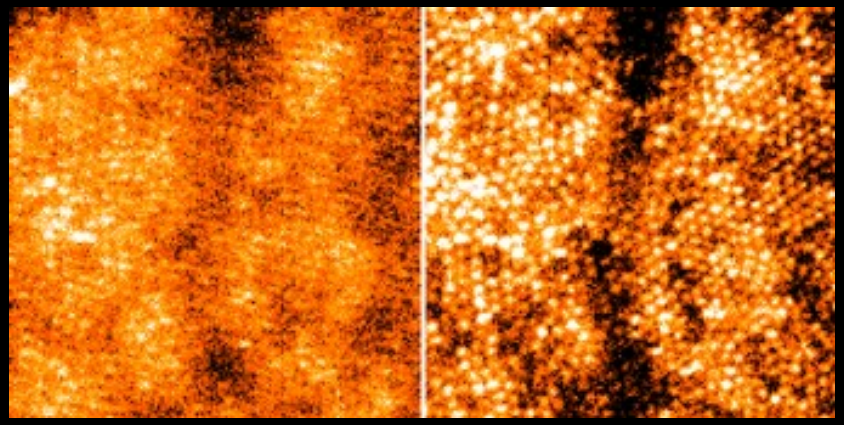
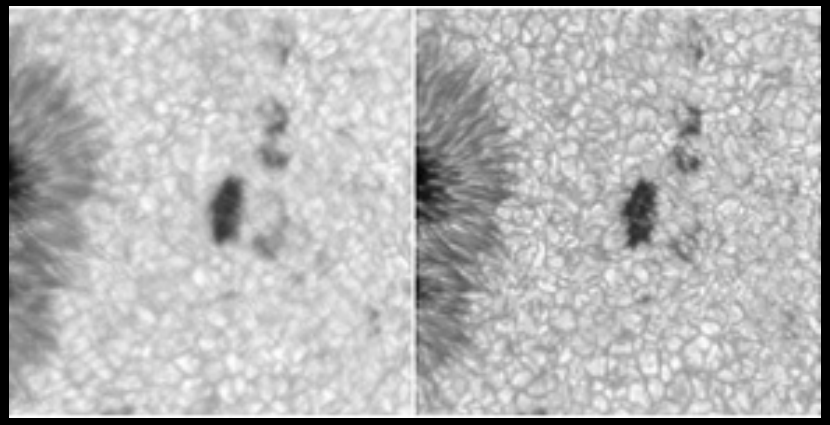
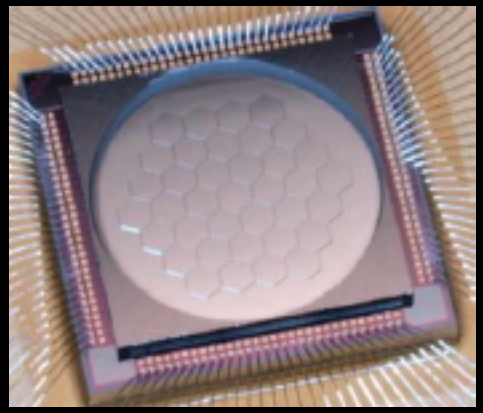


