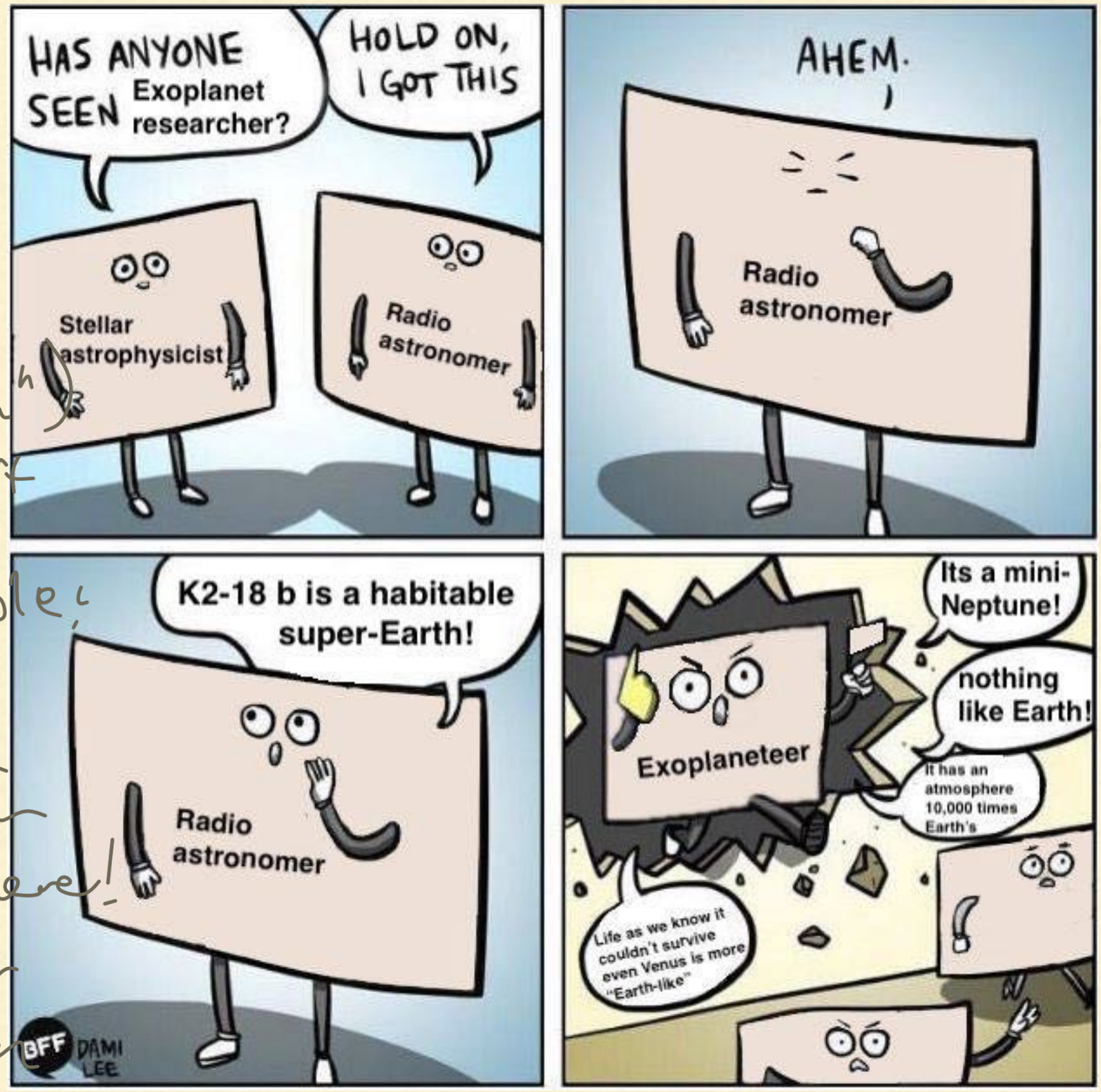
38pc
(124 ly)

