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Control of surface Brillouin scattering in photonic crystal fibers

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We report the first experimental observation of surface Brillouin scattering in photonic crystal fibers (PCFs) arising from interaction between light and surface acoustic waves (SAWs). We also show that this new type of light scattering is highly sensitive to the PCF air-hole microstructure, thus providing a passive and efficient way to control it. Our observations are confirmed through numerical simulations of the elastodynamics equation.

Brillouin light scattering (BLS) in conventional optical fibers has extensively been investigated over the past years with many applications ranging from optical telecommunications to sensing [1]. Although it is well known, recent works have shown that using micro and nanoscale waveguides offers the possibility to go towards new forms of BLS [2,3]. For instance, it has recently been shown that a light beam passing through a silica microfiber can generate and interact with surface acoustic waves (SAWs) [2]. This interaction gives rise to a new type of backward BLS with new frequency shifts that relies on the surface Rayleigh velocity ($\sim 3400 \text{ m.s}^{-1}$ for silica). This effect is absent in conventional fibers because of their large core and the weak difference of acoustic index between the core and the cladding.

Here we show that small-core PCFs offer a new way to investigate and control this new type of BLS, with the advantages of longer length than fiber taper and more degrees of freedom such as the air-filling fraction. Figure 1 shows the experimental Brillouin spectra measured in two different core-size silica PCFs shown in insets. In both cases, we can clearly see 3 main peaks around 6 GHz as the result of SAW-induced BLS. A further comparison of the two spectra shows a clear rightward shift of the Brillouin peaks due to the effective refractive index increase with the core size, while the amplitude difference comes from the microstructure irregularities. These observations indicate that one can finely control the properties of surface Brillouin scattering by tailoring the fiber air-hole microstructure.

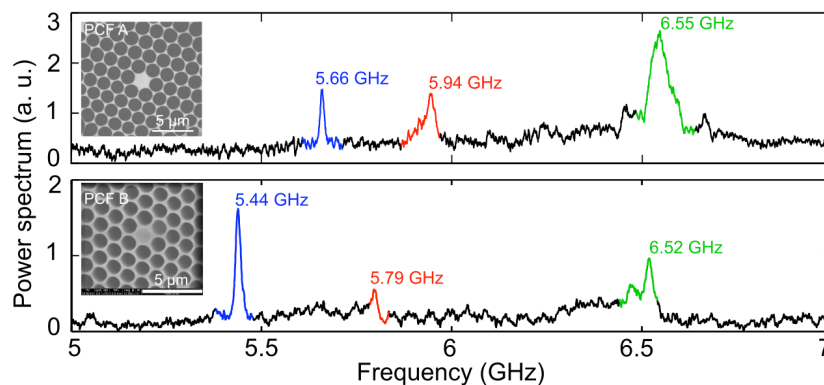


Fig. 1: Experimental Brillouin spectra, measured at $1.55 \mu\text{m}$ using heterodyne detection.

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