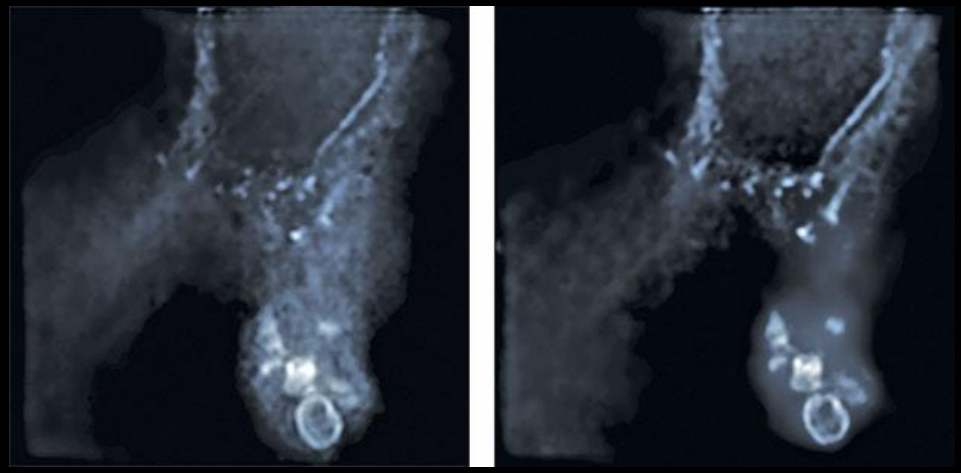


Adaptive Optics

Special Topic in Astrophysics

ASTRON 250 - Fall 2013



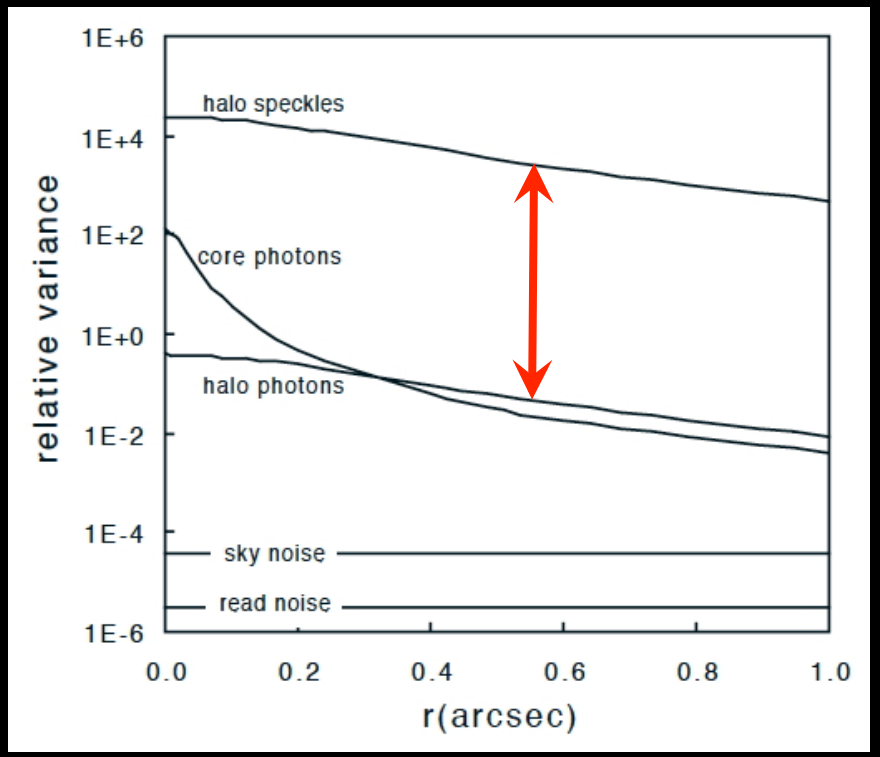


Speckle properties

- Hinkley et al. (2007)

Speckle properties

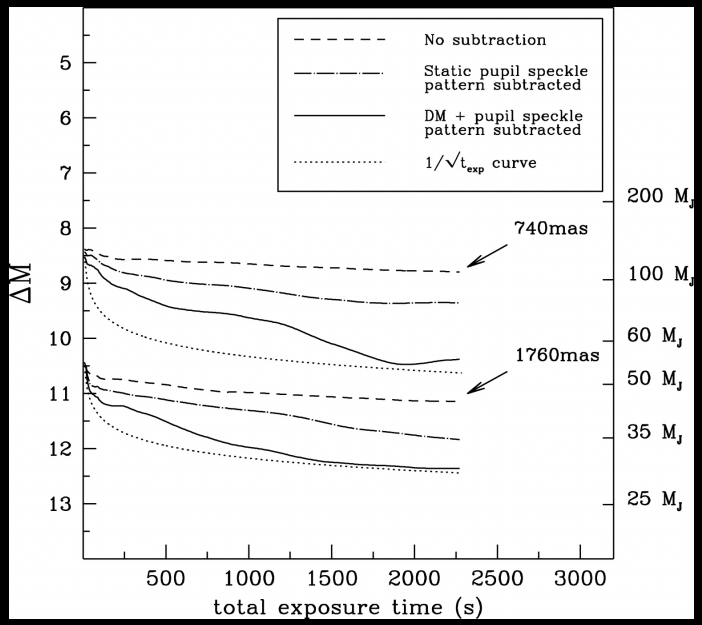
- Several types of speckles, different origins
  - Atmospheric turbulence
    - Random behavior, can be averaged out (BUT spatial and temporal correlations!)
    - Short timescale ($\approx\tau_0$)



