EXERCISES 4

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(a) Draw a simplified diagram of an adaptive optics system. Show the correct optical location of the deformable mirror.

・the disturbed wavefront enter the telescope aperture and re-imaged onto the deformable mirror (DM)

・the plane mirror is deformed to have the same shape but half the wavefront error of the incoming wave

→the reflected wavefront will be very nearly a plane wave after leaving the DM.

・using half the distortion on the DM

→・the corresponding part of the wave travel through the depression in the DM

・catching up with the rest of the wave as it reflects from the DM's surface.

・To determine what corrections are needed :
part of the light is picked off by a beam-splitter
sent to the wavefront sensor
correction signals generated by the wavefront sensor
fed back to the deformable mirror to close the loop
→compensate for the distortions

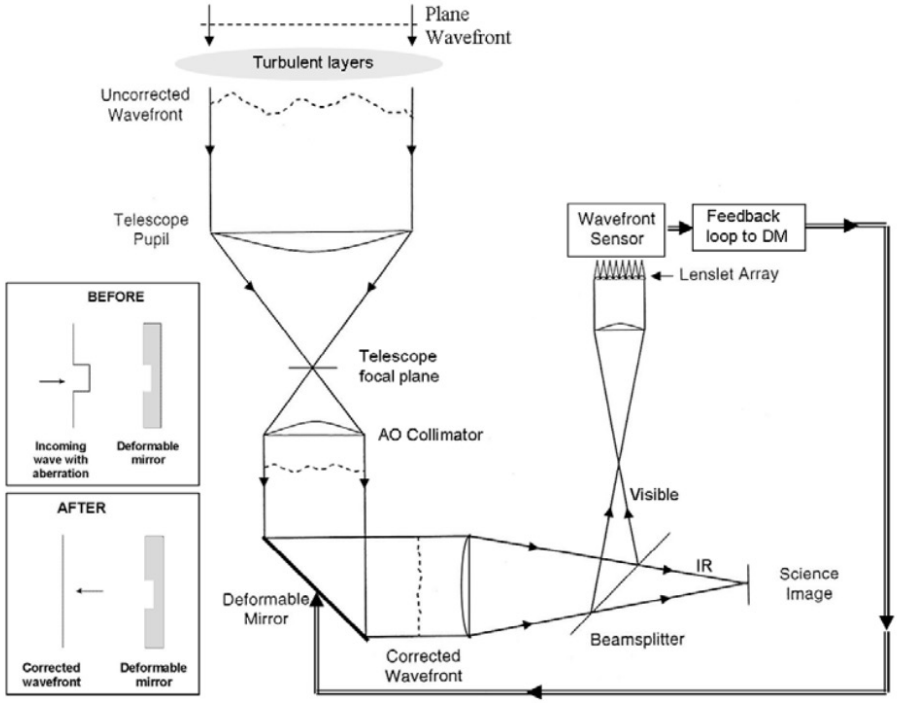

Figure 2.6. The basic layout of an AO system. Plane waves arriving at the Earth from a distant star become distorted by randomly moving cells of air with different indices of refraction. These distortions are sensed at high speed and corrections are sent to change the shape of a deformable mirror which corrects the wavefront at reflection.

(b) Explain the role of a Shack-Hartmann wavefront sensor.

・Shack-Hartmann wavefront sensor :

・Direct sensors split the pupil image plane into sub-apertures

→use the intensity in each sub-aperture to deduce the phase of the wavefront

・slope-sensing

・the basic construction is that of an array of tiny lenses or lenslets

・placed near a pupil image to produce a pattern of many star images on the detector, each corresponding to a different part of the primary aperture.

・rapidly finding the centroids of each image

→ derive the slope of the wavefront at that instant

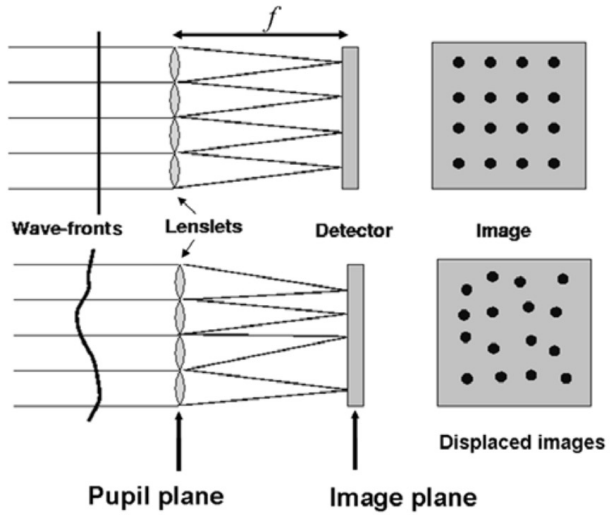

Figure 2.7. The operation of a Shack–Hartmann wavefront sensor system. A small format high-speed CCD is required to record the displacements of the images.

(c) What is meant by the Strehl ratio?

・Strehl ratio(SR)=(observed peak intensity)/(ideal peak intensity)

・Astronomers compare seeing-limited and diffraction-limited images using the Strehl ratio

・Typically, the Strehl ratio is 0.01.

・this ratio could be increased to 1

→・most of the light : in the central spike of the Airy diffraction pattern

・the contrast against the sky background : increase enormously

・S>0.8→ diffraction-limited

・It requires a huge number of terms to achieve a Strehl ratio as high as 80% under average seeing conditions on a very large telescope, which in turn implies a large number of actuators on the deformable mirror.