$M = M_\oplus \cdot 8$
("super-Earth")
33-day orbit

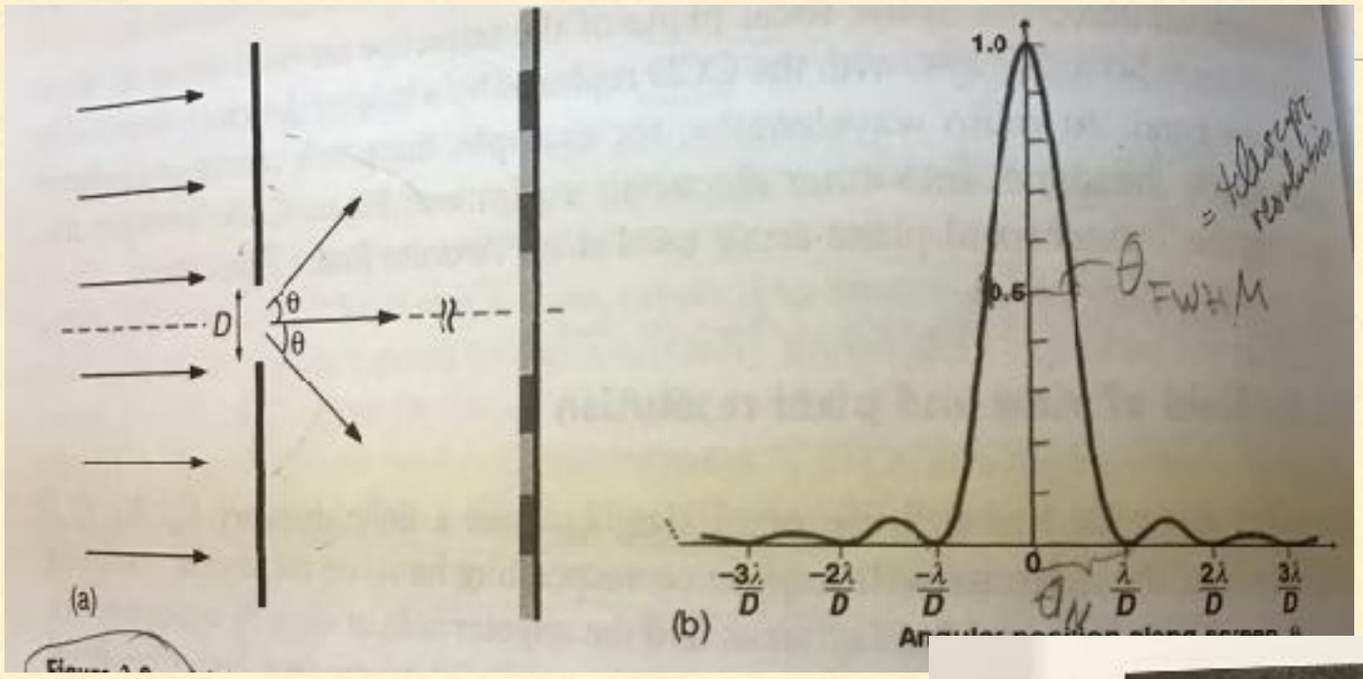
Spitzer + Hubble:
significant
amounts of
water vapour
in atmosphere!
1st time for
exoplanet in
habitable zone!

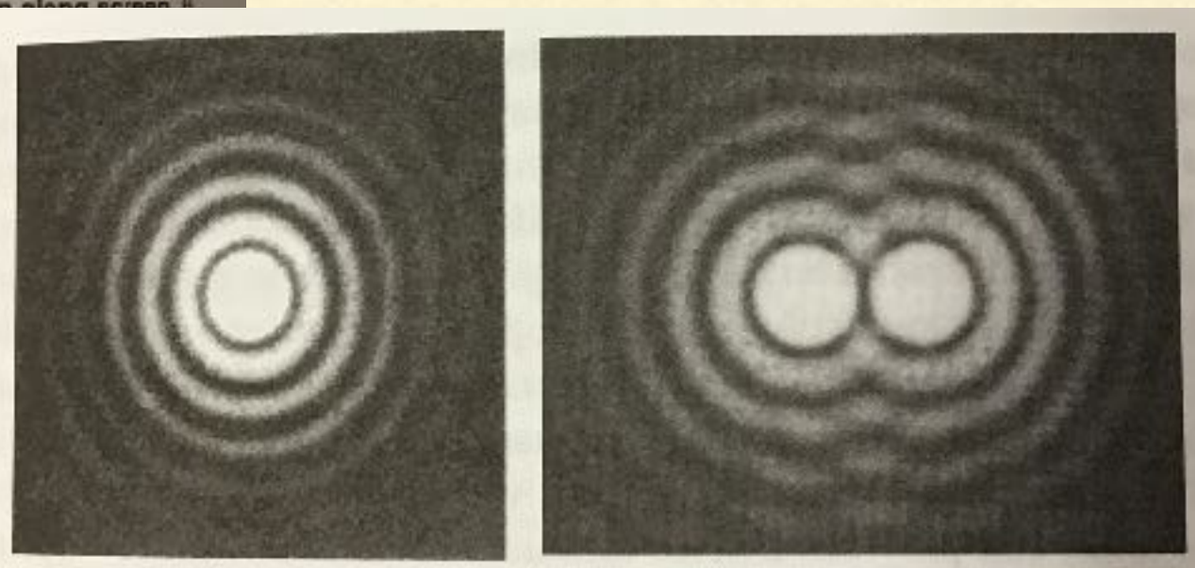


Nomenclature radio bands :)

