

Telescopes

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ASTR 1040 Rec



Today's Class - Telescopes

- Measuring a telescope's performance
- Ways to measure light
- Angular resolution
- Aperture synthesis

Telescope Fundamentals

Light is a wave

$$c = \lambda \cdot f$$

Light is a particle

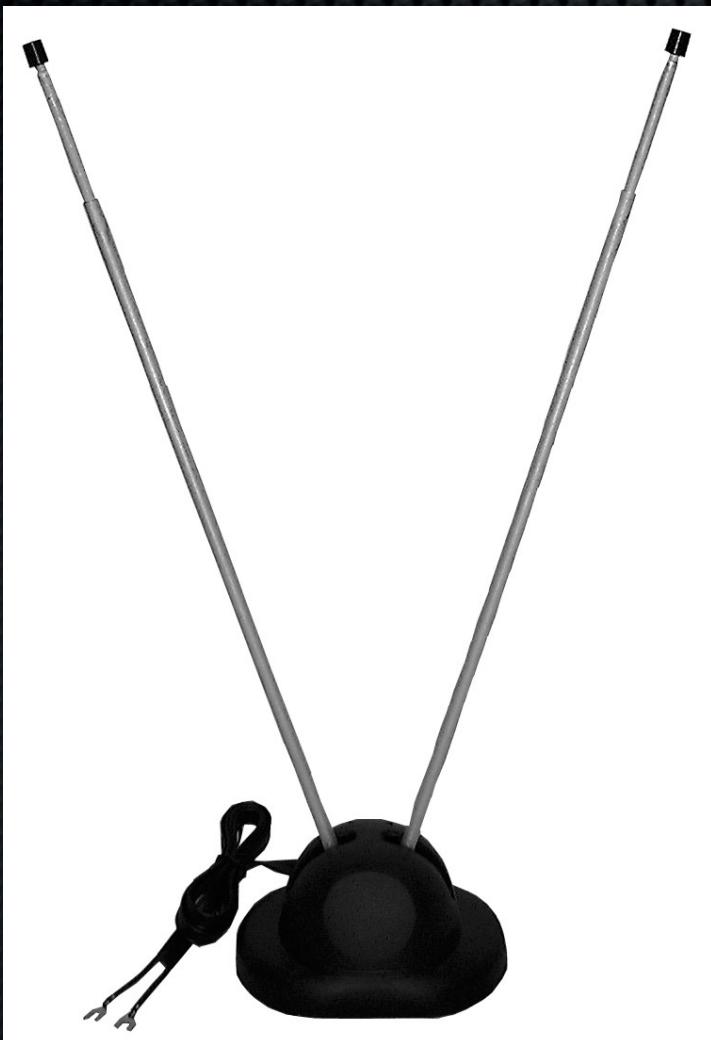
$$E = h \cdot f = h \cdot v = \frac{h \cdot c}{\lambda}$$