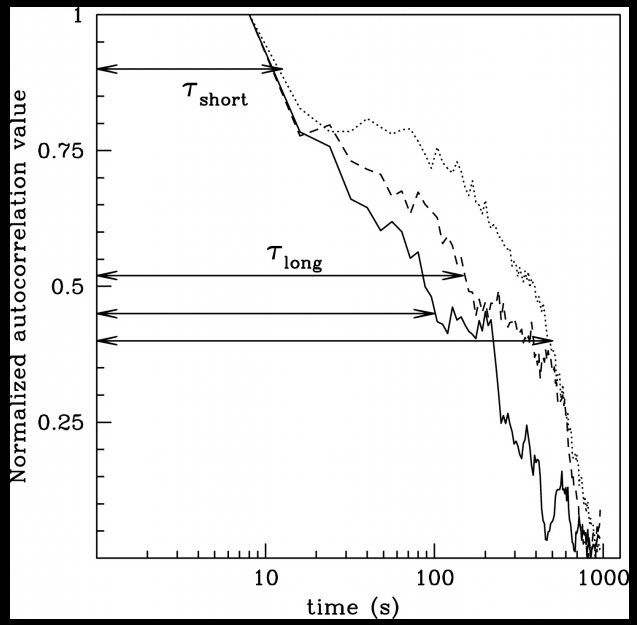
Racine et al. (1999)

Speckle properties

- Several types of speckles, different origins
  - Telescope and instrument, either
    - fixed/pinned (static speckles), can be calibrated out
    - very slowly varying (>> τ_0), need specific obs. stratregy

