Biological Brillouin Scattering with the HyperFine Spectrometer

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LightMachinery
Excellence in Lasers and Optics

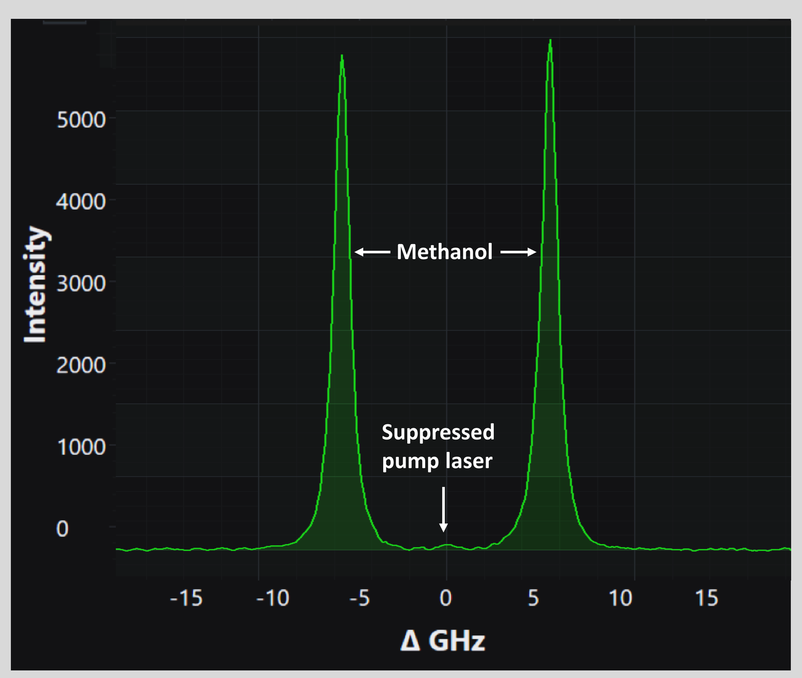
Introduction

A rapidly growing body of work shows that mechanical cues play a key role in regulating cellular behaviors and tissue homeostasis. Deregulation of such mechanical properties are thought to be essential in the onset and progression of many diseases, including cancer, osteoporosis, and atherosclerosis[1-4]. Characterizing these physical changes constitute a powerful tool to better understand their underlying mechanism, explore novel therapies (e.g. synthetic matrices[5]), and improve early diagnosis (e.g. ocular and dental fields).

LightMachinery has developed the Brillouin Hyperfine spectrometer to optically probe the mechanical properties of biological materials with unparalleled sensitivity. Its high contrast and ultrafast acquisition are indispensable for successful 3D Brillouin microspectroscopy.

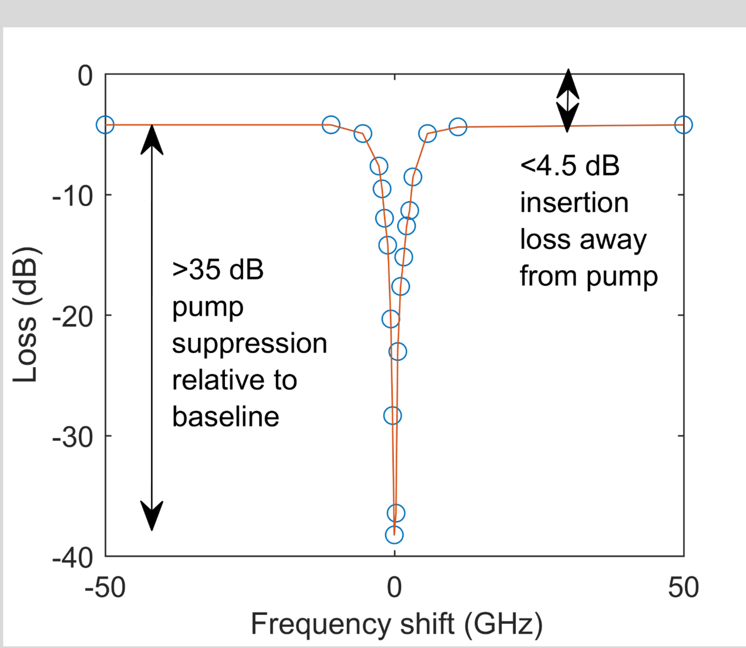
Brillouin HyperFine System with Pump Killer