Telescope Fundamentals

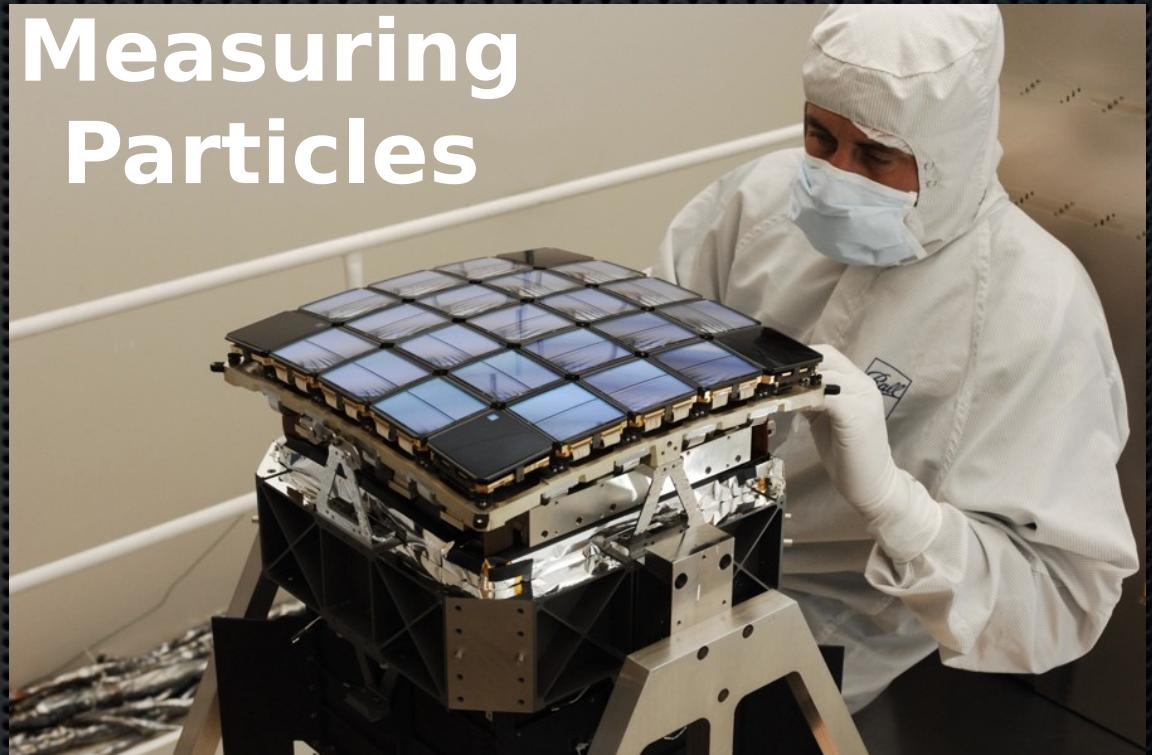
Measures of telescope performance:

- Ability to collect and measure light (effective area)
- How big does a point look? (angular resolution)
- Ability to separate wavelengths (spectral resolution)

