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Spectrometer Application Report

Brillouin Spectroscopy in a Diamond Anvil Cell

A study performed in collaboration with the CEA (Commissariat à l'énergie atomique et aux énergies alternatives), France

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A quick test was conducted using water in a diamond anvil cell (DAC) set to approximately 1 GPa. The Brillouin spectrum is presented in Figure 1. The measured frequency shift of such pressurized water is 15.91 ± 0.02 GHz, in line with Li et al[1]. This shift is significantly different from that of water at atmospheric pressure (7.48 ± 0.01 GHz), as shown in the inset of Figure 1.

A long working distance 20X objective was employed to collect the Brillouin spectrum in a backscattering geometry. The sample was approximately normal to the optical axis of the objective (limited tilt angle). Hence, the objective was collecting part of the pump reflection from various surfaces. Nevertheless, the high contrast and pump suppression of the HF-8999-532 spectrometer enabled unambiguous observation of the Brillouin signal. The pump signal can be reduced by several orders of magnitude with one of the following strategies: i) employing an additional Pump Killer system (HF-10237-532-AUTO), ii) increasing the tilt angle of the backscattering geometry, or iii) collecting the Brillouin signal in a platelet geometry (transmission geometry using a second objective).

The measured Brillouin shift of the DAC itself is 159.59 ± 0.02 GHz as seen in Figure 2. The unambiguous acquisition of such signal, well beyond the FSR of the VIPA, is enabled by the cross-dispersion of the echelle grating of the system.

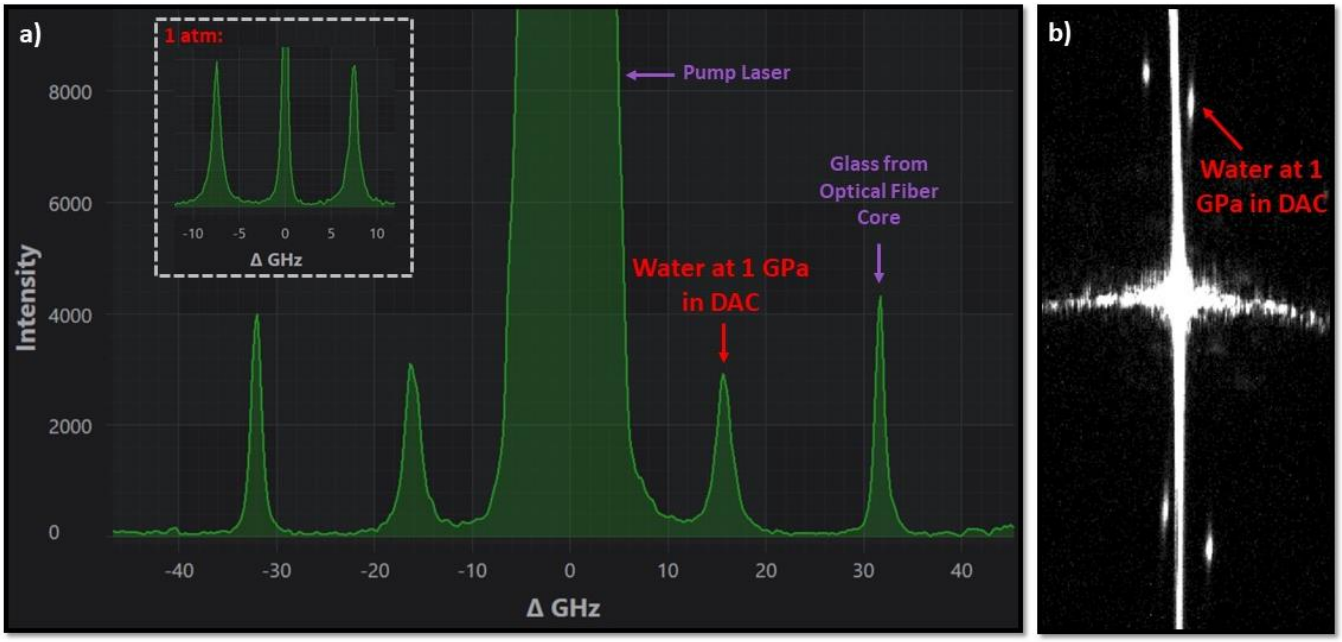

Figure 1: a) Brillouin frequency spectrum of water in a DAC at approximately 1 GPa. The inset shows the Brillouin spectrum of water at atmospheric pressure. b) Raw sensor image corresponding to the main figure. The exposure time was set to 5 seconds and the number of averages to 5.