Band	Frequency Range	Origin of Name
I	up to 200 MHz	Unknown
G	200 to 250 MHz	Unknown
P	250 to 500 MHz	P for "previous", as the British used the band for the earliest radars, but later switched to higher frequencies.
L	0.5 to 1.5 GHz	L for "long" wave.
S	2 to 4 GHz	S for "short" wave. Don't confuse this with the short wave radio band, which is much lower in frequency
C	4 to 8 GHz	C for "compromise" between S and X band.
X	8 to 12 GHz	Used in WW II for fire control, X for cross (as in crosshair)
Ku	12 to 18 GHz	Ku for "kurz-under".
K	18 to 26 GHz	German "kurz" means short, yet another reference to short wavelength.
Ka	26 to 40 GHz	Ka for "kurz-above".
V	40 to 75 GHz	V for "very" high frequency band (not to be confused with VHF)
W	75 to 110 GHz	W follows V in the alphabet

MEASURING THE SIGNAL, PART 2





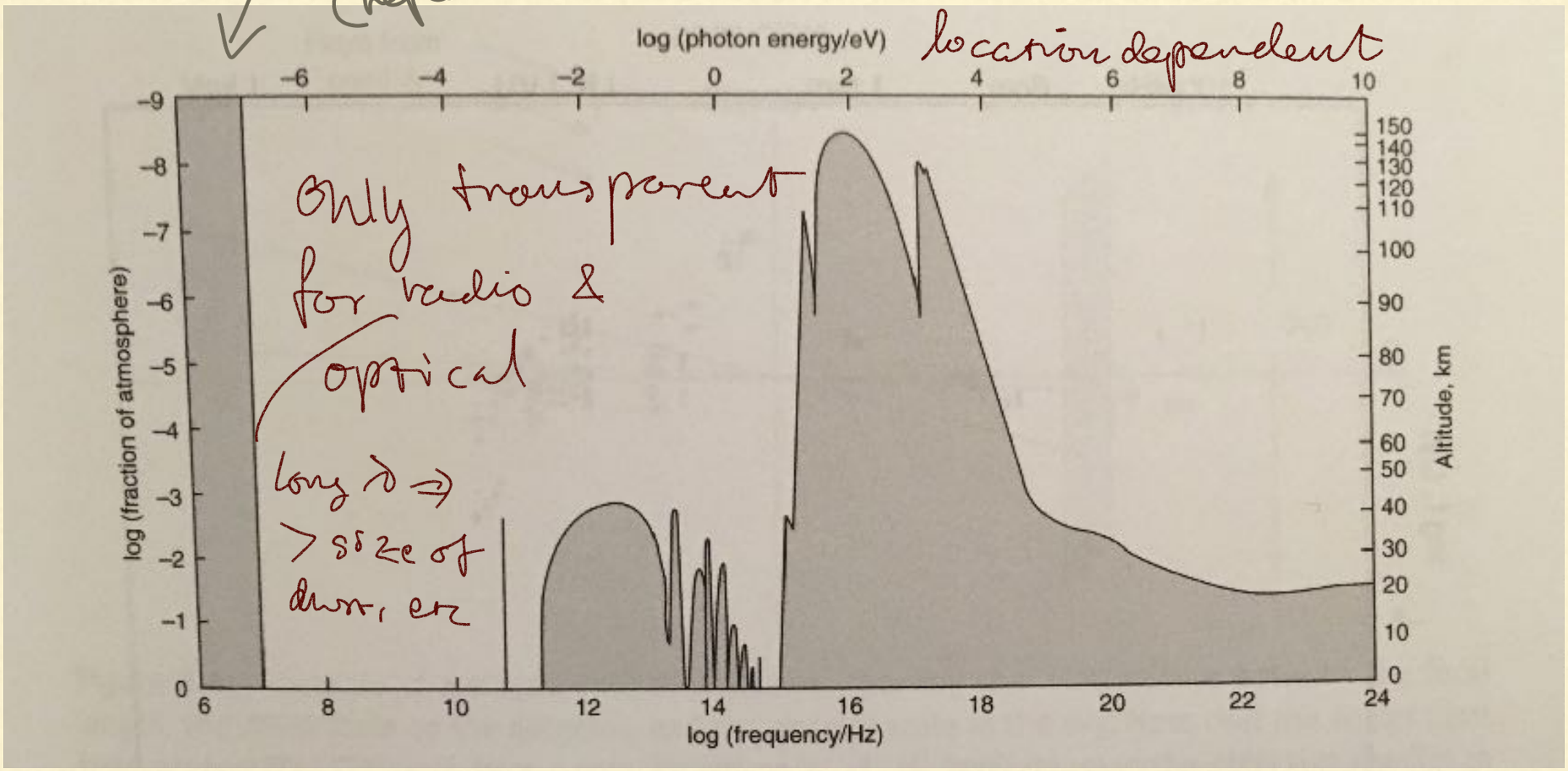
(a) (b)

Figure 2.10. **(a)** The two-dimensional diffraction pattern from a circular aperture illuminated by a single point source at infinity. The bright central spot is called the *Airy disk*. **(b)** Two closely spaced point sources in the sky would create a pattern like this on the detector.

MEASURING THE SIGNAL, PART 2

Atmosphere: cutoff due to ionosphere (reflects long λ)

Atmosphere: scattering, absorbing, emitting, λ-dependent, time-dependent location dependent



three telescopes @ high alt, use domes.

