Efficient interrogation method of forward Brillouin scattering in optical fibers using a narrow bandwidth long-period grating

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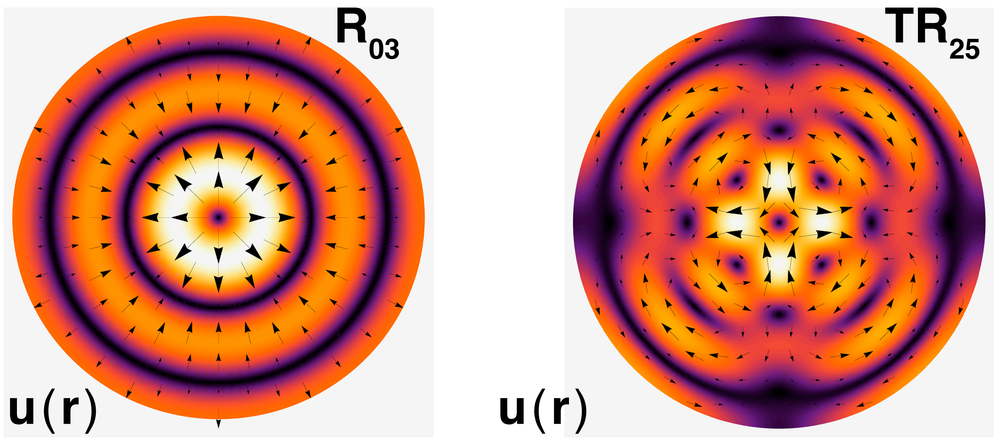
Abstract: A new technique for the characterization of the effective refractive index modulation in optical fibers due to transverse acoustic mode resonances excited by electrostriction is reported. Resonances excited by an optical pulse are probed by a narrow bandwidth long-period grating (LPG) inscribed in the fiber, which is interrogated by a CW beam. The LPG used is this experiment has a narrow bandwidth and high sensitivity to small mode index perturbations. Radial and torsional-radial acoustic modes were characterized up to 1.1 GHz. The linewidth of resonances was found to be much shorter than in previous reports in which long fiber lengths are typically required, obtaining Q factors as high as 5000.

Transverse acoustic modes in optical fibers

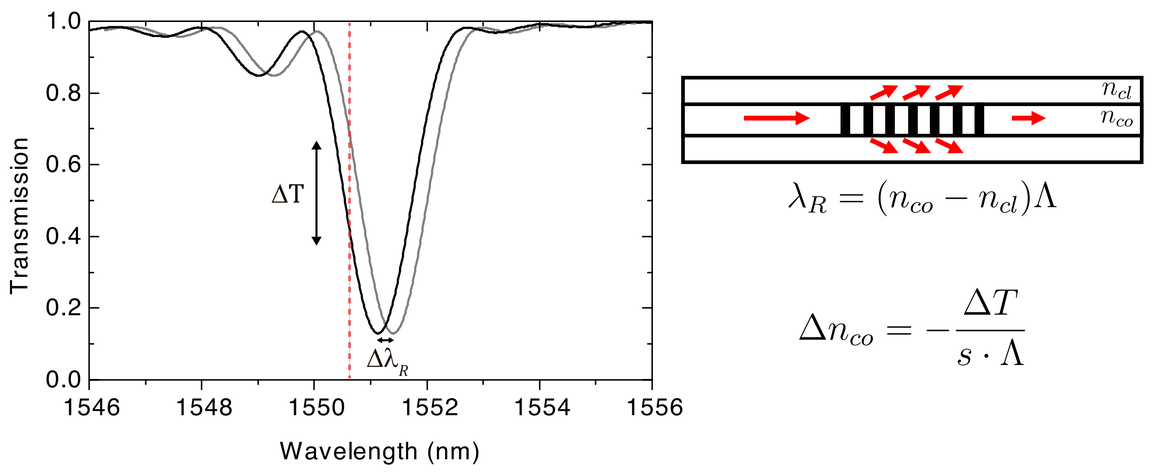


• Intense laser pulses guided in an optical fiber can generate elastic stresses in the fiber through electrostriction.

• The vibrational modes behind this interaction are the radial modes R_{0m} and torsional-radial modes TR_{2m}.

• This effect is known as forward stimulated Brillouin scattering (FSBS).