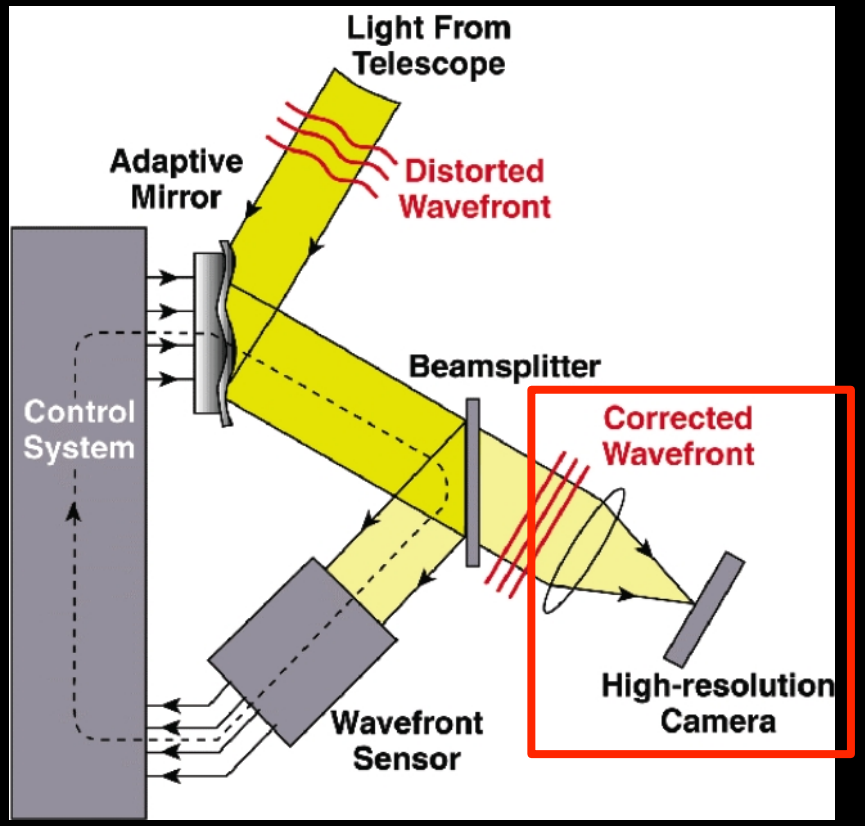


Hinkley et al. (2007)



Non-common path errors

- A critical (and easy to overlook) limitation of AO: aberrations that the wavefront sensor cannot detect
  - Instrument
  - Atmospheric layer if conjugated to another layer

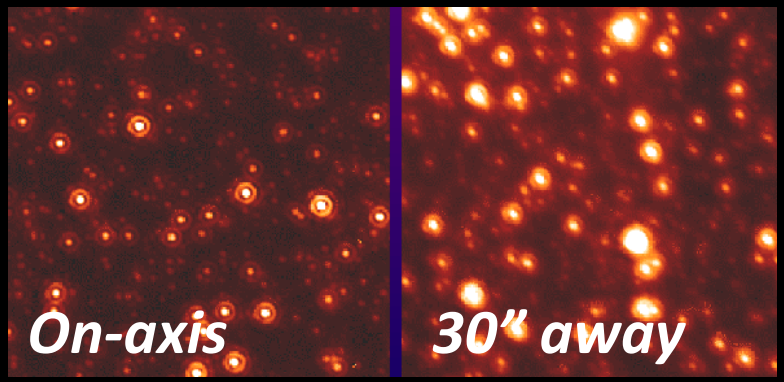


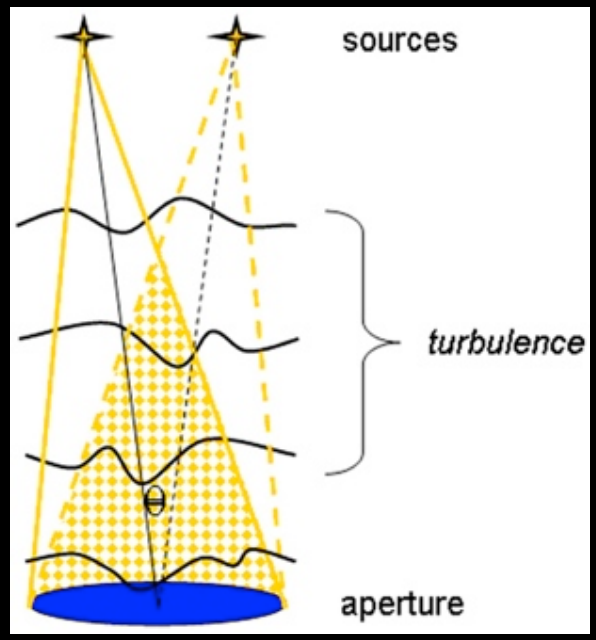
Anisoplanatism

- Generally speaking, turbulence sampled by the "sensing beam" differs from that of the "science beam"
- Can have a variety of origins
  - Angular displacement
  - Temporal delay
  - Chromatic effects
  - "Focus depth" mismatches

Anisoplanatism

- Angular anisoplanatism can be predicted in the case of Kolmogorov turbulence
- θ_0 measures decorrelation and is related to r_0
  - For a single layer: $\theta_0 \approx 0.314\, r0 \cos z / H$ *(a few “)*
  - Same behavior with λ
  - Steeper dependence on z