ATMOSPHERE

ukirt

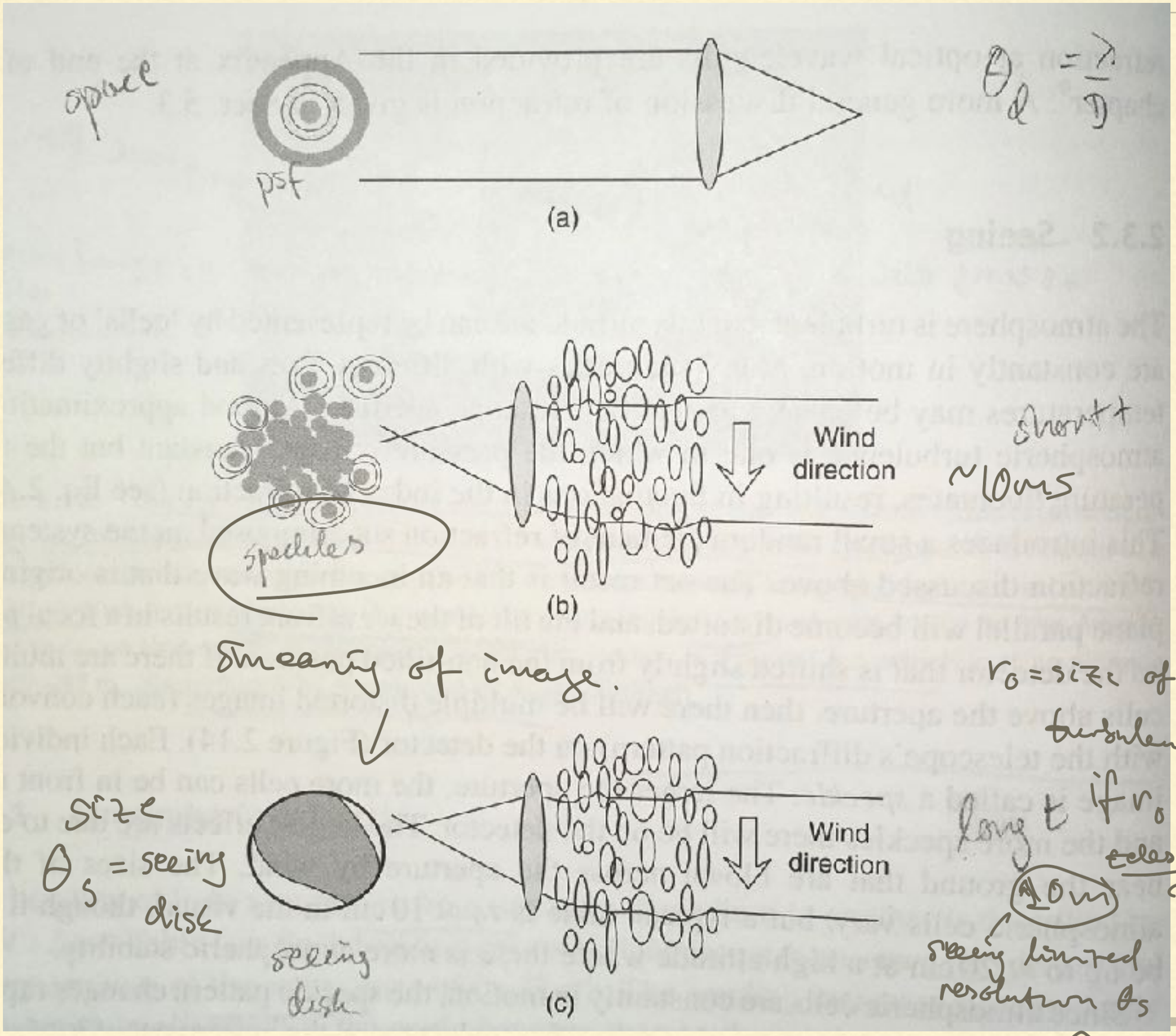
JCMT

0.35-2mm

The Kecks (optical, IR)
Subaru

OPTICAL - ATMOSPHERIC DISTURBANCES

- Refraction — Snell's law — bending of light, more the further from Zenith the source is
- Seeing (actually turbulence) + temp turbulence — bubbles. causes tilted wave fronts, shifted focal points. Speckles. highly time-dependent. v. short time ~ 10ms
  - adaptive optics
- Scintillation
- Reddening



$\theta_d = \frac{\lambda}{D}$

study ex 2.1 !

