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The influence of the telescope optical structures on adaptive optics compensation

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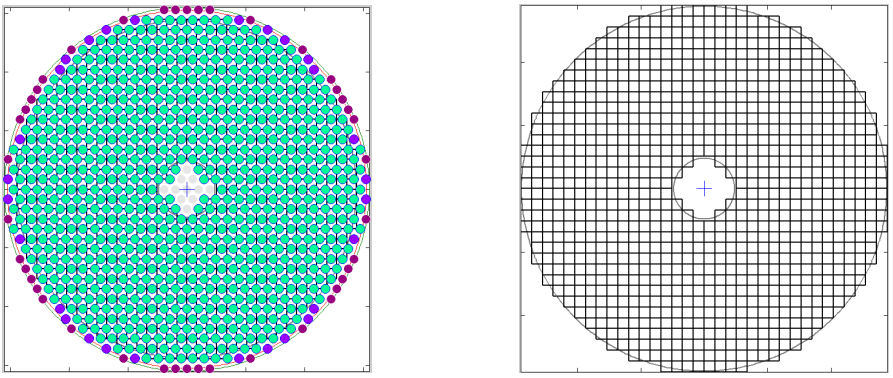

Deformable mirror layout and Hartmann wavefront sensor layout.

Abstract: In the process of high resolution imaging of celestial objects, adaptive optics system plays an important role in the compensation of atmospheric turbulence and the improvement of imaging quality. However, the adaptive optics system is in a certain condition between two extreme situations, which are fully uncompensated and fully compensated, and belongs to partially compensated optical system. Adaptive optics can achieve almost full compensation for low order aberrations, but the compensation ability for high order aberration is limited. The low order aberrations of the telescope can be completely compensated by adaptive optics, but it causes the loss of the compensation stroke of the deformable mirror. The middle and high order aberrations after compensating of the deformable mirror, which are produced mainly by telescope structures, alignment and processing, have some residual aberration. This residual aberrations result in severe degradation of imaging quality of the telescope. So we need control the residual aberration to ensure high resolution imaging quality, especially the high order residual aberration that can't be compensated, which should be strictly controlled in the beginning of the design of the telescope system.

We analyze the influence of the telescope optical structures on adaptive optics compensation, mainly for the 4 meter telescope. First of all, the simulation analysis of adaptive optics system layout of the 4 meter telescope is presented, in order to analyze the residual aberrations with compensated by 4 meter adaptive optical system. The specific analysis of the optical structures on the layout correction capability of our adaptive optical system contains the following content: the structure of primary mirror of the telescope optical system, mainly the honeycomb structure, the primary mirror support structure, the primary mirror temperature deformation, secondary mirror block, secondary mirror support bars block, and the static and quasi-static aberration of the optical processing. The influence of these factors on the adaptive optics compensation is analyzed, so that the requirements of the aberrations control are given.

Low order aberrations such as defocus and astigmatism caused by primary and secondary mirror alignment, primary mirror support, and primary mirror thermal deformation, can be completely corrected by adjusting the secondary mirror or using a single deformable mirror which has large compensation stroke. High order aberrations out the ability of adaptive optics compensation, such as the aberrations caused by honeycomb structure of primary mirror, can be compensated by data processing. In the process of telescope design and processing, the factors that lead to a large number of high order aberrations should be strictly controlled, and high control requirements are put forward.

Keywords: adaptive optics; optical structure; high aberration; secondary mirror support bars

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