Wavefront Error Sensing for LDR

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Wavefront sensing is a significant aspect of the LDR control problem and requires attention at an early stage of the control-system definition and design. The question has been addressed specifically for the two-stage optical configuration described at the last Asilomar conference. A combination of a Hartmann test (FIGURE 1) for wavefront slope measurement and an interference test for piston errors of the segments has been examined and is presented as a point of departure for further discussion. The assumption is made that the wavefront sensor will be used for initial alignment and periodic alignment checks but that it will not be used during scientific observations. Implicit in this is the assumption that there are point-like astronomical sources of sufficient brightness at the required wavelengths.

The Hartmann is a good initial test because it is a geometrical test and does not require the system to be near diffraction-limited performance. In addition to the source, the Hartmann test requires a diaphragm or mask pierced with multiple apertures which divide the incoming wavefront into separate beams and an array detector near the focal plane which can intercept the beams on a reference surface. The individual beams define the normal to the wavefront and their intercept on the reference surface can be calculated from the software model of the system. Comparison of calculated and measured intercepts gives a measure of the slope error of that portion of the wavefront.

The two-stage configuration of LDR facilitates the use of a Hartmann test. The mask is located at the fourth element. It must be deployable, but this can be accomplished by making it segmented as shown in the figure. The 12 segments are hinged along their outer edges. The apertures shown in the figure are approximately 40 mm in diameter and there is one aperture per segment. The mask itself is approximately one meter across. The array detector shown in the figure is 55 mm on a side and is located 0.5 m in front of the focal plane. The diffraction spreading of the spot limits the wavelength to less than 5 mm. Since the spots are spread by diffraction they will cover several pixels permitting accurate centroiding.

Once the Hartmann test has been used to correct wavefront slope, piston errors can be addressed. For this an interferometric test at wavelength for which the science detectors can be used offers significant advantages. Possible methods are the point diffraction (Smartt) interferometer and the Zernike phase-contrast test. Both generate reference waves from the central peak of the diffraction pattern of a point source and interfere them with the wavefront under test. These methods require that the piston errors be small compared to the wavefront used in the measurement. For this reason it is advantageous to use as long a wavefront as practical, given the limitations of the available astronomical sources and the sensitivity of the science detectors.

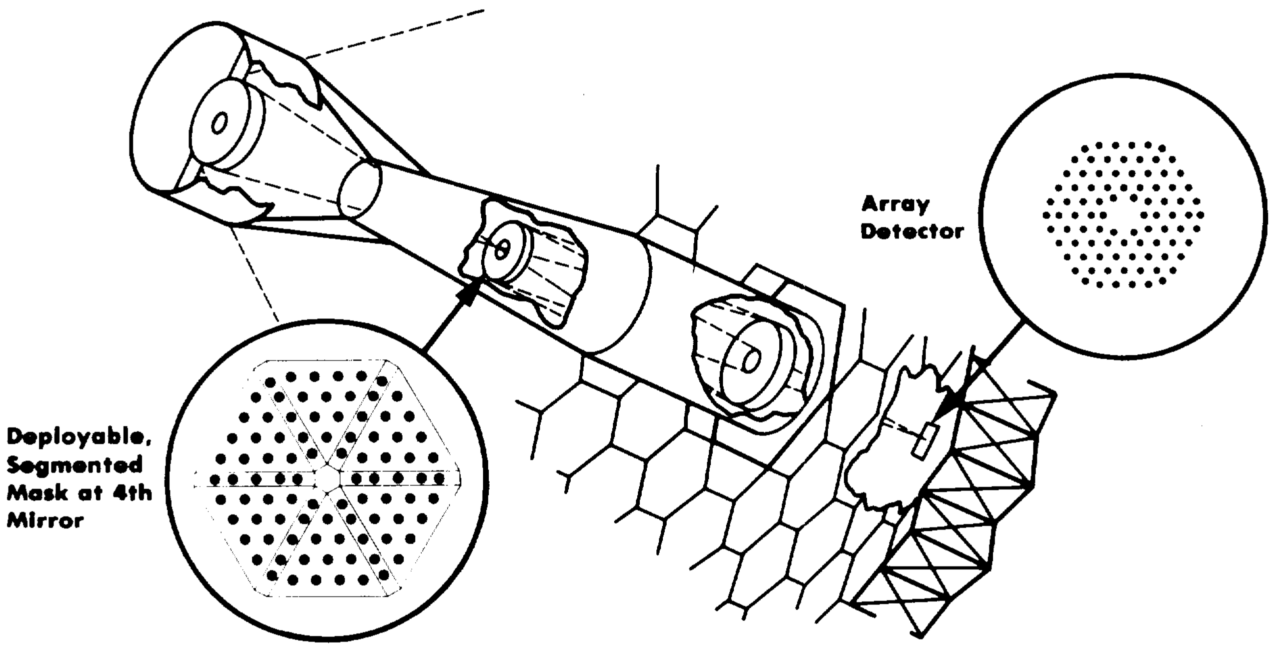

FIGURE 1. Hartmann Test for Wavefront Slope Errors