# Spectrograph stabilization of 1000x using a single-delay interferometer on the Hale Telescope

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**Abstract.** Astrophysics demands extremely stable wavelength measurements, e.g. few cm/s scale Doppler radial velocimetry for Earth-like planet detection or multi-year cosmic redshift drift measurements. A fundamental problem of dispersive spectrographs that they use a direct link between position on a detector and output wavelength. Since practical spectrographs cannot be perfectly rigid, they can suffer a wavelength drift error. We present new techniques for $\sim$1000$\times$ improvement in stability using an interferometer in series with a spectrograph to form an Externally Dispersed Interferometer (EDI). The interferometer determines fine wavelength by measuring the sinusoidal intensity variation under interferometer delay dithering (phase stepping), while simultaneously observing an absolute spectral reference to determine the delay. When the dispersed spectrum suffers a wavelength drift, the phase of the moiré from the interferometer shifts in opposite directions for two simultaneous signal components, nonfringing and fringing. With appropriate weightings ("crossfading") the net phase reaction cancels, stabilizing the output spectrum. We present an improvement to our previous technique of multiple delay crossfading, using a single delay to crossfade, and demonstrate stabilization of $\sim$1000$\times$ on Hale Telescope data.

**Keywords:** high-resolution spectroscopy; spectrograph stabilization; Doppler radial velocimetry; exoplanet detection; externally dispersed interferometry; dispersed fixed delay interferometry; cosmic redshift drift.

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