



Wavefront control for the coronagraphic TPF

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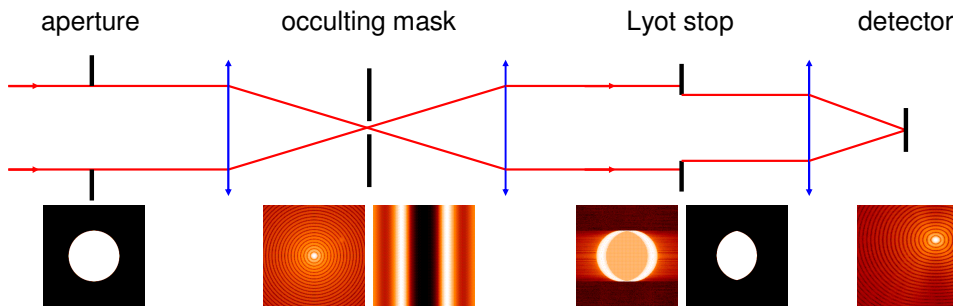
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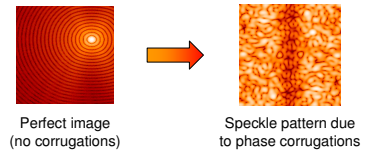
Abstract

Detecting Earth-like planets with a coronagraphic telescope implies that we must attain a planet-to-star contrast ratio on the order of 10^{-10} or smaller in the visible. Even with a very high-quality optical train, speckle noise due to residual wavefront defects (both in phase and amplitude) will severely impair the planet detection. In order to decrease the speckle noise below the planet level, an active control of the wavefront is required. Wavefront sensing should be done directly with the scientific image, because a separate optical arm would introduce its own wavefront defects. To demonstrate this concept for the ECLIPSE and TPF missions, JPL has set up the High Contrast Imaging Testbed (Trauger et al. 2003). This facility makes use of a band-limited image-plane mask (Kuchner & Traub 2002) and a 32x32 deformable mirror. We present here our approach to the wavefront analysis and correction problems.

Image-plane coronagraph



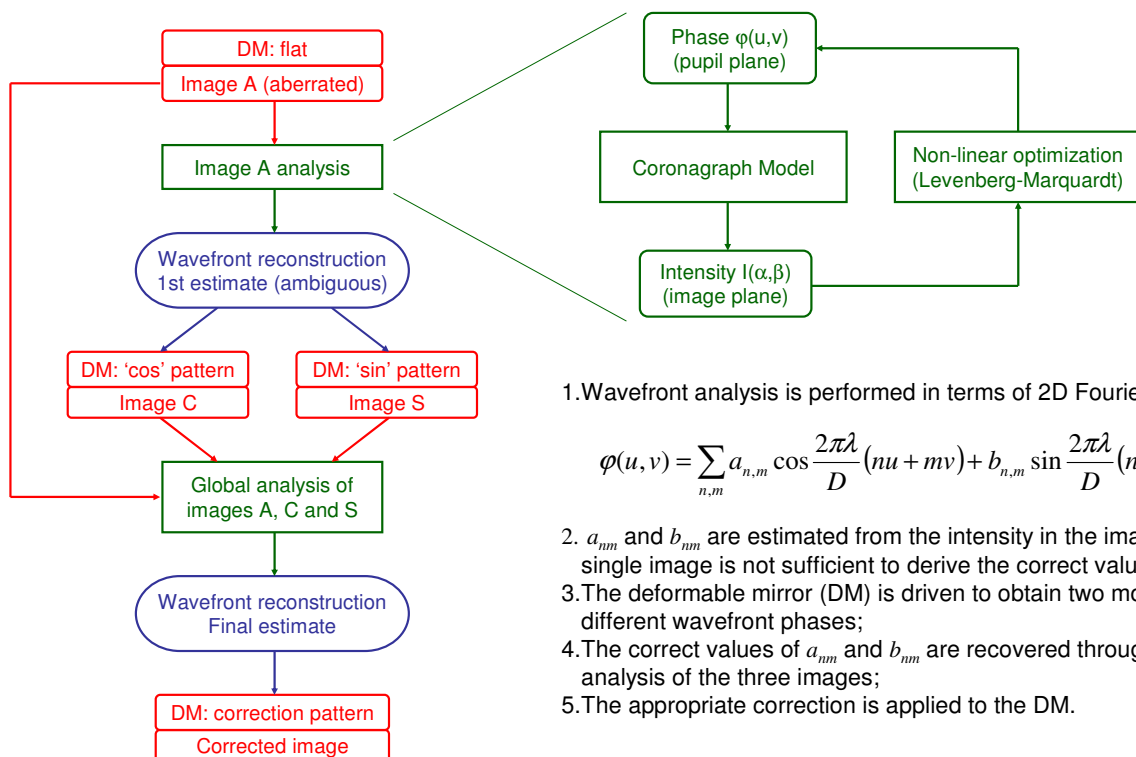
Effect of phase corrugations:



⇒ Necessity for an active control of the wavefront

Layout of a Kuchner and Traub band-limited image-plane mask and corresponding Lyot stop.

Wavefront sensing & control



1. Wavefront analysis is performed in terms of 2D Fourier series:

$$\phi(u, v) = \sum_{n,m} a_{n,m} \cos \frac{2\pi\lambda}{D} (nu + mv) + b_{n,m} \sin \frac{2\pi\lambda}{D} (nu + mv)$$

- a_{nm} and b_{nm} are estimated from the intensity in the image plane, but a single image is not sufficient to derive the correct values;
- The deformable mirror (DM) is driven to obtain two more images with different wavefront phases;
- The correct values of a_{nm} and b_{nm} are recovered through a global analysis of the three images;
- The appropriate correction is applied to the DM.