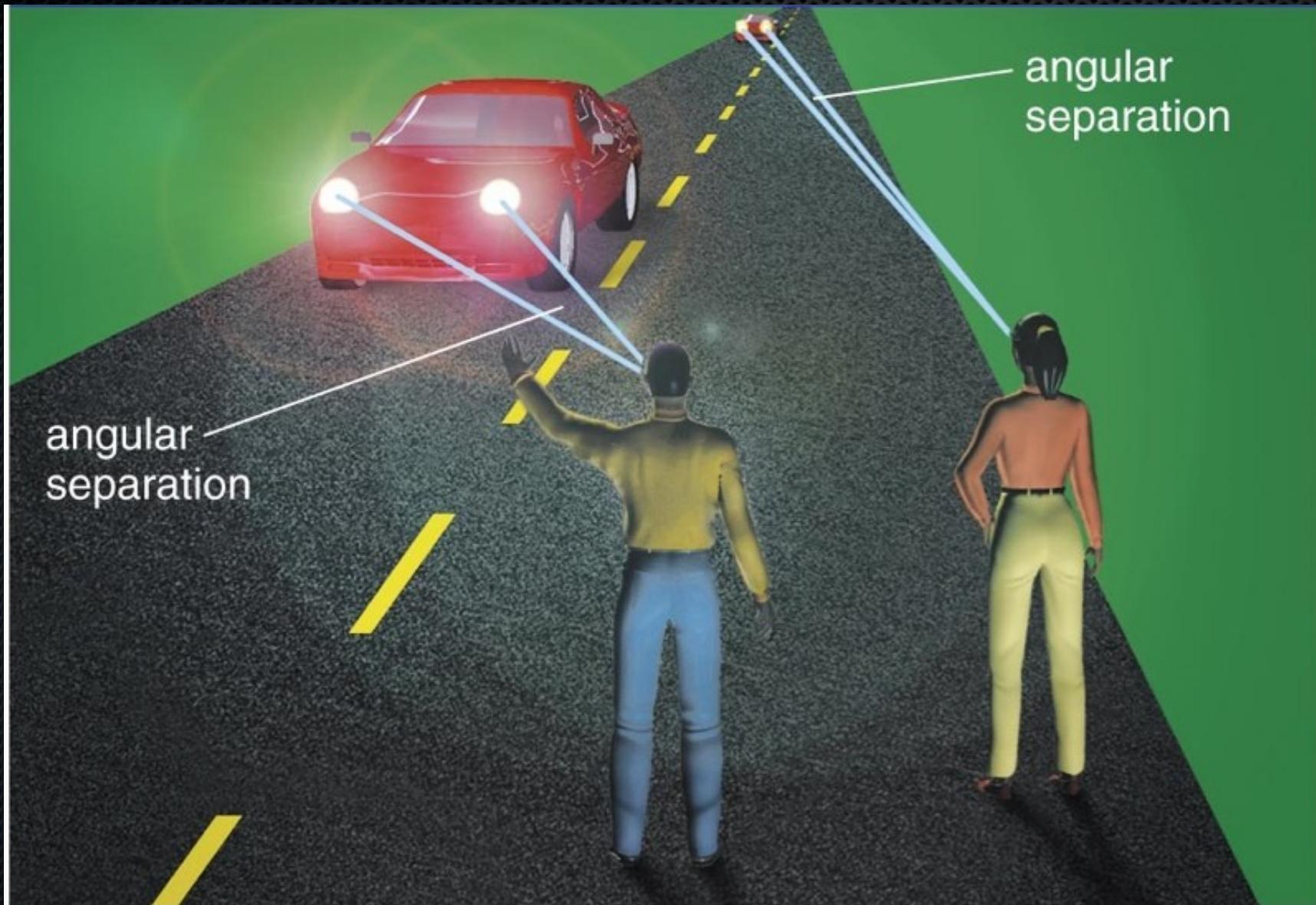
Collecting & Measuring Light



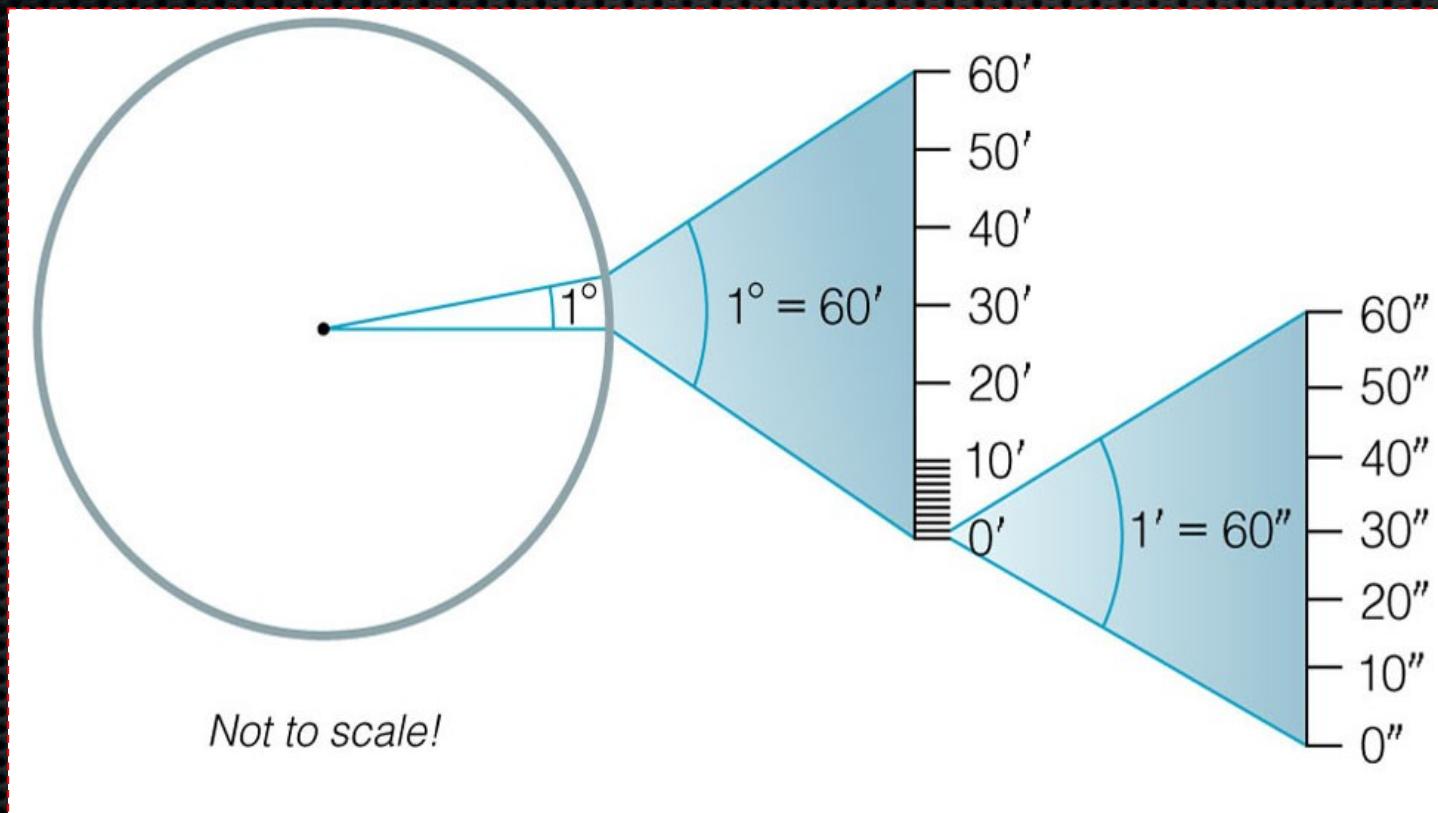
Measuring
Particles



Angular Resolution

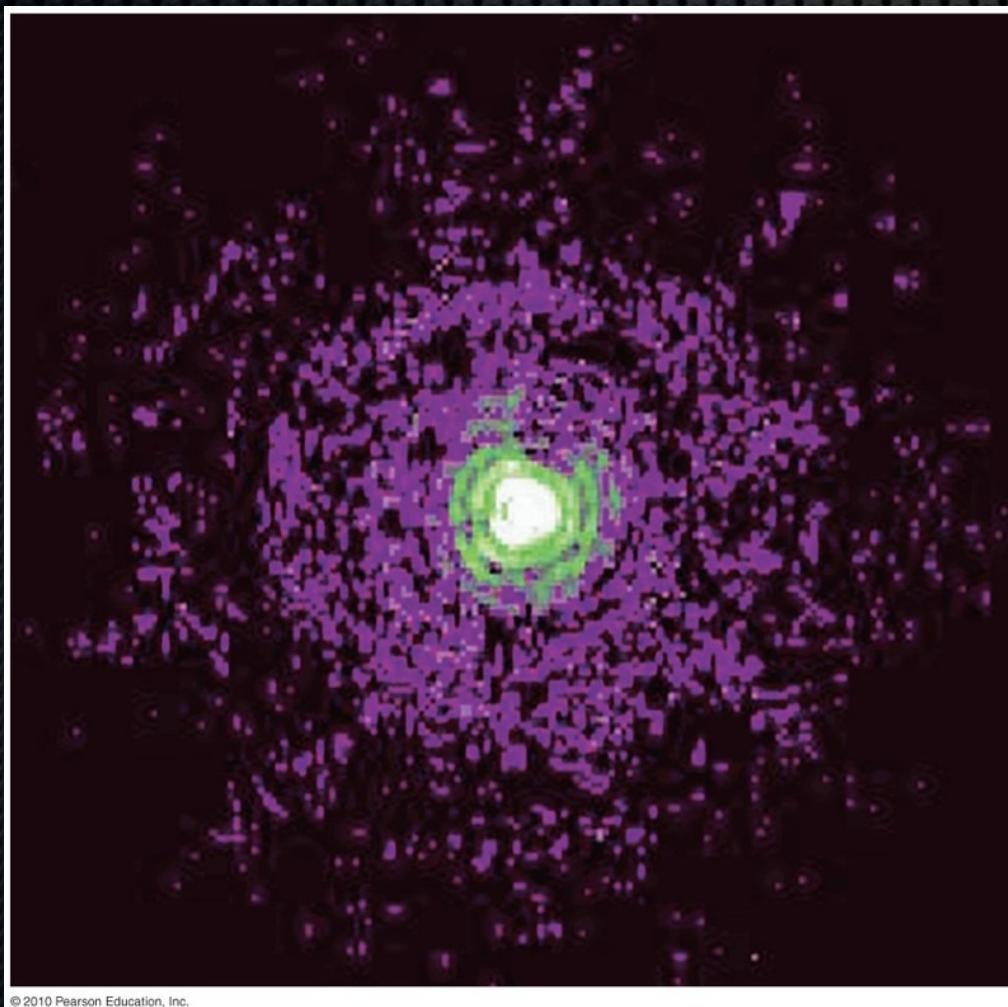


Angular Resolution



Angular Resolution

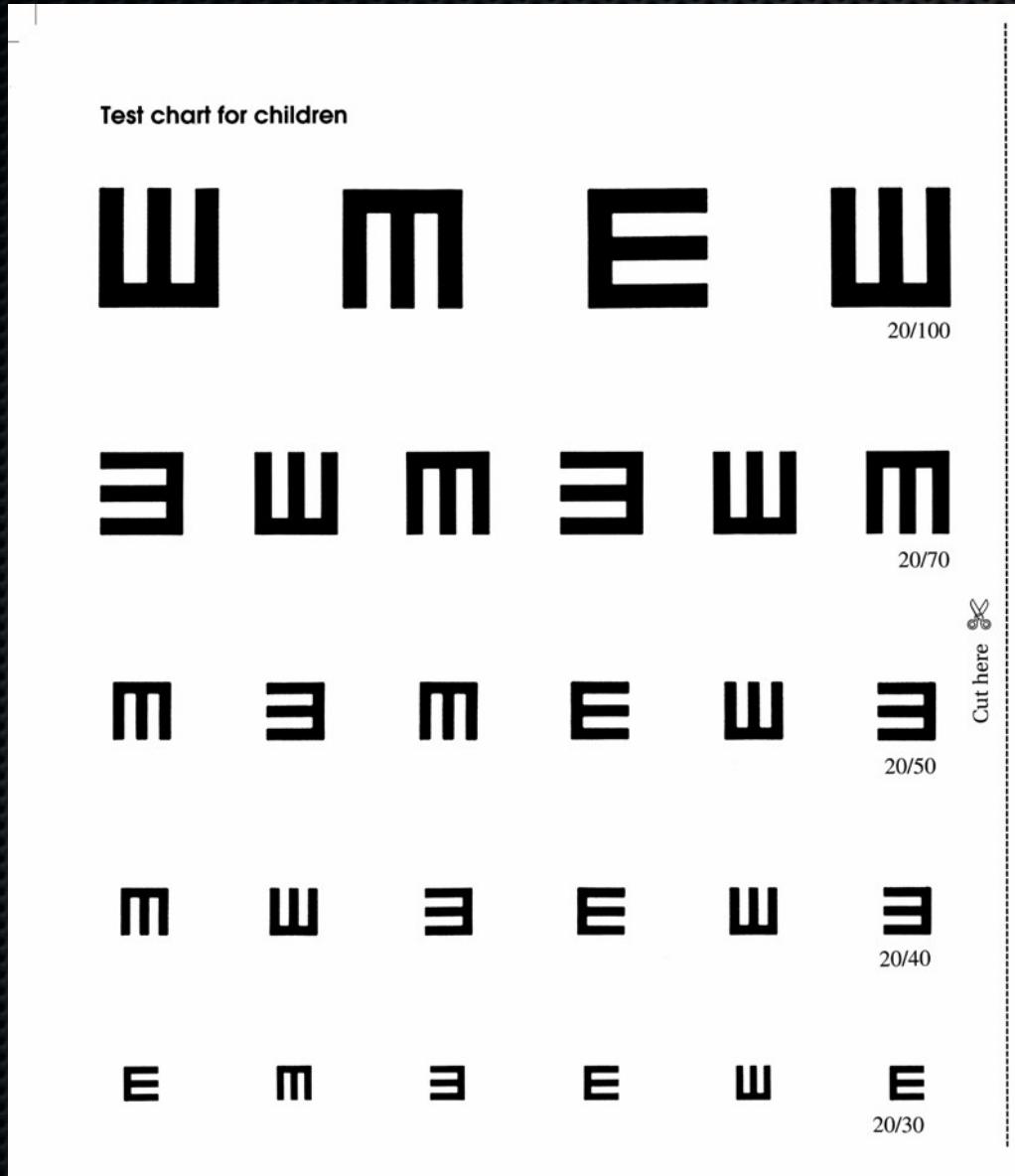
Diffraction



For a circular aperture:

$$\Delta\theta = \frac{1.22\lambda}{D}$$