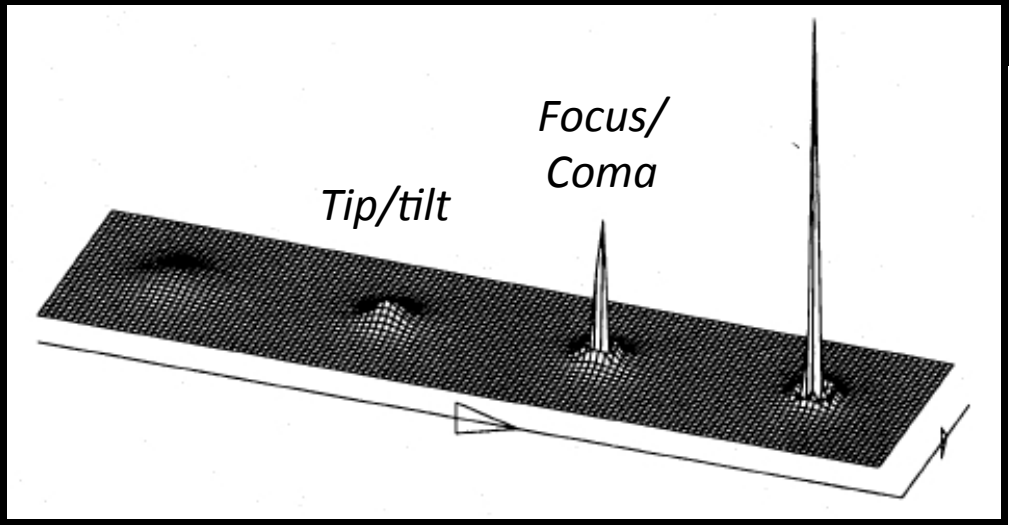




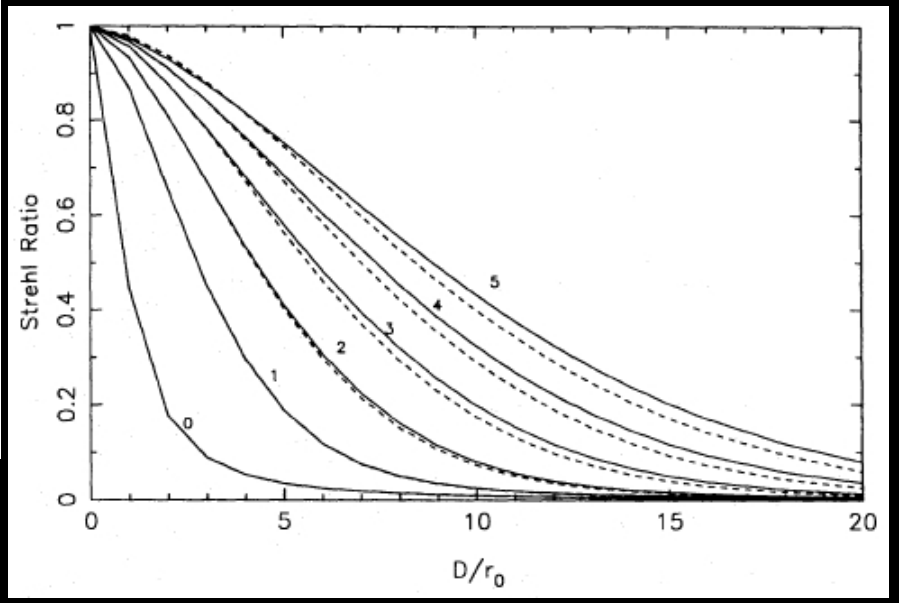
Bolbasova & Lukin (2009)

AO performance

- Performance of AO systems depend primarily on D/r_0 and the number of orders corrected
  - It doesn't take much to be diffraction-limited!

