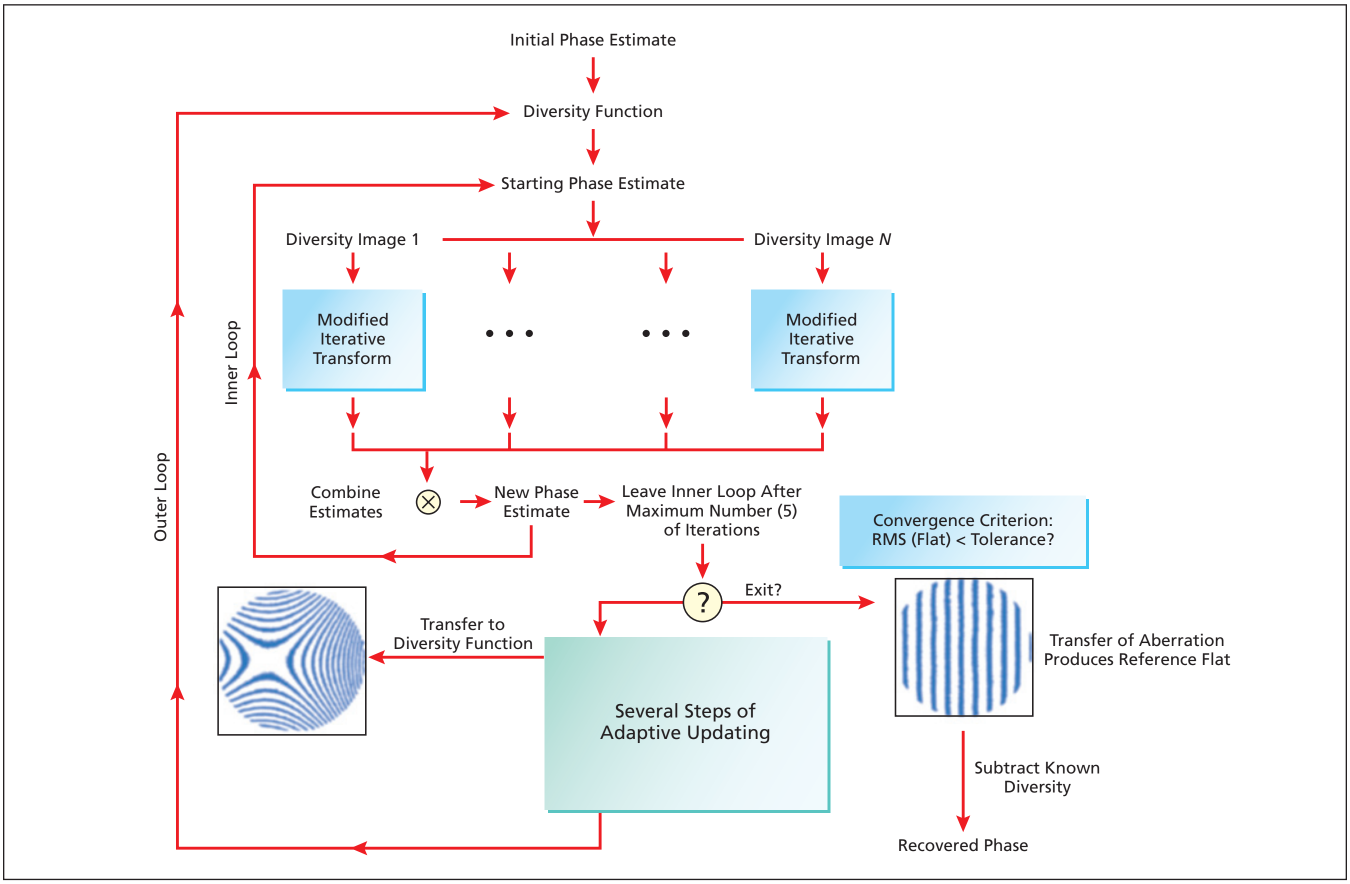


This **Phase-Diverse Iterative-Transform Phase-Retrieval Algorithm** incorporates an adaptive diversity function, which acts as feedback that makes it possible to avoid phase unwrapping while preserving high-spatial-frequency recovery.

several steps, which constitute the outer-loop portion of the algorithm.

