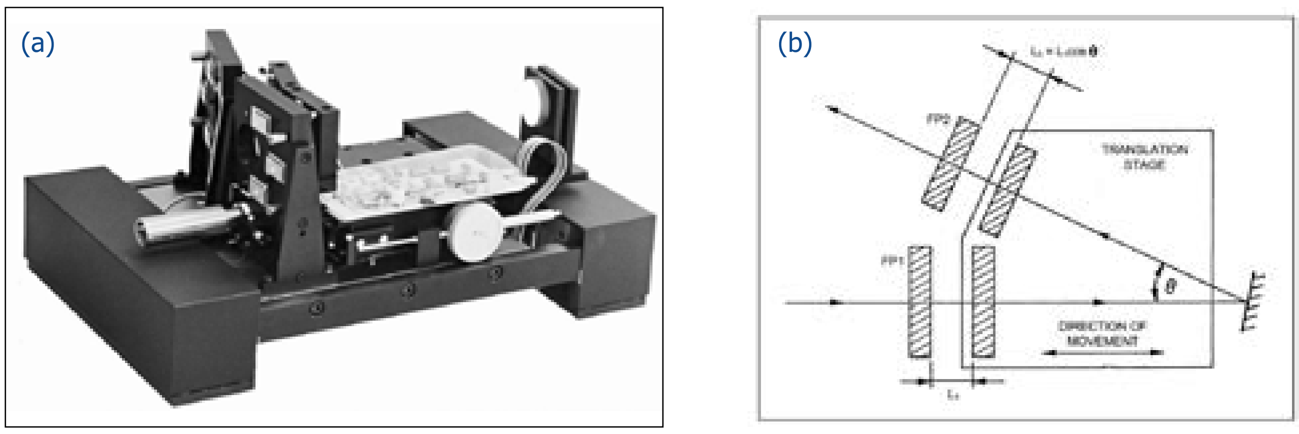
Whitepaper

Torus SLM laser shows excellent spectral purity

***Abstract**: The spectral purity of the **torus 532** laser is shown to be 110 dB when measured with a Tandem Fabry-Perot interferometer, resulting in high resolution Brillouin scattering measurements in bulk materials.*



Figures 2: (a) external view and (b) schematic layout of the double interferometer part of the TFP-1 from JRS Scientific Instruments.

Introduction

Brillouin scattering describes the scattering process of an electromagnetic wave (a photon) and a complex, space- and time-varying acoustic mode within a medium, described by phonons. The photon/phonon interaction is inelastic, causing the interacting photon to gain or lose energy. The shift in photon energy (called the Brillouin Shift) resulting from this interaction is tiny and commonly requires a high resolution interferometer to measure it. Such a measurement, however, provides important information about the medium's bulk properties.

Owing to the small energy transfers between photons and acoustic phonons in the medium, Brillouin scattering experiments require a single frequency laser (also known as a single longitudinal mode or SLM laser) with no observable sidebands. The very small frequency shifts of the photons are in the MHz to GHz frequency range and can be resolved with Fabry-Perot interferometers. The resulting spectra depends upon the medium and the number of interacting phonon energies and can be difficult to analyse when using a single Fabry-Perot interferometer because the transmission function is periodic in frequency and hence the spectra of the different orders of the transmission function can overlap (figure 1).

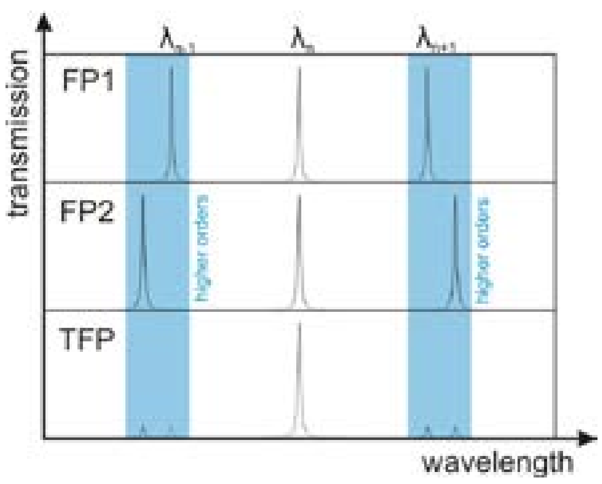


Figure 1: Ideal spectrum from single and tandem (lower graph) Fabry-Perot interferometer

