SIM White Light On-Board Processing Algorithms

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Abstract

The Space Interferometry Mission (SIM) is a space-based long baseline optical interferometer designed to perform precision astrometry to an unprecedented accuracy. Highly accurate white light fringe estimation is one of the enabling technologies that SIM relies upon. In the ideal setting, the combined light from the two arms of the interferometer is sent through a prism so that fringes formed at different wavelengths are dispersed linearly in wavenumber over a line of detector pixels. The relative optical path difference (OPD) between the two arms is modulated so that an estimate of the phase in each of spectral channels can be obtained using phase shifting interferometry (PSI) techniques. The phase estimates combined with knowledge of the wavenumbers in each channel are used to determine the pathlength delay, one of the basic astrometric measurements that the instrument makes.

Many non-idealities can compromise the performance of this procedure. Low light levels on dim stellar objects require long integration times to produce adequate SNR. Because of these long integration times the delay cannot be treated as a constant, and characterizing or compensating for this effect in phase estimation is important. The effect of error in the wavenumber in a given channel can also adversely impact the phase estimation. Finite spectral bandwidths, rendering inaccuracies in the monochromatic approximations in the PSI algorithms may also present difficulty.

The present paper presents a unified view of several of these difficulties in white light fringe estimation. Beyond characterizing their relative contributions to error in the optical pathlength delay estimate, alternatives for reducing these errors are introduced, analyzed and simulated. These alternative approaches include both new sets of algorithms that reduce sensitivities to various errors, as well as bringing specific SIM subsystems into the solution space to reduce certain forms of error.