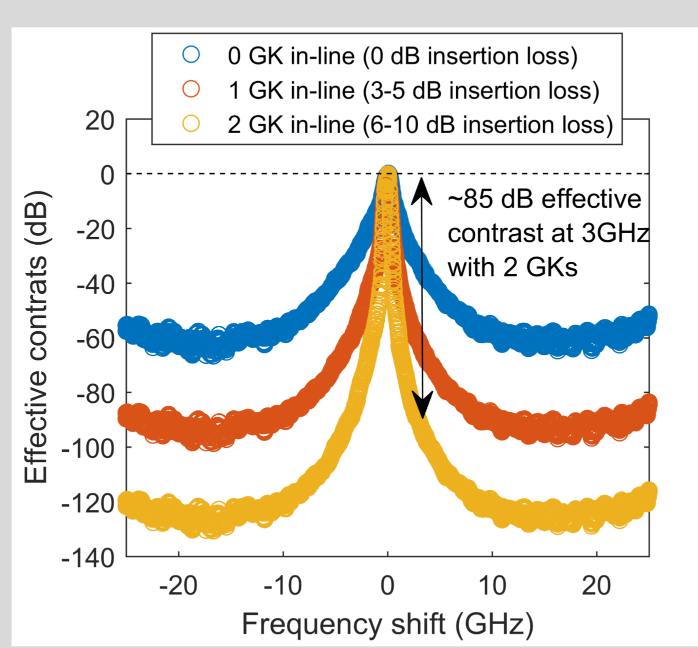
Methanol



- Brillouin spectrum of methanol, 250 msec, 25 mW at 532 nm.
- Signal-to-noise ratio ~ 200.
- The pump signal is completely suppressed (with 2 Pump Killer modules, > 70 dB suppression is achieved).

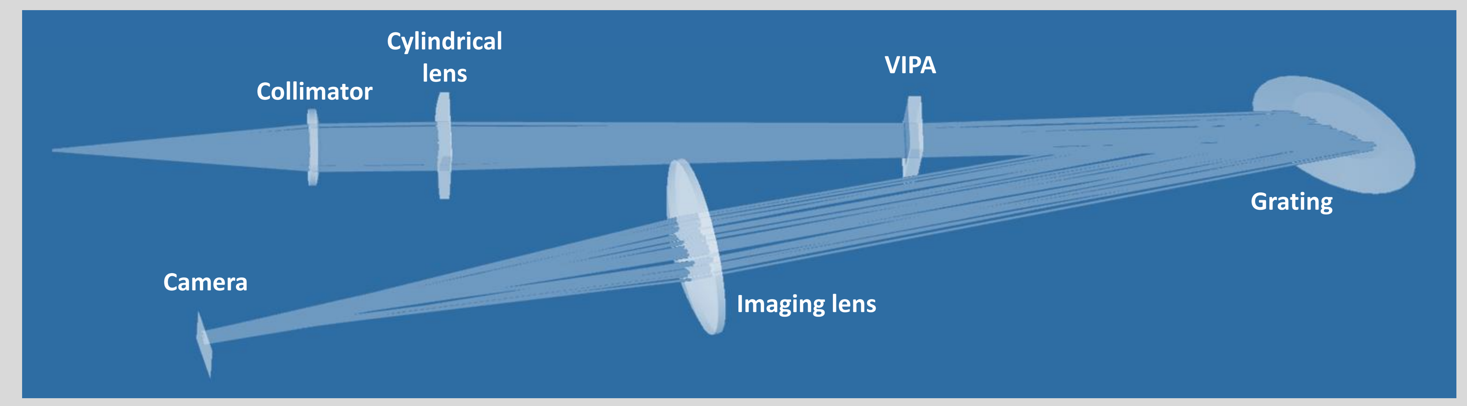
- > 120 dB of effective contrast achievable with the full system.
- Ultra-fast acquisition[6], massive dynamic range.
- Customizable excitation wavelength from UV to IR.
- Customizable resolution from 0.25 GHz to 5 GHz.
- Up to several THz of spectral range captured simultaneously.