short t ~10ms

resolution of large ground-based telescopes

$\cancel{\theta_d}$ θ_s

$\theta_s = \frac{\lambda}{r_0}$

r_0 = size of atmospheric turbulence cell ~ 10-20cm

long t if r_0 = 10cm ⇒

size θ_s = seeing disk

telescopes

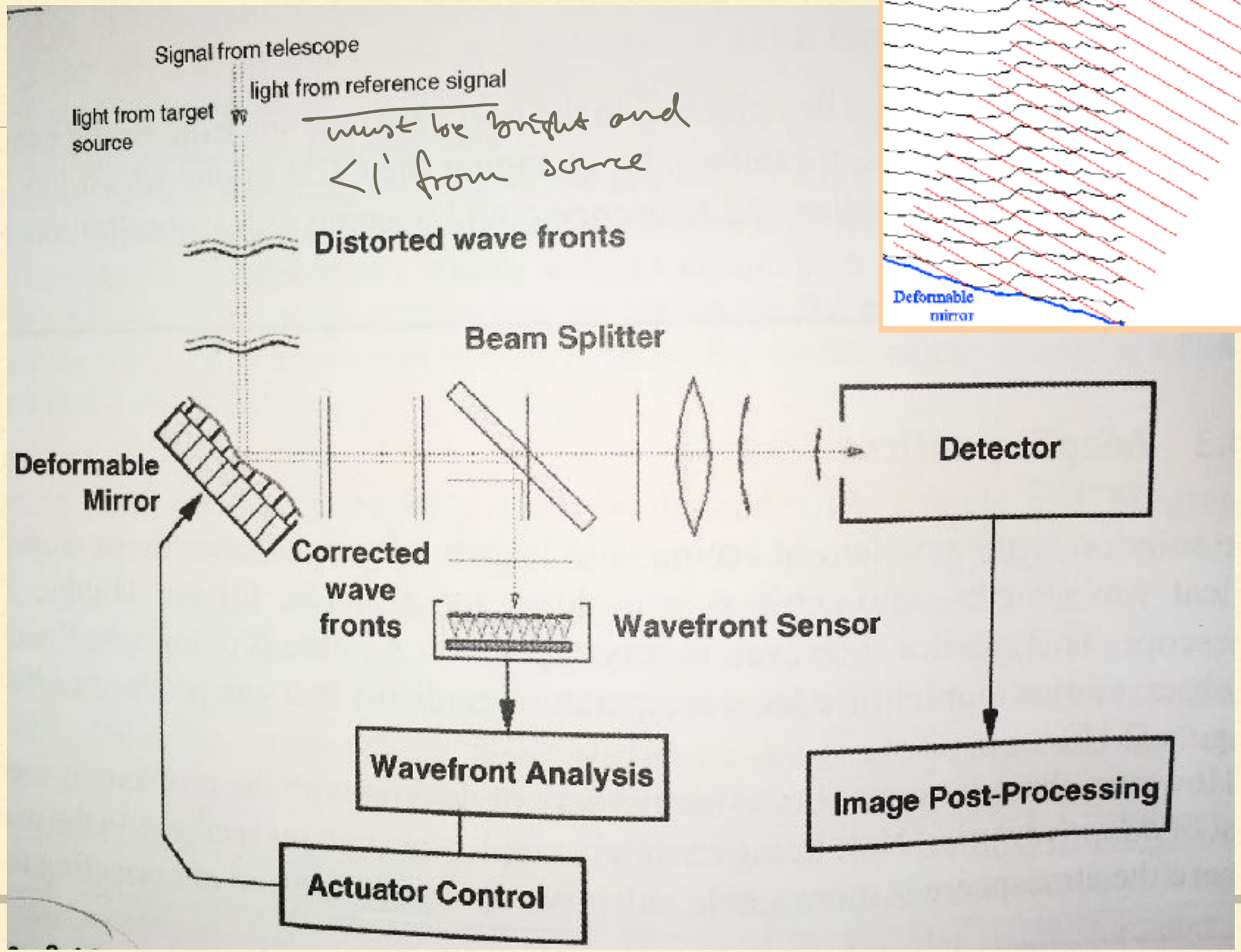
10m ~ 10 cm

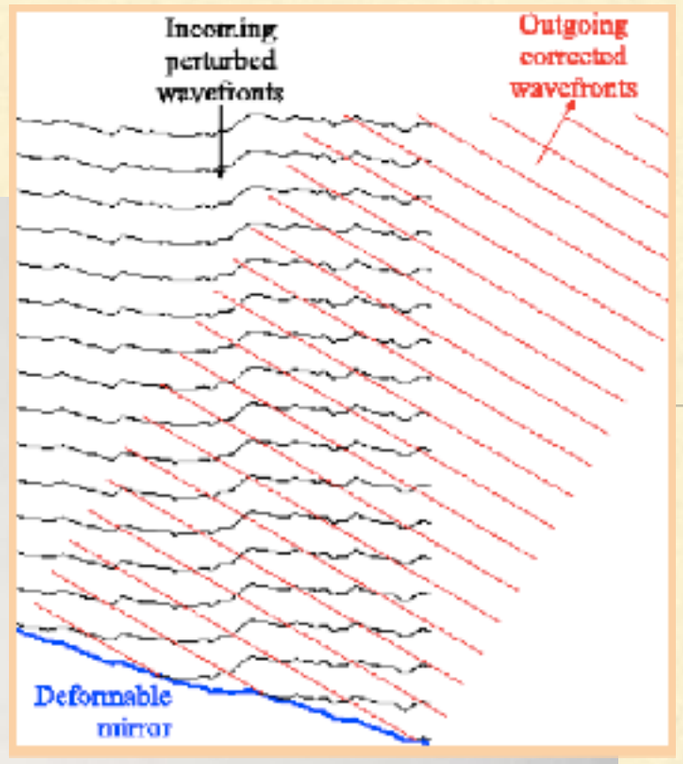
seeing limited resolution θ_s

diffraction limited resolution θ_d

Same resolution!

