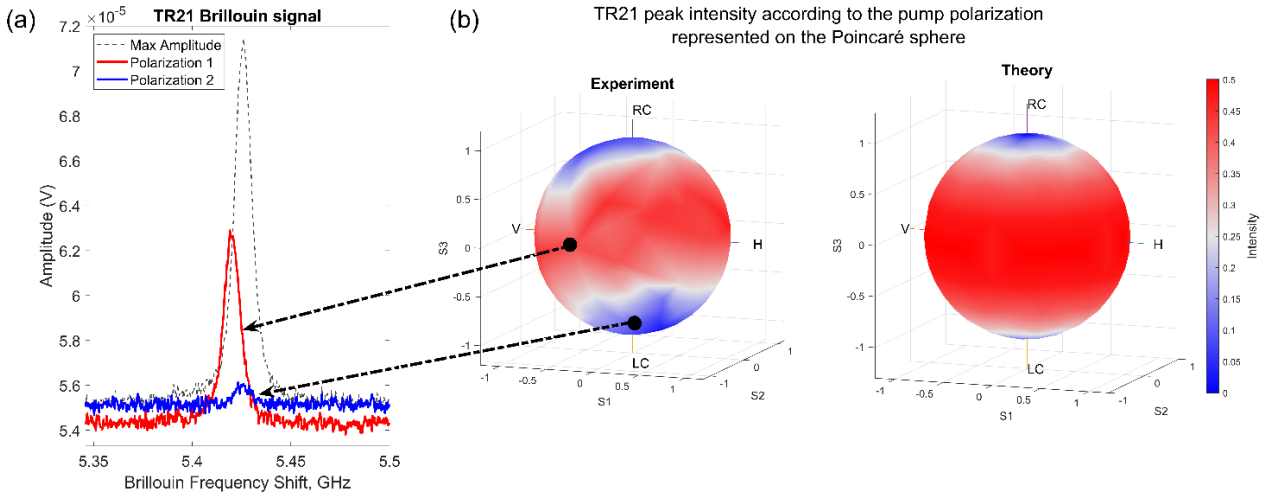
Silica optical nanofibers (ONFs) represent highly suitable environments for the study of Brillouin scattering due to their submicron transverse dimensions giving rise to the existence of various kinds of acoustic modes [1]. Among them, surface acoustic waves (SAWs) are very sensitive to the polarization of the incident wave.

We describe the evolution of the polarization state of backscattered Brillouin waves by the surface acoustic torso-radial mode (TR21). Because of the slightly elliptical transverse profile of the ONF, the latter is doubly-degenerated which leads to a polarization scrambling of the backscattered signal [2]. Recently, we have shown that this variation of polarization state along the nanofiber can be cancelled by tuning the polarization of the incident pump laser, paving the way to all-optical Brillouin memory applications [3]. The impact of the pump polarization state on the Brillouin TR21 backscattered waves' polarization has been investigated both experimentally and analytically.

Polarization measurements on Brillouin backscattered waves are carried out using a standard heterodyne detection setup [4] with a 1550nm-centred laser source. Fig.1a shows two Brillouin spectra centred on the TR21 frequency shifts obtained for two different pump polarization configurations. The heterodyne set-up was calibrated so that the reference wave that interferes with the backscattered signal has always the same polarization as the pump wave to ensure a maximal visibility of the longitudinal peaks.



(a) Experimental backscattering Brillouin spectrum on the nanofiber diameter of 730 nm and length of 100mm centred to TR21 resonance for linear (red) and circular (blue) pump polarization states. Maximum amplitude of TR21 (grey) has been measured after the experiment by optimizing the reference signal polarization state for normalization. Frequency shifts are due to temperature differences. **(b)** Experimental and numerical calculation of the TR21 backscattered light intensity (colour data) as a function of the polarized pump light state on the Poincaré sphere.

The red signal is half the maximum amplitude of TR21, reflecting a depolarization of the signal, while the blue signal is almost extinct, translating a TR21 polarized signal. The study has been extended to a set of pump wave polarization states equally distributed over the Poincaré sphere and is shown in Fig.1b. We note that the TR21 signal is polarized when the pump wave is circularly polarized, otherwise it is depolarized. We also notice the very good occurrence of the experimental results with the proposed analytical model based on the double degeneracy of the TR21 phonon.

References

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