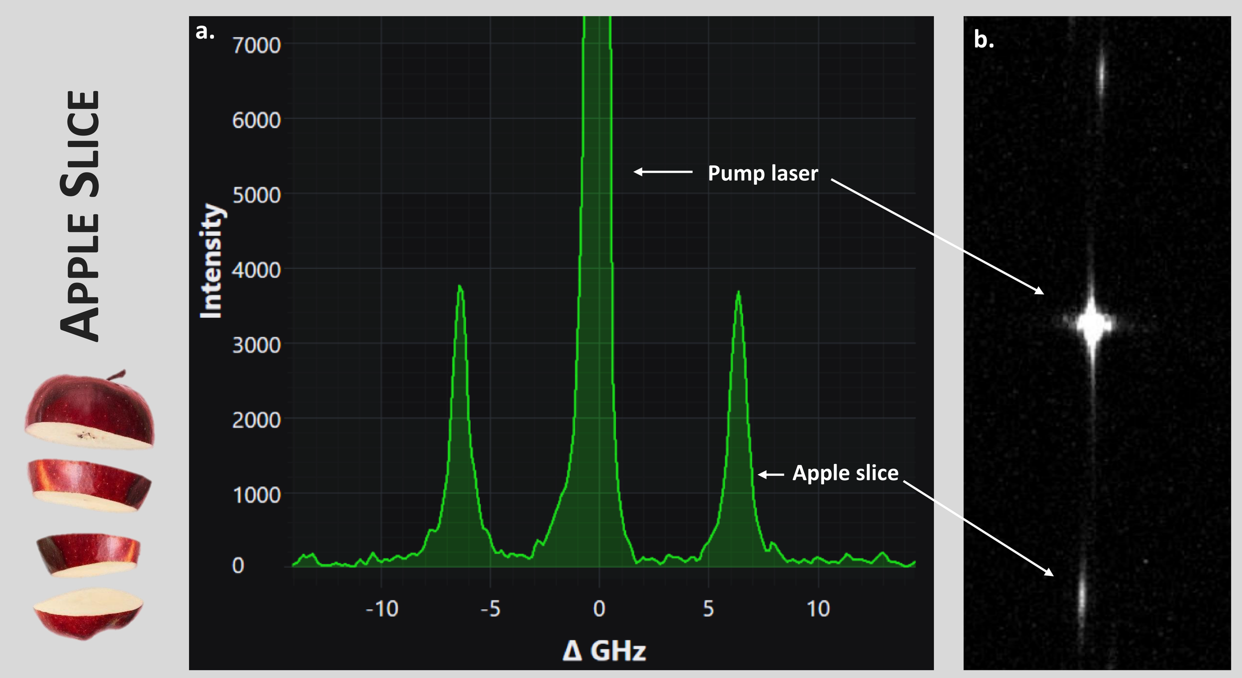
HyperFine Spectrometer Operating Principle

Schematic layout of the optical components[7]. The etalon disperses the incident light in the vertical direction, providing a high resolution, but also overlapping orders. The grating separates the overlapping orders in the horizontal direction. The Pump Killer (not shown) is a tunable dual pass air-spaced etalon in reflection.



Brillouin Scattering Spectra – Preliminary Results

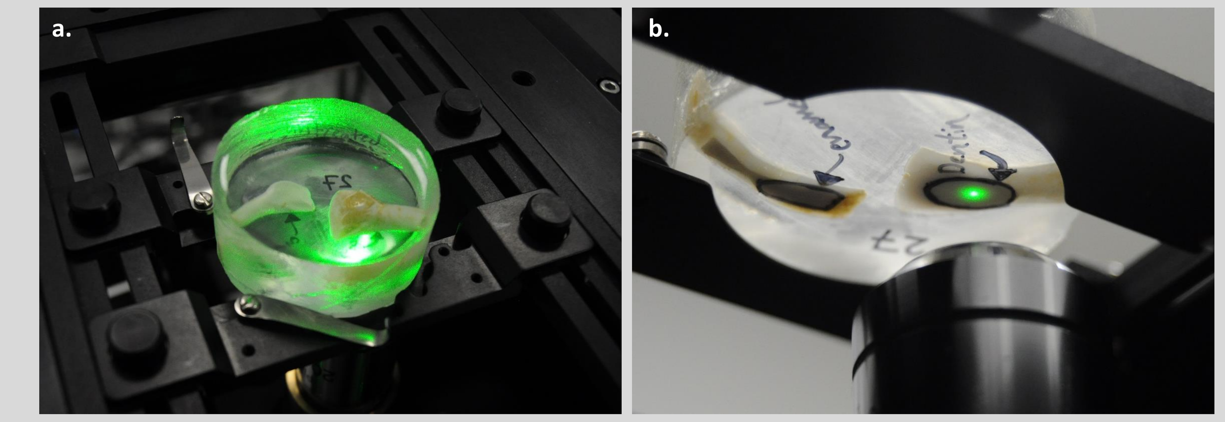
Apple slice



a. Brillouin spectrum of an apple slice, 2 sec, 5 mW at 660 nm. b. Raw sensor image corresponding to the spectrum.