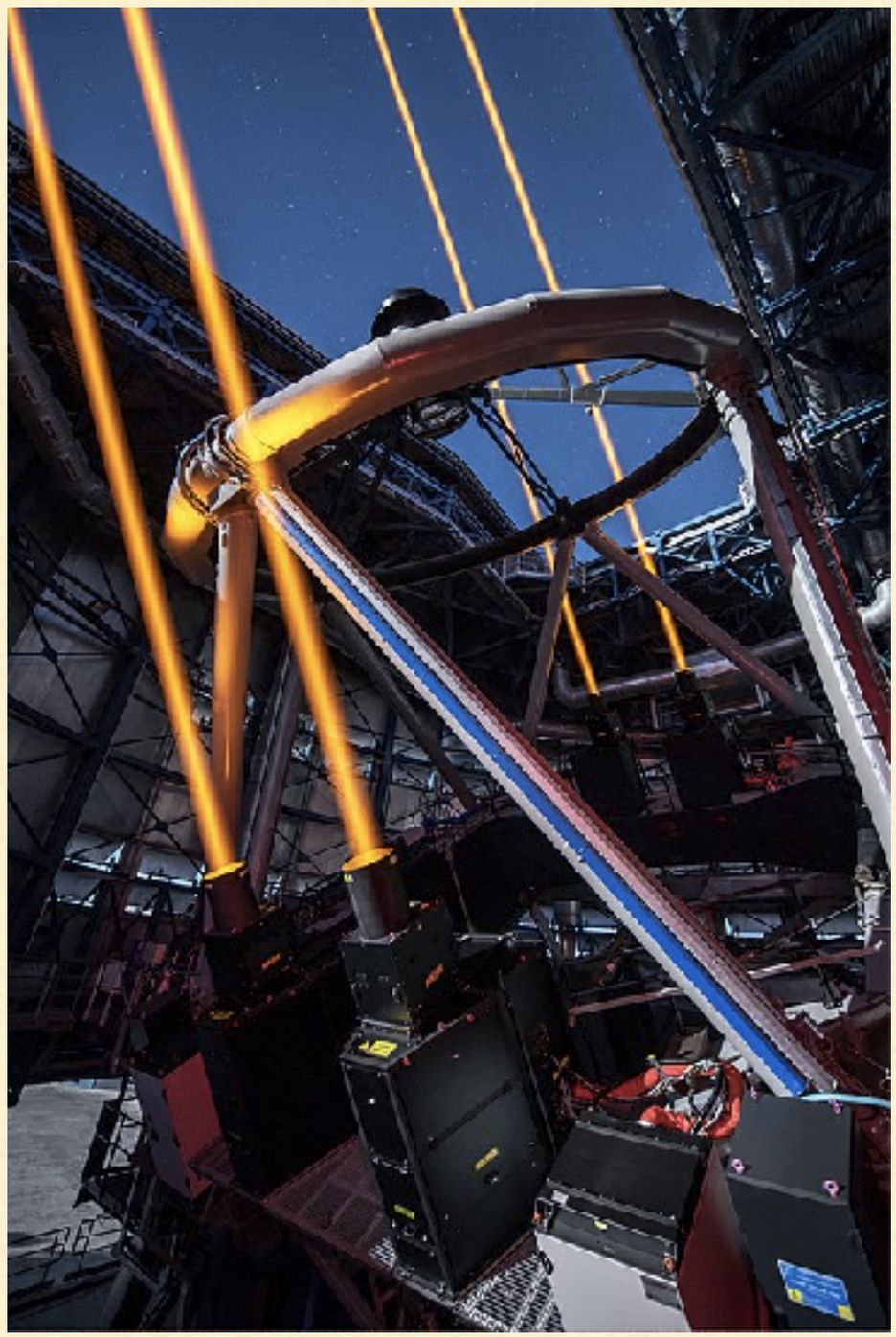
ADAPTIVE OPTICS





Laser guide star

powerful, scatters off particles.
point like reference
(mimics a star on sky
to use as reference signal)