The details of the next several steps must be omitted here for the sake of brevity. The overall effect of these steps is to adaptively update the diversity defocus values according to recovery of global defocus in the phase estimate. Aberration recovery varies with differing amounts as the amount of diversity defocus is updated in each image; thus, feedback is incorporated into the recovery process. This process is iterated until the global defocus error is driven to zero during the recovery process.

The amplitude of aberration may far exceed one wavelength after completion of the inner-loop portion of the algorithm, and the classical iterative transform method does not, by itself, enable recovery of multi-wavelength aberrations. Hence, in the absence of a means of "off-loading" the multi-wavelength portion of the aberration, the algorithm would produce a wrapped phase map. However, a special aberration-fitting procedure can be applied to the wrapped phase data to transfer at least some portion of the multi-wavelength aberration to the diversity function, wherein the data are treated as known phase values. In this way, a multi-wavelength aberration can be recovered incrementally by successively applying the aberration-fitting procedure to intermediate wrapped phase maps. During recovery, as more of the aberration is transferred to the diversity function following successive iterations around the outer loop, the estimated phase ceases to wrap in places where the aberration values become incorporated as part of the diversity function. As a result, as the aberration content is transferred to the diversity function, the phase estimate resembles that of a reference flat.

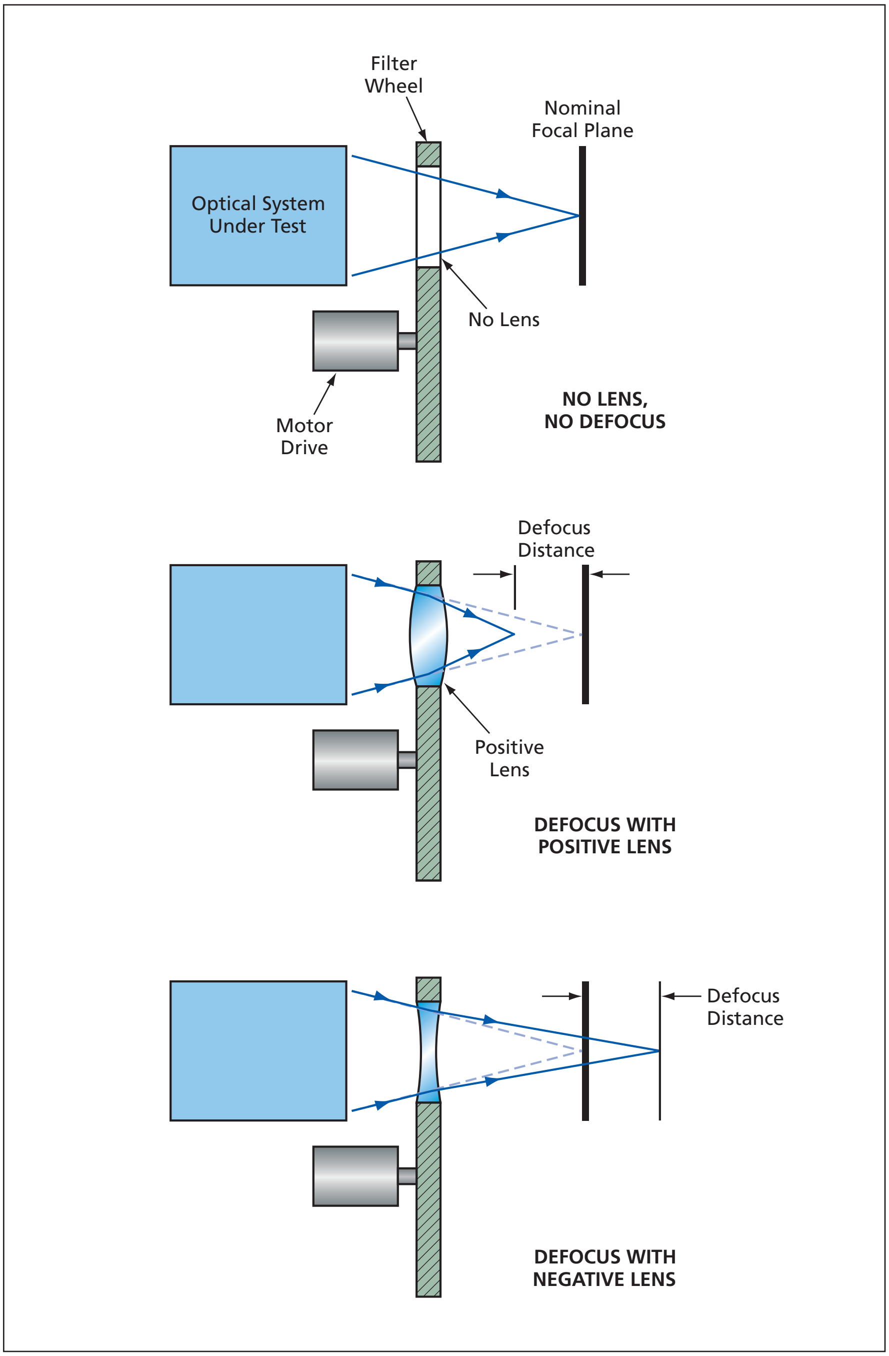
This work was done by Bruce H. Dean of Goddard Space Flight Center. Further information is contained in a TSP (see page 1).
GSC-14879-1

