Experimental investigation of picosecond pulse reflection from fibre gratings

D. Taverner, D.J. Richardson, J.-L. Archambault, L. Reekie, P.St.J. Russell, D.N. Payne

Optoelectronics Research Centre,

University of Southampton,

Hants SO9 5NH,

United Kingdom

Tel: +703 592693, Fax: +703 593142

Abstract

The dispersion of psec pulses upon reflection from efficient photorefractive fibre gratings is explored for the first time. Unlike simple measurements of reflectivity, this approach allows both amplitude and phase of the grating response to be explored as a function of frequency.

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Summary

The development of high-reflectivity photorefractive fibre gratings [1] has created a wide range of exciting new possibilities for fibre-based devices. Some applications rely solely upon the spectral filtering properties of the grating structure (e.g. their use as bandwidth limiting elements in single-frequency fibre lasers [2]); however in other applications, particularly those involving ultrashort optical pulses, dispersion becomes important and requires a detailed understanding [3].

In this paper, we report initial results from an experimental investigation of the effects of grating dispersion on the reflection and transmission of picosecond optical pulses from uniform fibre gratings. Transform-limited ps hyperbolic secant pulses were used, and the reflected and transmitted response measured both in the temporal and spectral domain as a function of wavelength offset between the

reflection peak of the grating and the central wavelength of the pulses.

Two Type I gratings [4] were examined, both fabricated using a multi-pulse exposure, U.V. interferometric side-writing technique [4]. Grating A had a peak reflectivity R=0.86 at 1.532μm, with spectral half-width $\Delta\lambda_g =$ 0.78nm, and grating B had R=0.47 at 1.531 μm and $\Delta\lambda_g$=1.46nm. The peak reflectivity wavelength could be tuned up to 5 nm towards longer wavelengths by stretching the grating. The spectral transmission characteristics of the unstrained gratings are presented in Fig.1. along with the best fit grating response function used to model the reflection and transmission data.

A plot of the observed pulse half-width broadening factor on reflection of 5.6ps hyperbolic secant pulses from grating A ($\Delta\lambda_{pulse}/\Delta\lambda_g$ = 0.56), and 2.9 ps hyperbolic secant pulses (spectra centered at 1.532 μm) from grating B ($\Delta\lambda_{pulse}/\Delta\lambda_g$=0.59nm), in both the temporal and spectral domains as a function of wavelength offset are presented in Fig.2 (note that in the time domain the broadening factor is calculated from the half-width of the autocorrelation trace to accommodate changes in pulse shape). Minimum temporal broadening factors of 35% and 50% at wavelength offset $\Delta\lambda_{offset}$=0 for gratings B and A respectively are observed (time-bandwidth product $\approx$ 0.4). Increased broadening and pulse deformation are observed as the reflection peak moves from the pulse centre until at $\Delta\lambda_{offset}/\Delta\lambda_g$ $\approx$1 where the pulse is observed to become multi-peaked. Superimposed on the plots in Fig.2 are the theoretical pulse broadening factors obtained by fitting the grating response functions in Fig.1 to the solutions of simple coupled mode theory for a uniform sinusoidal grating. The theory is found to be in good agreement with the experimentally observed results.

In Fig.3, we present data for the transmission of 3.1ps hyperbolic secant pulses through Grating B ($\Delta\lambda_{pulse}/\Delta\lambda_g = 0.54$). Well away from the reflection peak, minimum broadening is observed; however, within the transmission band significant pulse distortion is obtained and found to agree reasonably well with that theoretically predicted.

Although our measurements have been made on very basic grating structures, the results confirm that the gratings we have fabricated are highly uniform and give us confidence to extend the coupled mode theory to more complicated grating structures e.g. multi-grating arrays and chirped gratings. These more elaborate structures have great potential for a range of applications such as pulse compression [3,5] and broadband dispersion compensation in transmission systems [5].

References

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Figure Captions

Fig.1 Experimental (solid line) and fitted (dashed line) transmission characteristics of Gratings A and B.