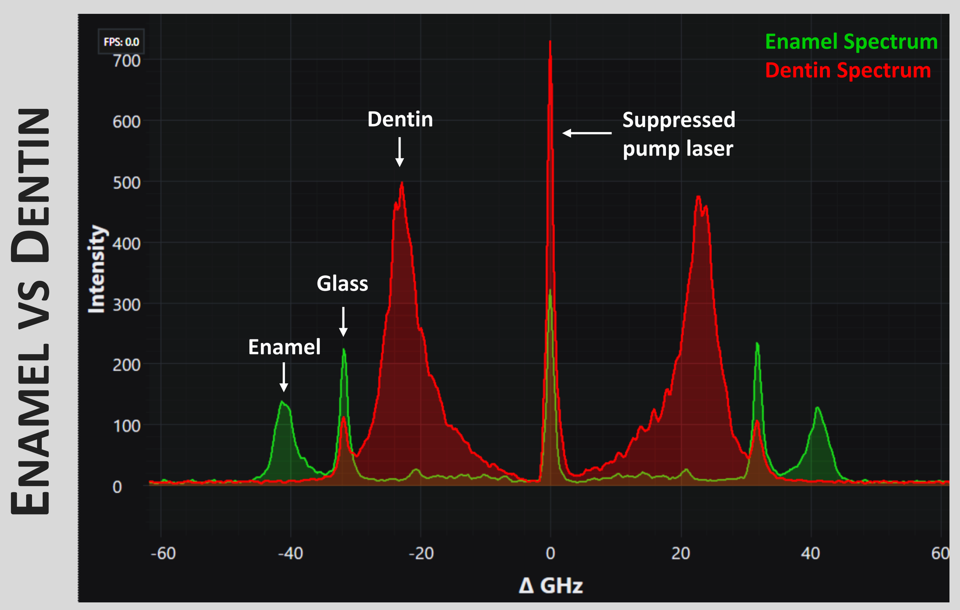
Blood vs Water

a. Brillouin spectra of blood (green) and water (blue). Brillouin frequency shift between water and blood ~ 0.4 GHz. 15 mW at 532 nm, blood spectrum: 1 sec (avg x10), water spectrum: 200 msec (avg x10). b. Excitation configuration showing blood wells.



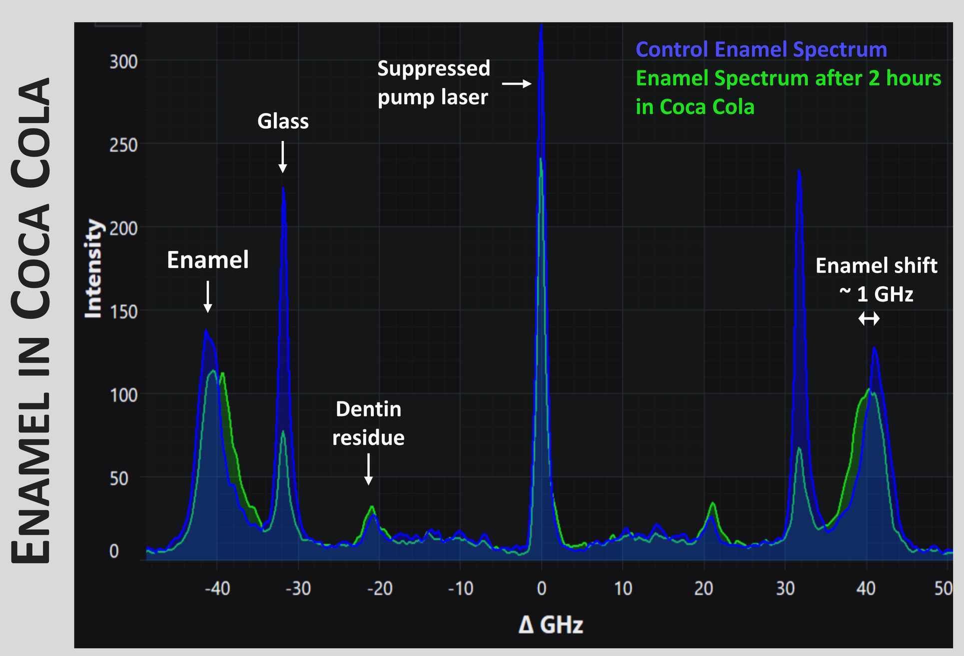
a. Bovine tooth sample on the Brillouin confocal microscope. b. Excitation configuration showing enamel and dentin samples. Samples provided by MSTATT LLC.

Enamel vs Dentin



- Brillouin spectra of bovine enamel (green) and dentin (red).
- 10 sec (avg x20), 15 mW at 532 nm.
- In collaboration with MSTATT LLC.

Enamel in Coca Cola



- Brillouin spectra of bovine enamel before (blue) and after (green) soaking for 2 hours in Coca Cola. Brillouin shift of enamel ~ 1 GHz.
- 10 sec (avg x20), 15 mW at 532 nm.
- In collaboration with MSTATT LLC.

Conclusions

LightMachinery is proudly joining this brilliant collective effort to push the boundaries of biological Brillouin scattering technologies. We are driven by the exploration of uncharted waters in fundamental and applied biological physics.

References

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