Wavefront Sensing With Switched Lenses for Defocus Diversity

It is no longer necessary to translate a camera to precisely controlled defocus positions.

Goddard Space Flight Center, Greenbelt, Maryland

In an alternative hardware design for an apparatus used in image-based wavefront sensing, defocus diversity is introduced by means of fixed lenses that are mounted in a filter wheel (see figure) so that they can be alternately switched into a position in front of the focal plane of an electronic camera recording the image formed by the optical system under test. [The terms "image-based", "wavefront sensing", and "defocus diversity" are defined in the first of the three immediately



A **Known Amount of Defocus** is introduced by rotating the filter wheel to place a known positive or negative lens in front of the focal plane.

preceding articles, "Broadband Phase Retrieval for Image-Based Wavefront Sensing" (GSC-14899-1).] Each lens in the filter wheel is designed so that the optical effect of placing it at the assigned position is equivalent to the optical effect of translating the camera a specified defocus distance along the optical axis.

Heretofore, defocus diversity has been obtained by translating the imaging camera along the optical axis to various defocus positions. Because data must be taken at multiple, accurately measured defocus positions, it is necessary to mount the camera on a precise translation stage that must be calibrated for each defocus position and/or to use an optical encoder for measurement and feedback control of the defocus positions. Additional latency is introduced into the wavefront-sensing process as the camera is translated to the various defocus positions. Moreover, if the optical system under test has a large focal length, the required defocus values are large, making it necessary to use a correspondingly bulky translation stage.

By eliminating the need for translation of the camera, the alternative design simplifies and accelerates the wavefront-sensing process. This design is cost-effective in that the filter-wheel/lens mechanism can be built from commercial catalog components. After initial calibration of the defocus value of each lens, a selected defocus value is introduced by simply rotating the filter wheel to place the corresponding lens in front of the camera. The rotation of the wheel can be automated by use of a motor drive, and further calibration is not necessary. Because a camera-translation stage is no longer needed, the size of the overall apparatus can be correspondingly reduced.

This work was done by Bruce H. Dean of Goddard Space Flight Center. Further information is contained in a TSP (see page 1).
GSC-14901-1