Fig.2 Experimental (points) and theoretical (curves) autocorrelation halfwidth and spectral halfwidth broadening factors for 5.6 ps hyperbolic secant pulse reflection from grating A and 2.9ps nyperbolic secant pulse reflection from grating B.

Fig.3 Experimental (points) and theoretical (curves) autocorrelation halfwidth and spectral halfwidth broadening factors for transmission of 3.1 ps hyperbolic through grating B.

Fig 1 D. TAVERNER et al.

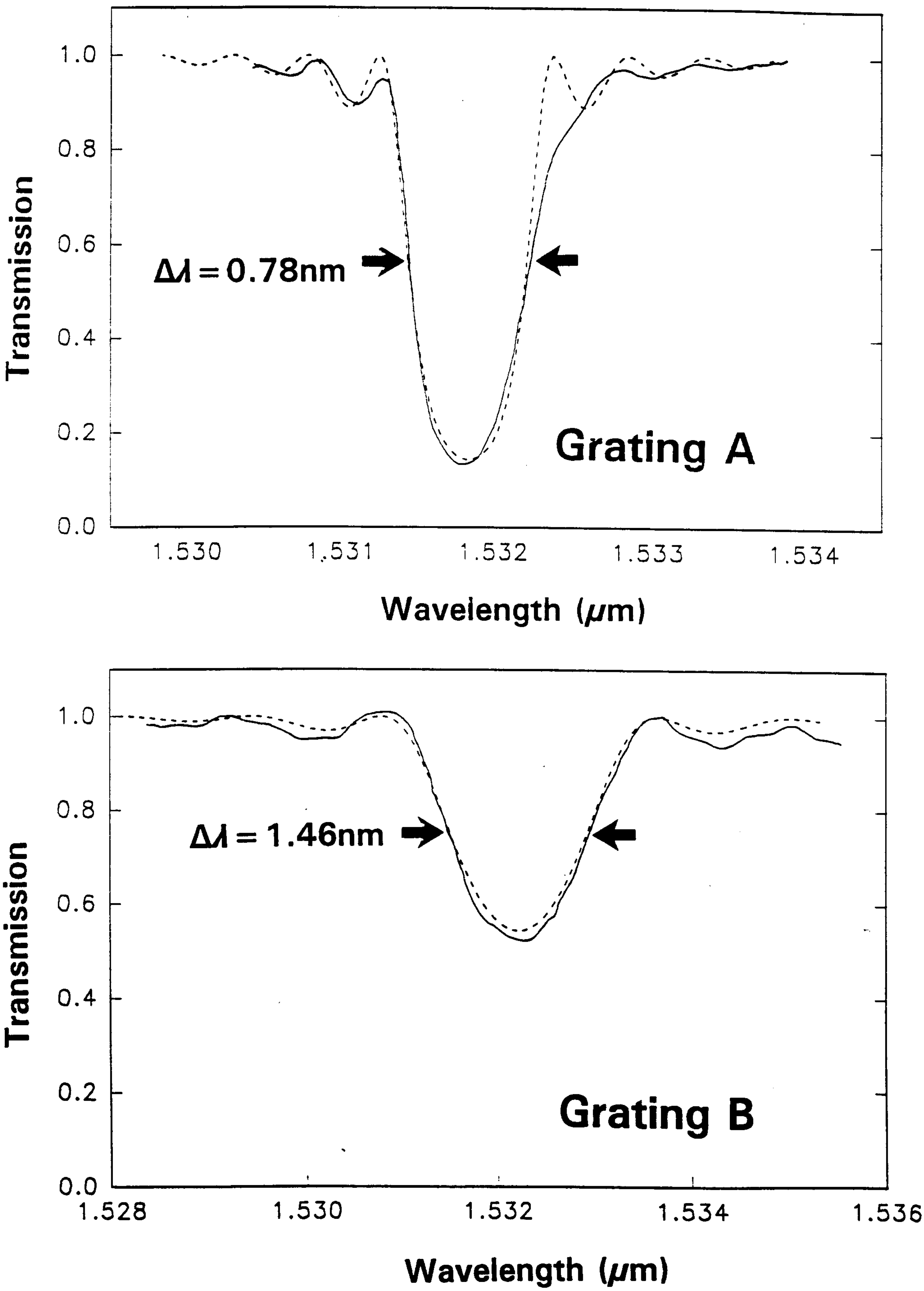

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Fig 2

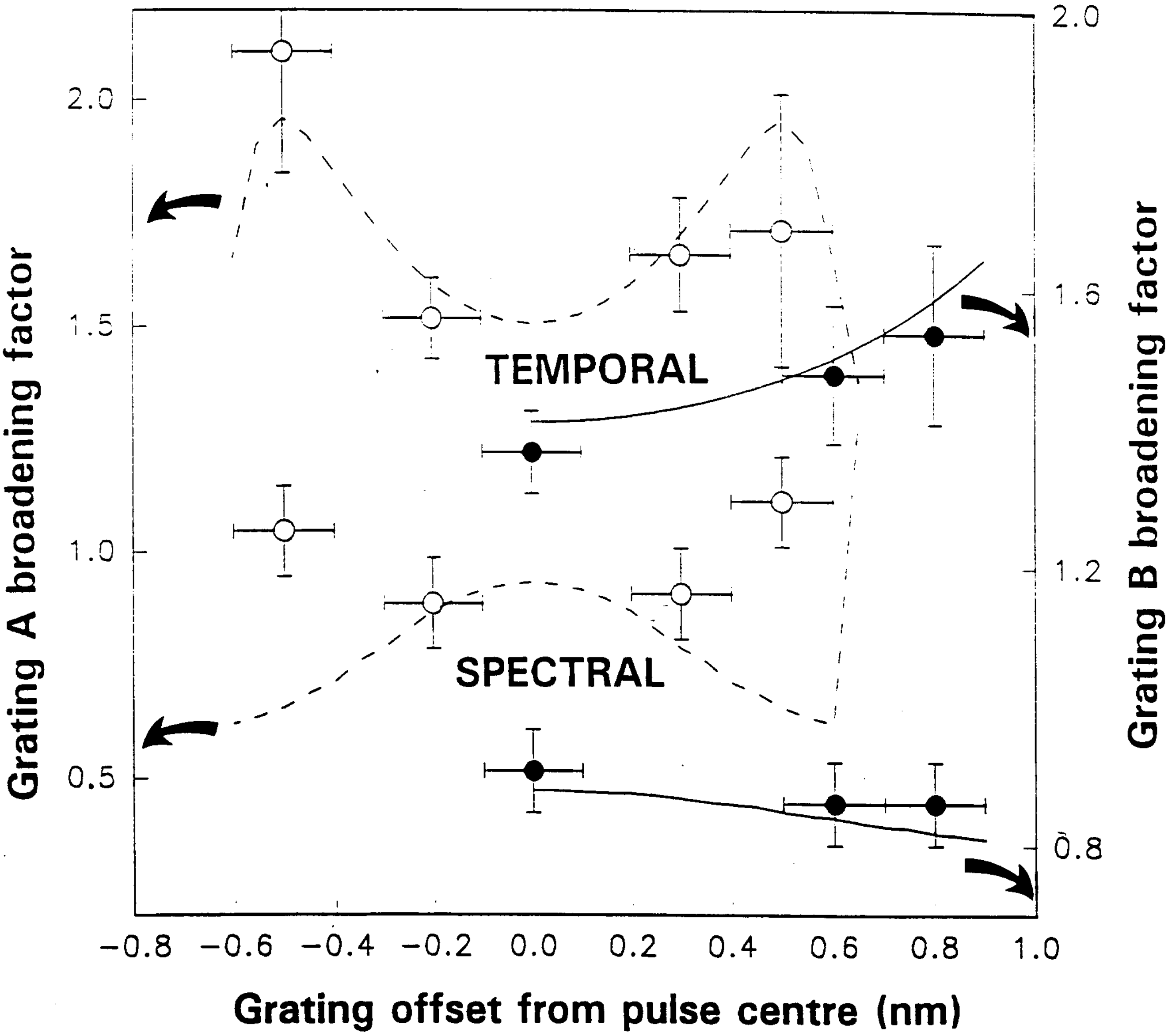

Fig 3

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