Angular Resolution



$$\Delta\theta = \frac{1.22\lambda}{D}$$

What is D?

Angular Resolution

Suppose you wanted to take an image (2 pixels by 2 pixels) of Alpha Centauri A, one of our nearest stellar neighbors at 4.3 ly away. Assume that it has a radius of $1.2 R_{\text{sun}}$ and you want a picture in optical light ($\lambda = 500 \text{ nm}$). How big of a diffraction limited telescope would you need?

Constants and

Conversions

$$R_{\text{sun}} = 700 \text{ Mm}$$

$$1 \text{ ly} = 9.5 \times 10^{15} \text{ m}$$

$$\Delta \theta = \frac{1.22 \lambda}{D}$$

Angular Resolution

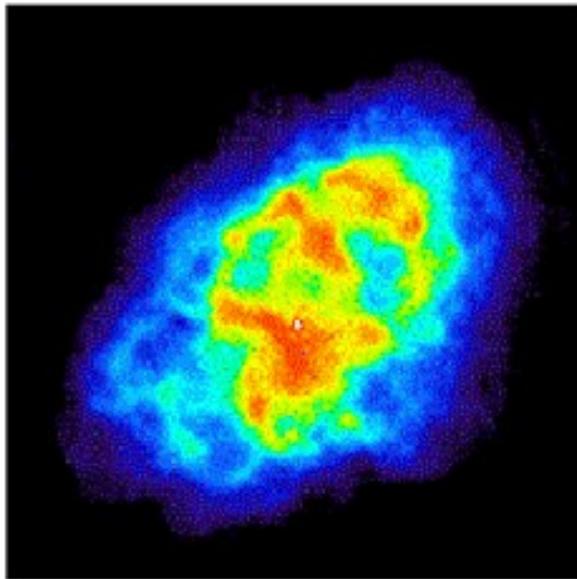
Clicker Question: Now suppose you want both an optical ($\lambda = 500 \text{ nm}$) image of alpha Centauri and a radio ($\lambda = 5 \text{ mm}$) image with the same angular resolution. What how big of a diffraction limited radio telescope would you need?

- A. 2.89 mm
- B. 2.89 m

- C. 2.89 km
- D. 289 km

Angular Resolution

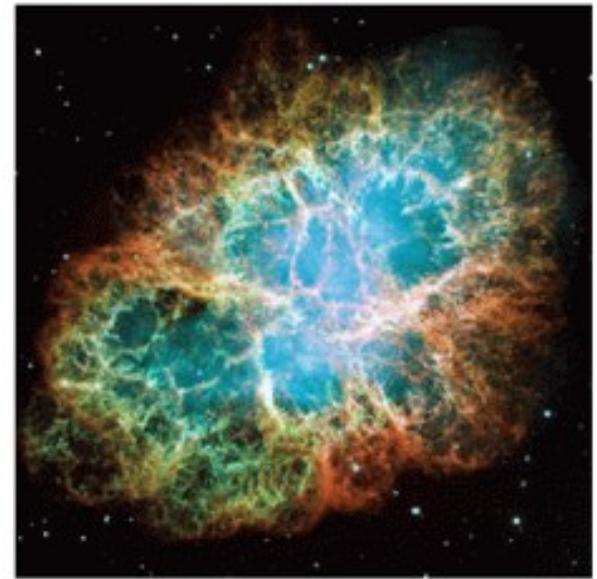
Crab Nebula: Remnant of an Exploded Star (Supernova)



