Sec.2 – Question 3

McLean seminar
2024.05.10

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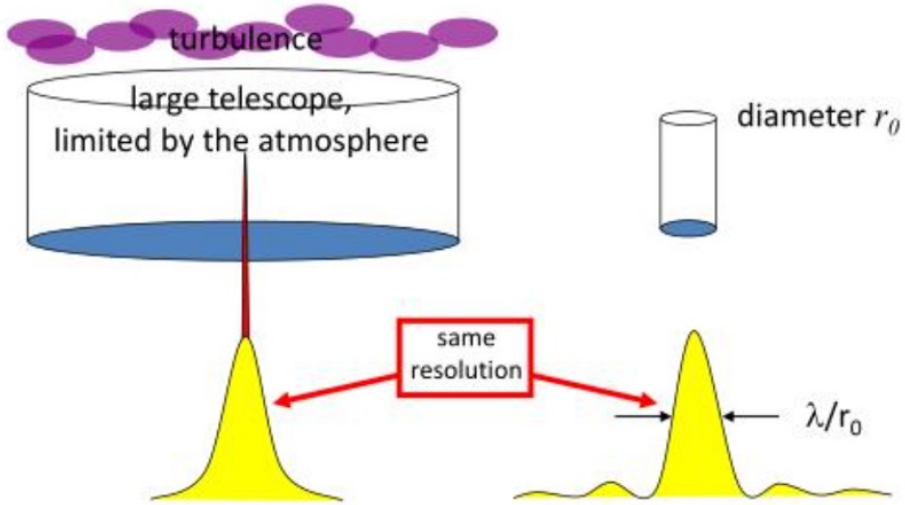
3 Explain the terms Fried parameter and isoplanatic patch? What is the order of magnitude of the Fried parameter for an 8 m telescope with seeing of 0.75″ at (a) visible wavelengths (5,000 Å) and (b) near-infrared wavelengths (2.2 μm)?

3-1. Fried parameter (r_0), (2.3.2):
Length over which the wavefront is not significantly perturbed.

Two physical interpretations:
1. aperture over which there is approximately one radian (1/2π waves) of rms phase error.
2. Aperture which has the same resolution as defined by Fried as a diffraction-limited aperture in the absence of turbulence.

Fried (1966): Diameter of a diffraction-limited telescope having the same resolution as an infinitely large telescope limited by the atmosphere

A larger r_0 implies less turbulence, which leads to better image quality and sharper astronomical observations.



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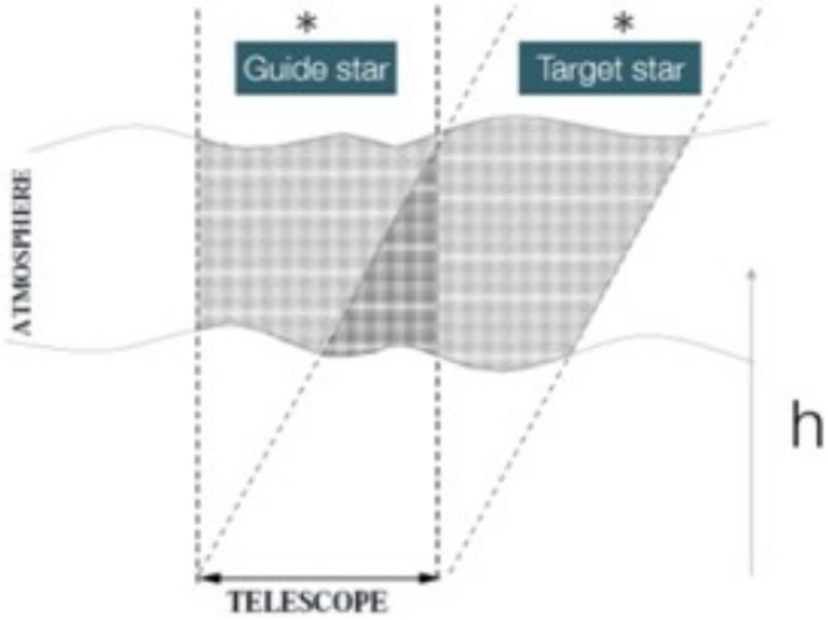
3-2. Isoplanatic patch (2.4.2):

- The isoplanatic patch (= isoplanatic angle) refers to the angular size over which the distortions caused by atmospheric turbulence are approximately the same.

- Within this patch, the same correction applied by an adaptive optics system would improve the quality of the observed image. Therefore, the isoplanatic patch represents the region of the sky over which adaptive optics corrections can be applied effectively.



isoplanatic angle: $\theta_0 = 0.314 \frac{r_0}{H}$

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3-3-(a).

$$\text{seeing} = 0.976\frac{\lambda}{r_0} \approx \frac{\lambda}{r_0}$$

1 radian = 206,265 ″
-> 1″ = $\frac{1}{206,265}$ radian

$$r_0 = \frac{\lambda}{seeing} = \frac{5000\times10^{-10}\ m}{0.75''} = \frac{5000\times10^{-10}\ m}{0.75\times\frac{1}{206,265}\ radian} = 0.13751\ \text{m}$$

3-3-(b).

$$r(\lambda) = \left(\frac{\lambda}{\lambda_0}\right)^{6/5} r_0 = \left(\frac{2.2\ \mu m}{0.5\mu m}\right)^{6/5} \times 0.13751\ \text{m} = 0.811309\ \text{m}$$