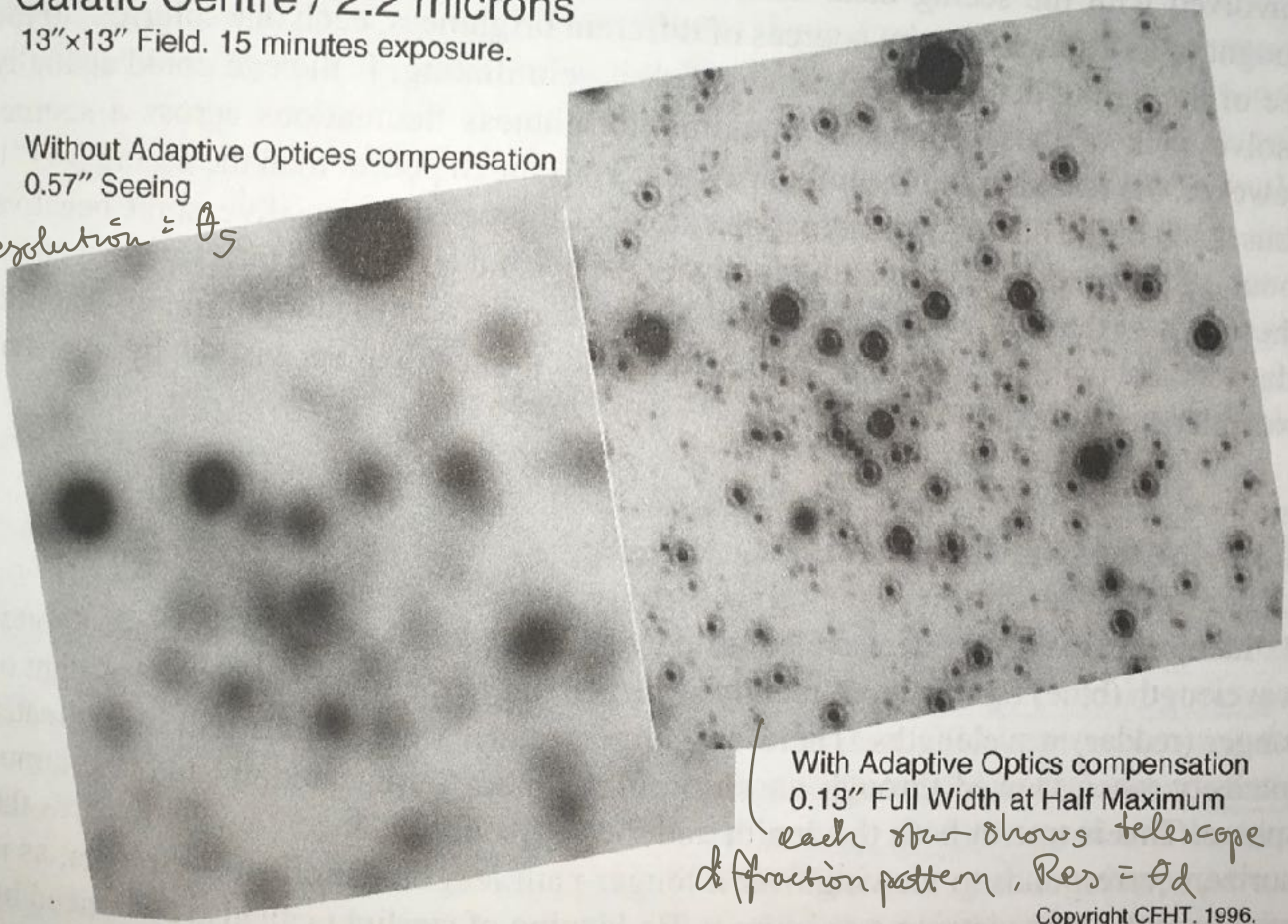
Paranal

Galatic Centre / 2.2 microns

13″x13″ Field. 15 minutes exposure.

Without Adaptive Optices compensation
0.57″ Seeing

resolution ≈ θ_S



With Adaptive Optics compensation
0.13″ Full Width at Half Maximum

each star shows telescope diffraction pattern, Res = θ_d

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OPTICAL - ATMOSPHERIC DISTURBANCES

