

OPTIMISATION OF VIPA SPECTROMETERS

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Abstract: Brillouin spectroscopy is a technique used to obtain information on the mechanical properties of materials in a non-contact manner. The sample is illuminated using a microscope objective lens and the scattered light, containing both elastic (Rayleigh signal) and inelastic (Brillouin signal) components, is detected by the same lens and is analysed by a single mode fibre coupled spectrometer. Virtually Image Phased Array (VIPA) spectrometers [1] have been widely used in Brillouin spectroscopy to spatially disperse the scattered light onto a CCD camera using a lens between the VIPA and the CCD. A single free spectral range of the spectrum contains three peaks: a central Rayleigh peak, flanked by the Stokes and Anti-Stokes Brillouin peaks on either side. The intensity of the Rayleigh peak is orders of magnitude higher than the intensity of the Brillouin peaks. An interferometric filter [2] can, however, be used to suppress the Rayleigh signal so that all three peak intensities are of the same order of magnitude. One of the outputs of the measurement is the distance between the Rayleigh and one of the Brillouin peaks. Distortions to the shape of the measured peak can, however, affect the localisation accuracy of that peak and thus yield erroneous Brillouin frequency shifts. Aberrations introduced by optical components of the system on the localisation accuracy has not been studied.

In this talk we examine the effect of optical components on the overall performance of a spectrometer. Fisher Information is used to maximise the information content in the system. Spherical aberration, for example, imparted by the plano-convex cylinder lens at the entrance of the spectrometer reduces signal quality, but it otherwise does not affect the accuracy of measurements. On the other hand, field dependent aberrations (coma, astigmatism, curvature of field) produced by the lens between the VIPA and CCD can result in significant loss in localisation accuracy of the peaks. Our approach will aid users of VIPA-based spectrometers in designing better quality systems.

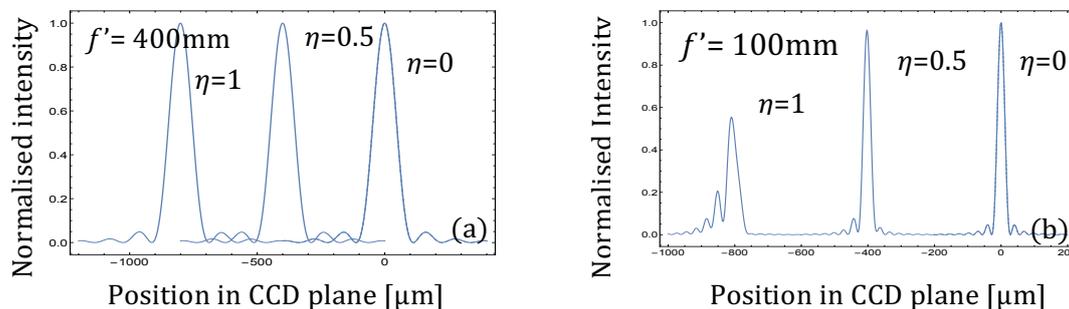


Fig 1. (a) Effect of aberrations on the observed spectral peaks assuming a marginal ray height of 1 mm, CCD width of 30 mm and a 400 mm focal length lens. (b) Effect of aberrations on the spectral peaks assuming a marginal ray height of 1 mm, CCD width of 30 mm and a 100 mm focal length lens. The displacement of the peaks is not shown to scale

Reference:

- [1] Shirasaki, M, Virtually Imaged Phased Array, FUJITSU Sci. Tech. J., Vol. 35, 1, pp. 113-125, July 1999.
- [2] Lepert, G, et al. "Assessing corneal biomechanics with Brillouin spectro-microscopy." Faraday discussions 187 (2016): 415-428.