This can be avoided by the use of two Fabry-Perot interferometers in series. An innovative configuration using the dual interferometer is the Tandem Fabry-Perot interferometer first demonstrated by Dr. John R. Sandercock [1]. The principle configuration of such an interferometer is shown in Fig. 2, further details can be found in other publications [2]. A further advantage is the high contrast achievable with a Tandem Fabry-Perot interferometer, resulting from the light travelling through the combination of both Fabry-Perot interferometers 3 times. Today, the Tandem Fabry-Perot interferometer is commercially available from JRS Scientific Instruments.

Historically, large and energy-consuming Argon Ion lasers were used as a source for single frequency laser light; nowadays compact and reliable DPSS laser sources, like Laser Quantum's **torus** laser (figure 3), are available. Using intelligent electronics, the **torus** continually tracks its single longitudinal mode position to ensure there is no mode-hop or drift over a wide temperature range (only ±2pm wavelength drift over 20°C). The **torus** is the only actively locked SLM laser commercially available. The output power of the **torus** can be easily controlled via a jog dial on the power supply while the laser emits SLM light over a wide range (from 50% to 100% of the specified power, up to 750mW output power). To be able to measure the Brillouin Shift, however, the spectral purity of the laser is paramount, since any side-bands in the SLM laser will lie in the range of the Brillouin Shift, thereby masking the signal.

To verify the very high spectral purity of a single frequency laser, the light from two single frequency lasers (Laser Quantum's **torus 532** and a Spectra Physics Excelsior) were coupled into the Tandem Fabry-Perot interferometer TFP-1 from JRS Scientific Instruments. A typical spectrum is shown in figure 4. The central peak is the weak reference beam (roughly 10nW) used to stabilize the interferometer. The rising slopes in the greyed area belong to the non-attenuated residual from the measured laser beam (10mW). The spectrum shows that both lasers allow the measurement of tiny frequency shifts because they are true single frequency lasers with sidebands of less than -110 dB.

It has been shown that the combination of the Tandem Fabry-Perot interferometer TFP-1 from JRS Scientific Instruments with Laser Quantum's **torus 532** single frequency laser results in a smart and flexible instrument suited for high resolution Brillouin scattering measurements.

Figure 3: **torus 532** from Laser Quantum

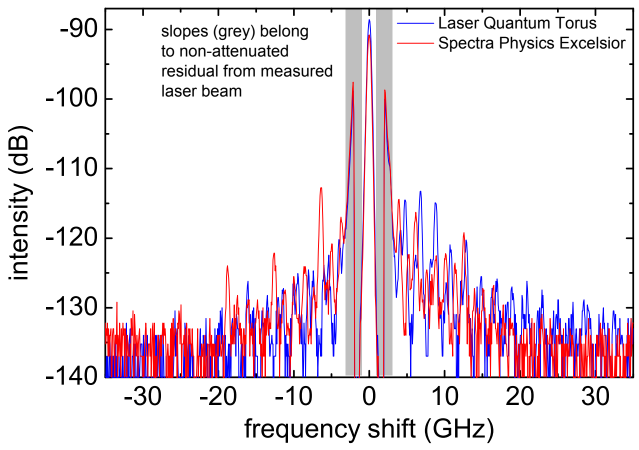


Figure 4: Spectrum obtained with the TFP-1 showing the suppression of the side modes

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References:
[1] Sandercock, in Proc. 7th Int. Conf. on Raman Spectroscopy, Ottawa (1980)
[2] Lindsay et al., Construction and alignment of a high performance multipass vernier tandem Fabry–Perot interferometer, Review of Scientific Instruments Vol. 52, Issue 10, p. 1478 (1980).

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