Radio wave (VLA)



Infrared radiation (Spitzer)

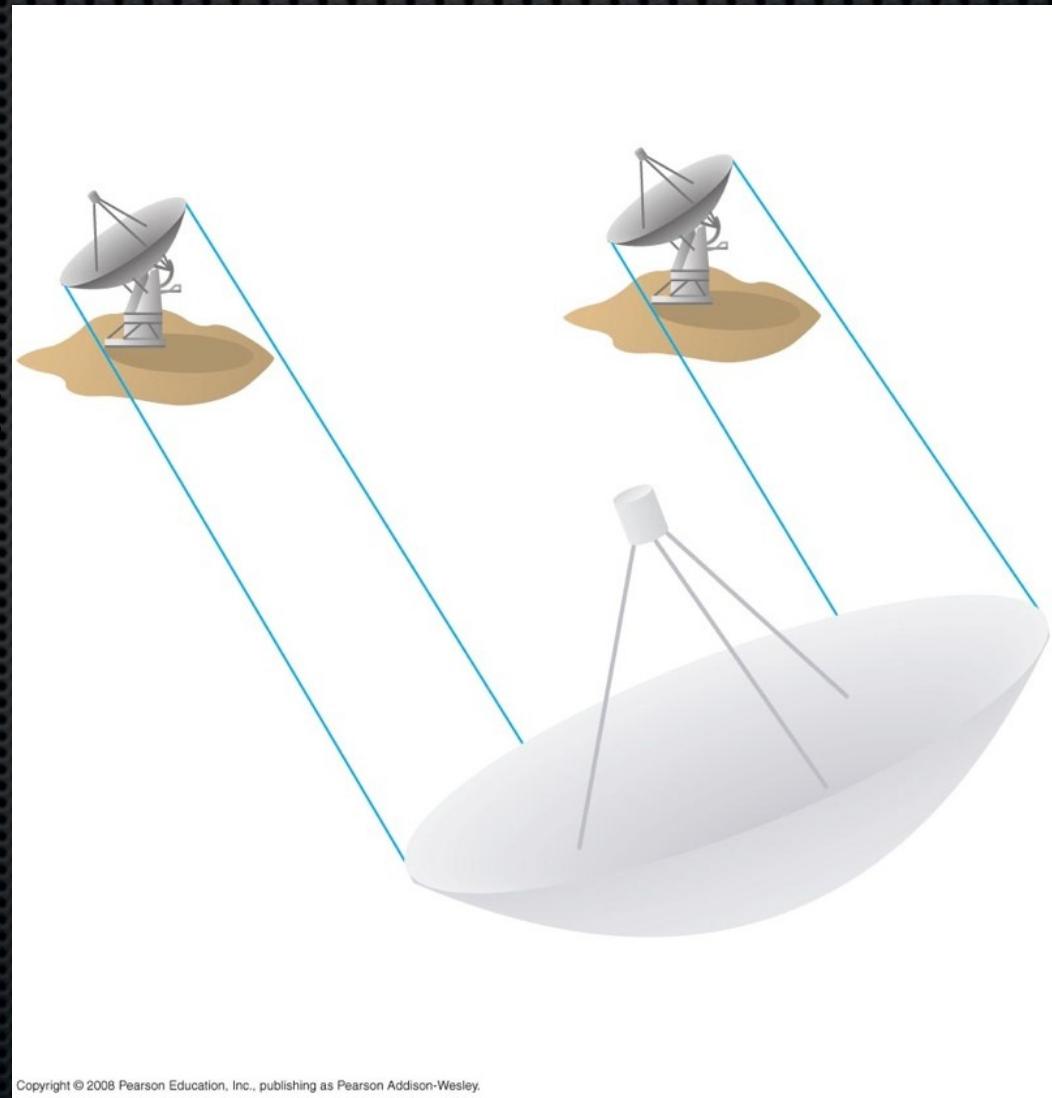


Visible light (Hubble)