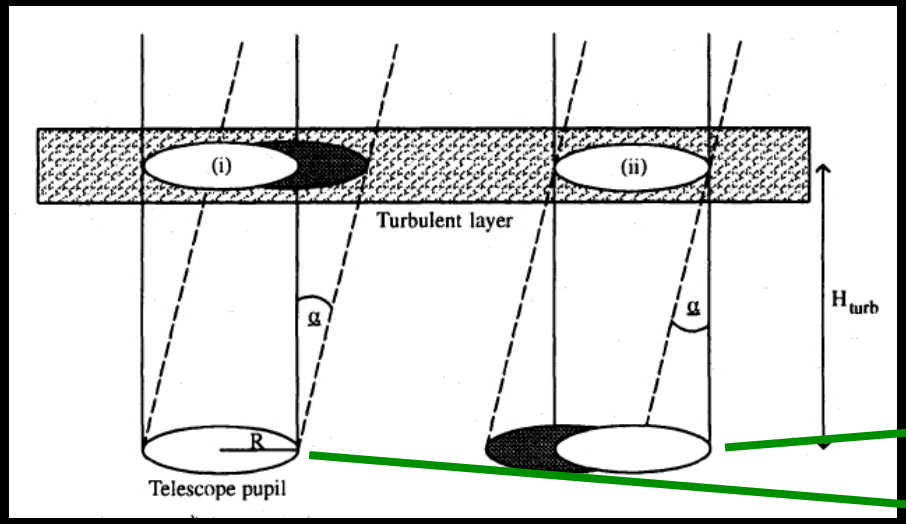


Wilson & Jenkins (1996)

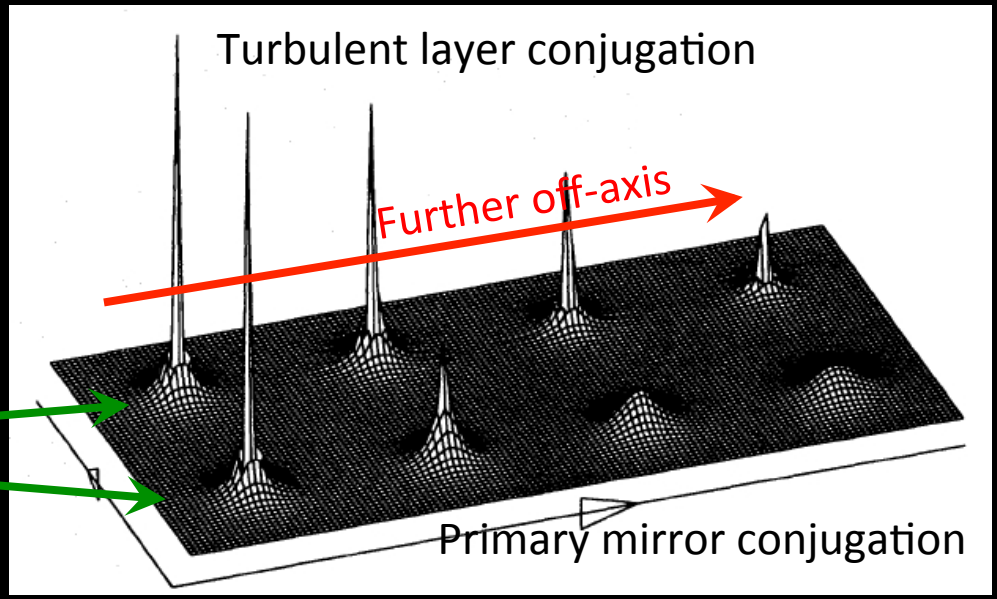


Optimal optical conjugation

- What is the best choice of pupil plane: primary mirror or turbulence layer?
  - Compromise between performance and implementation constraints (Which layer? SNR?)



Wilson & Jenkins (1996)



Homework

- Lick AO near-IR images of a single star and a binary system at multiple wavelengths
  - Compute theoretically "perfect" PSF
    - D_{tel} = 3m, $D_{obscuration}$ = 80cm (+4 "spider arms")
  - Measure Strehl ratio and r_0
  - Quantify PSF variability
  - Measure the flux ratio and separation of the binary system
- This is not a test!

Homework

- The simplest data reduction cookbook:
  - Median all images in a given sequence
  - Subtract it off each image (sky+dark current)
  - Align individual images
  - Combine all images
- This neglects bad pixels and flat field issues; they are minor for these particular datasets

Next week readings

- Wavefront sensing techniques
  - § 5.1-5.3 in Roddier (1999)
  - Gonsalves (1982)
  - Kocher (1983)
  - Ragazzoni (1996)
- See also Tyson's § 5.1-5.4 [more detailed]