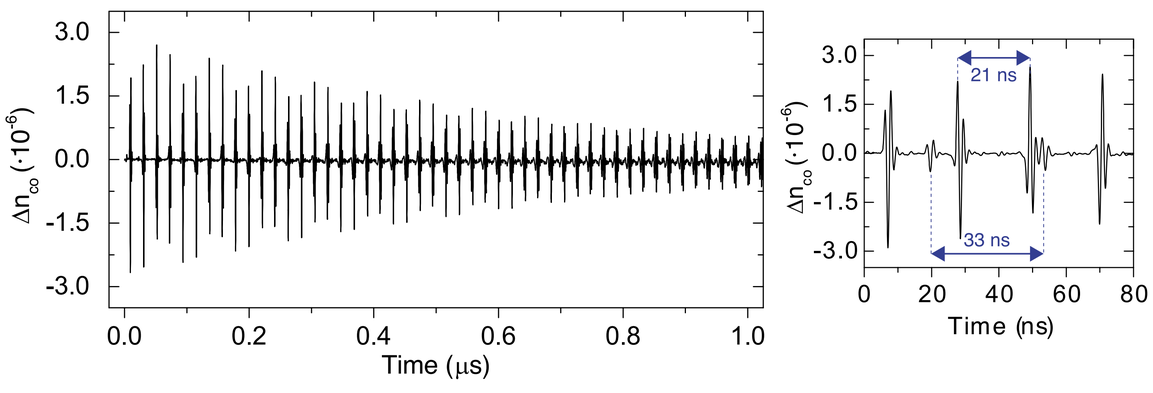
Detection using a LPG



• LPG couples light from a guided mode into forward propagating cladding modes. The resonant wavelength of the LPG will change in the presence of an acoustic wave.

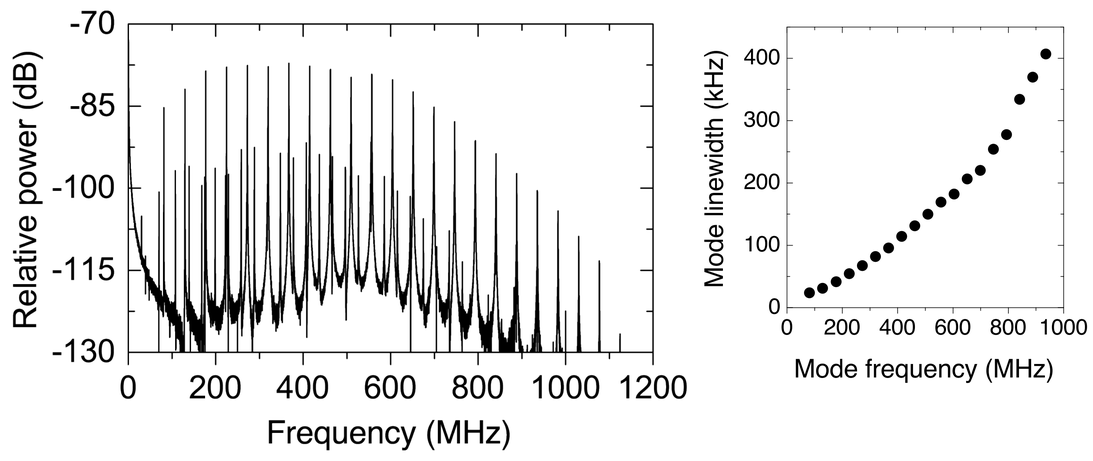
• The transmission of a probe wave aiming to the linear region of one of the notch edges of the LPG is proportional to the index change and the slope *s* of the edge.

Results



• Purely radial modes produce a periodic pattern of beats separated by ~21 ns, while torsional-radial modes contribute with a ~33 ns periodic pattern.

• For a 125 μm diameter silica optical fiber, such periods of time agree with the roundtrip time of an acoustic pulse travelling in the radial direction across the fiber at the longitudinal acoustic velocity and at the shear velocity, respectively.



• The spectra consist on a series of peaks located at the resonance frequencies of the different acoustic mode resonances excited by the pump.

• The dominant contribution to the R_{0m} linewidths using this method is the viscous damping term, in contrast to previous reports in which long fiber lengths are required and fiber non-uniformity is one of the main contributions to the resonances broadening.

Conclusion

- New efficient method for the characterization of transverse acoustic modes induced by optical electrostriction using a narrowband LPG.
- Measurement of small core effective index perturbations.
- R_{0m} linewidths in the order of hundreds of kHz due to short fiber section that reduces significantly the structural inhomogeneities contribution to linewidth broadening.