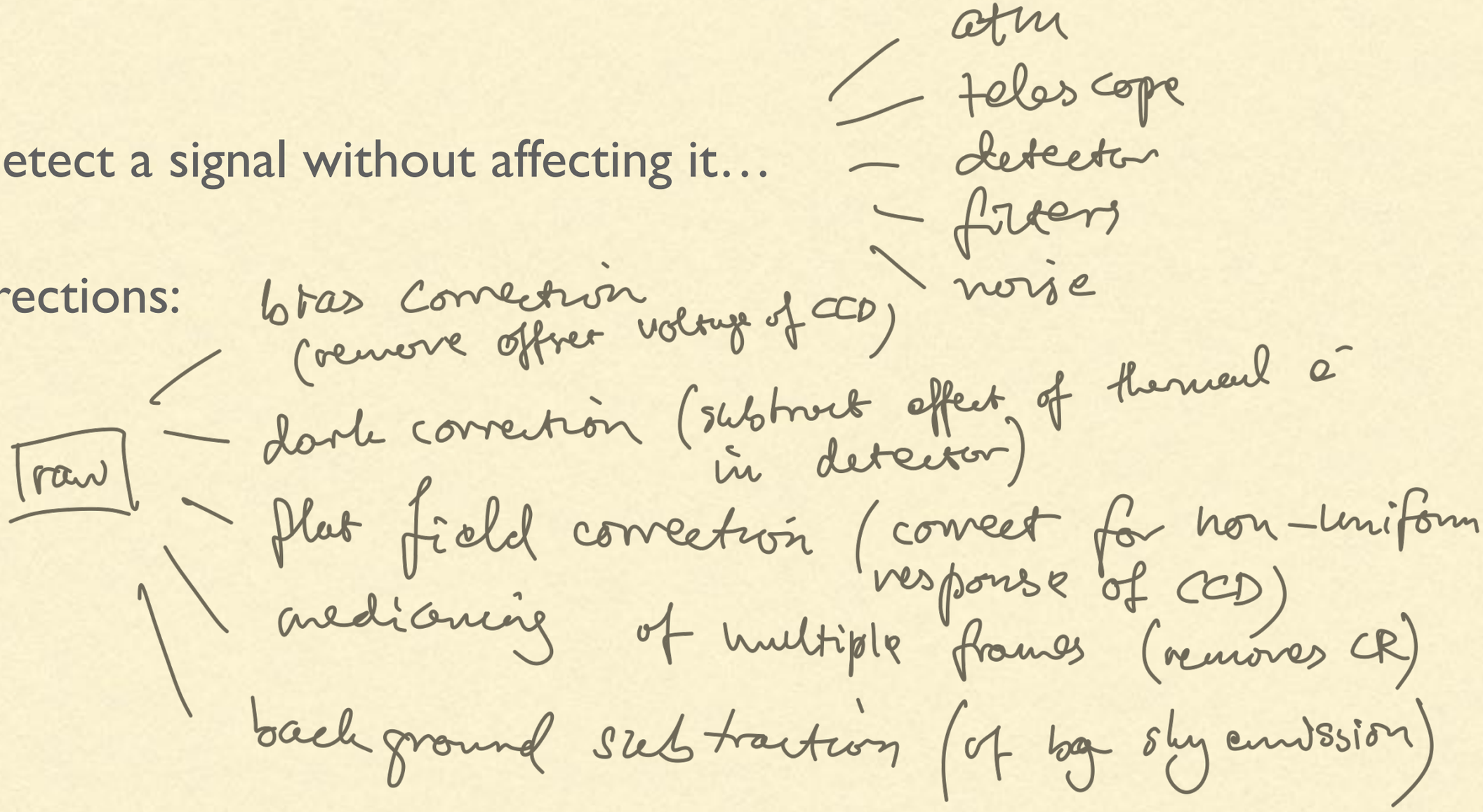
- Refraction

- Seeing (actually turbulence)
  - adaptive optics

- Scintillation — twinkling brightness change due to atm. like seeing, but causes a change of curvature of the wave front rather than tilt
- Reddening — mainly in point sources (due to eye resolution)
  λ-dependent absorption and scattering
  Blue scatters easier ⇒ more red intensity
  (more in ch. 5)

PROCESSING

- Can't detect a signal without affecting it…
- Corrections:



PROCESSING…

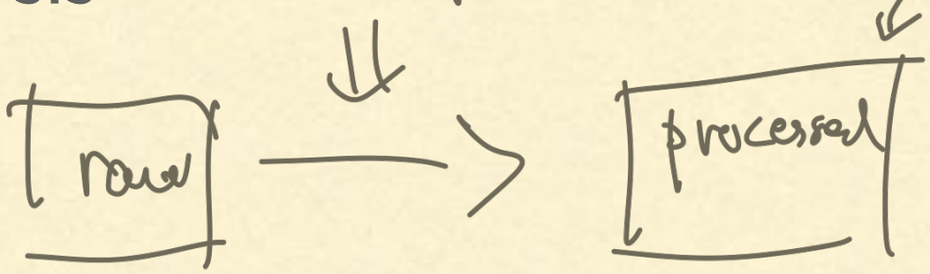
Ref signal of known flux density
or brightness, stars (Vega, Sirius) in optical
(Quasars (3C286, 3C48) in radio
asteroids / planets for submm / IR

- Calibrations: Primary flux calibrator, secondary calibrator, other (zeropol)

your data will be in "counts" and calibrators are used to figure out magnitudes/counts or Jy/counts for your data ⇒ useful measurements

- Analysis

loads of work



- 8 characteristics of processed data:
  - coordinates (map centre)
  - FOV
  - Spatial resolution defined by θ_d / telescope size θ_{pixel} / pixelsize θ_s / seeing
  - central wavelength
  - bandwidth range of λ
  - Spectral resolution waveband split up in channels (see cube). channel width = sp. res.
  - Noise level non emission regions of image values above/below zero ! called rms
  - S/N longer exposure time $\Rightarrow$ better S/N 3-10x rms = real signal

$$N = \sqrt{\langle x^2 \rangle}$$

averaged calibrated pixel values