[1] Li, F., Cui, Q., He, Z., Cui, T., Zhang, J., Zhou, Q., Zou, G. and Sasaki, S., 2005. High pressure-temperature Brillouin study of liquid water: Evidence of the structural transition from low-density water to high-density water. *The Journal of chemical physics*, *123*(17), p.174511.

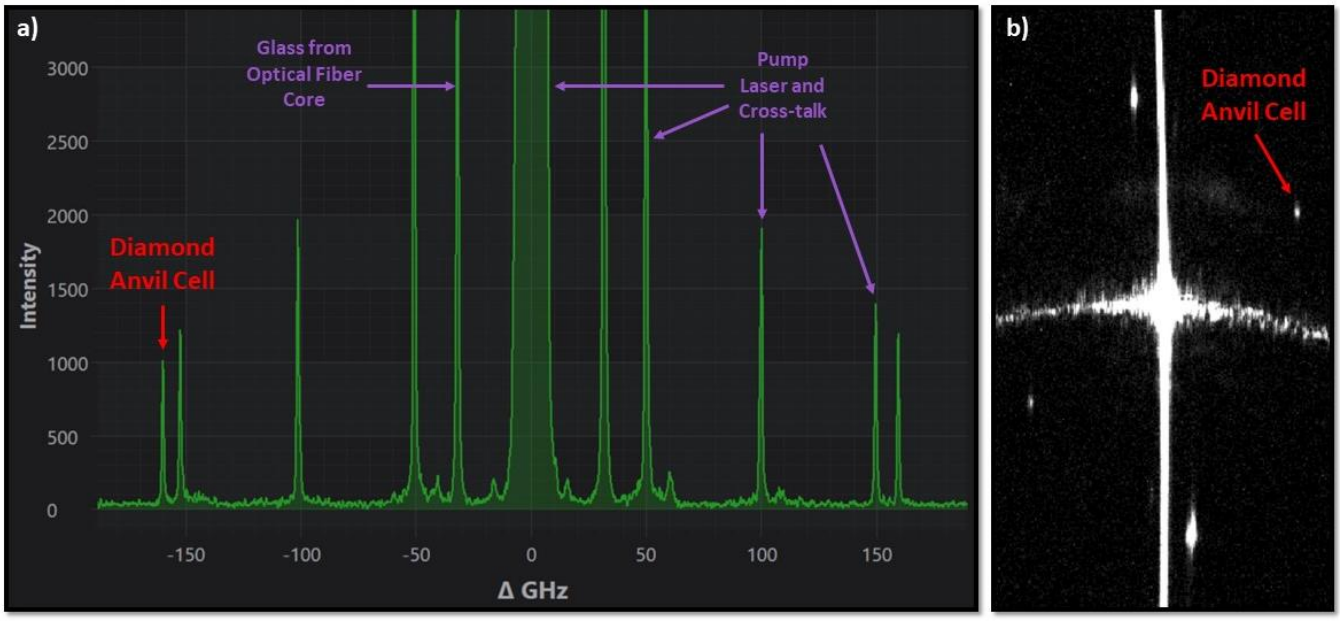

Figure 2: a) Brillouin frequency spectrum of a DAC. The pump laser and cross-talk can be significantly reduced by employing one of the methods mentioned above. b) Raw sensor image. The exposure time was set to 15 seconds and the number of averages to 5.

Specifications

Sample	System
• Water in a DAC set to approximately 1 GPa	• Pump wavelength: 532.2 nm • Power at sample: 12 mW • Excitation/collection with long distance 20X objective • FWHM of the instrument response: nominal 0.9 GHz • Repeatability of Brillouin shift: highly sample and exposure dependent; < 10 MHz is possible