INTRODUCTION

Uncontrolled drifts to spectrograph lineshape (PSF) is a major limit to precision in Doppler radial velocimetry and high resolution spectroscopy (Fig. 1). Traditional countermeasures include heavy expensive temperature controlled vacuum tanks and fiber scramblers.

METHOD: EDI with multiple delays

We demonstrate that by using an interferometer (EDI) with multiple delays, and mixing delay pairs during analysis, we can reduce effect of PSF drift by a factor of 350 or more. The apparatus “TEDI” tested on starlight at Hale 5 m telescope.

RESULTS

Fig. 3 When the environmental insult shifts the native spectrograph PSF by ∆A, the embedded interferometer comb (red) is shifted by the same amount. Hence the phase of the Moire patterns, which depends on the relative difference between input spectrum and comb, remains about the same, and TRC ~ 0.05, whereas for the native alone TRC=1.

Crossfading two Moire cancels PSF shift

However, we can do better. By using two or more delays, we can theoretically make TRC=0. We use a technique called crossfading which modifies the lineshape prior to summation into a special shape and width.

Fig. 4 Simulation showing that for two different delays, the Moire patterns can have opposite slopes in phase vs λ. Hence under a ∆A insult shift, they will react oppositely, so combining them can cancel the net reaction. The numerical simulation results in TRC=0.003, which is 350x smaller reaction than the native spectrograph alone. A special crossfading lineshape of triangle or sinc function produced this effect (sinc produces less ringing artifact). (b)(c) Moire patterns of two delays 1.4, 1.6 cm, were deliberately shifted to left by 0.75 cm-1. (d) Output spectrum reacts oppositely for different delays (dash, solid). (e) Crossfaded output, which is avg of two delays. The original (blue dash) and deliberately shifted data (black) align almost perfectly.

CONCLUSIONS

Users of externally dispersed interferometers should modifying their apparatus to use 2 or more delays. This could dramatically reduce radial velocity instrumental noise, if PSF drifts are the dominant noise source.

A single delay can also stabilize the native peak, but at 1x resolution boost (hence useful if native is already high res.)

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