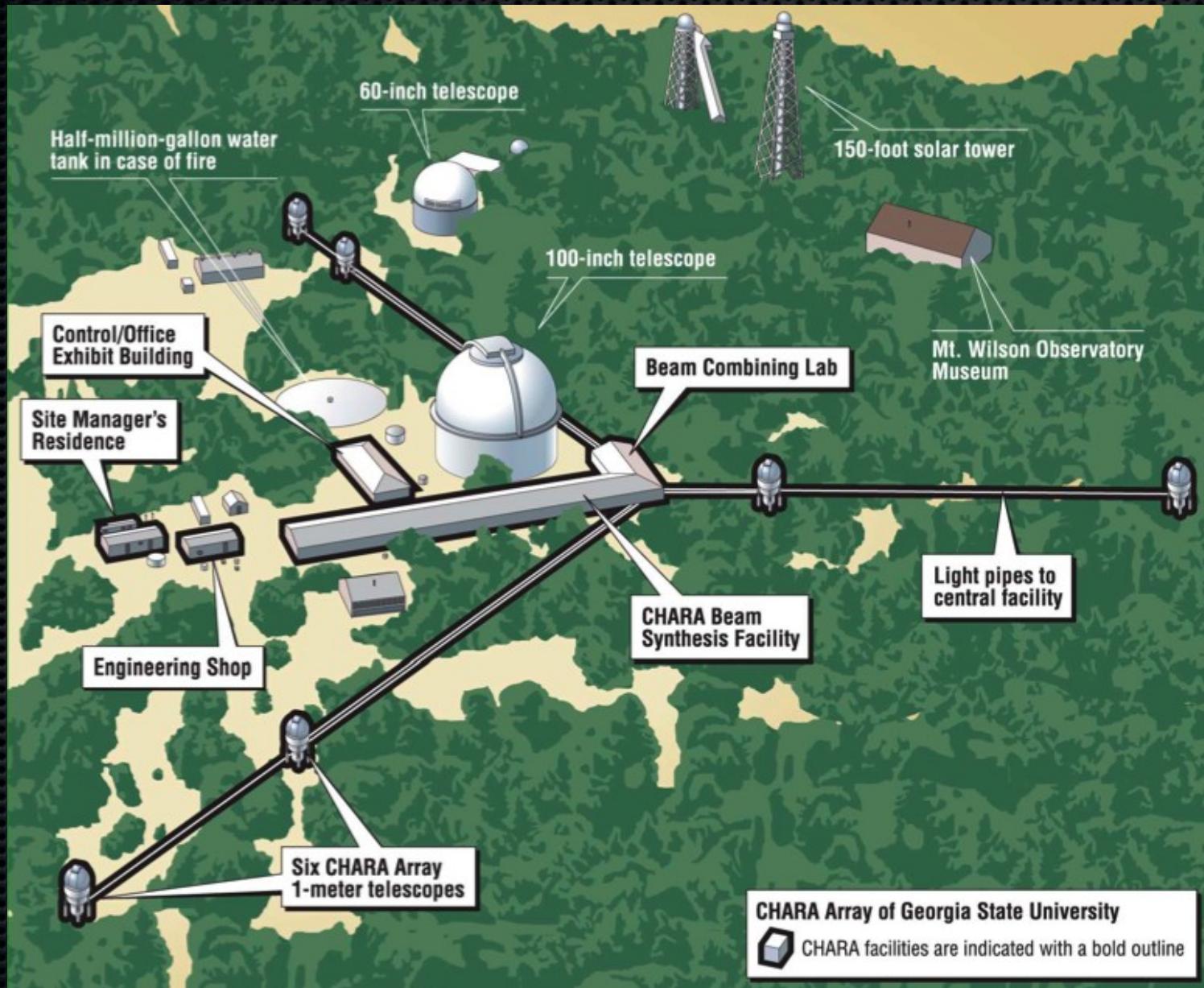
Aperture Synthesis

Interferometers

- Combine signals from different telescopes
- Get the diffraction limit of a telescope as big as the distance between the telescopes
- Requires very careful optics or atomic clocks and fast computers

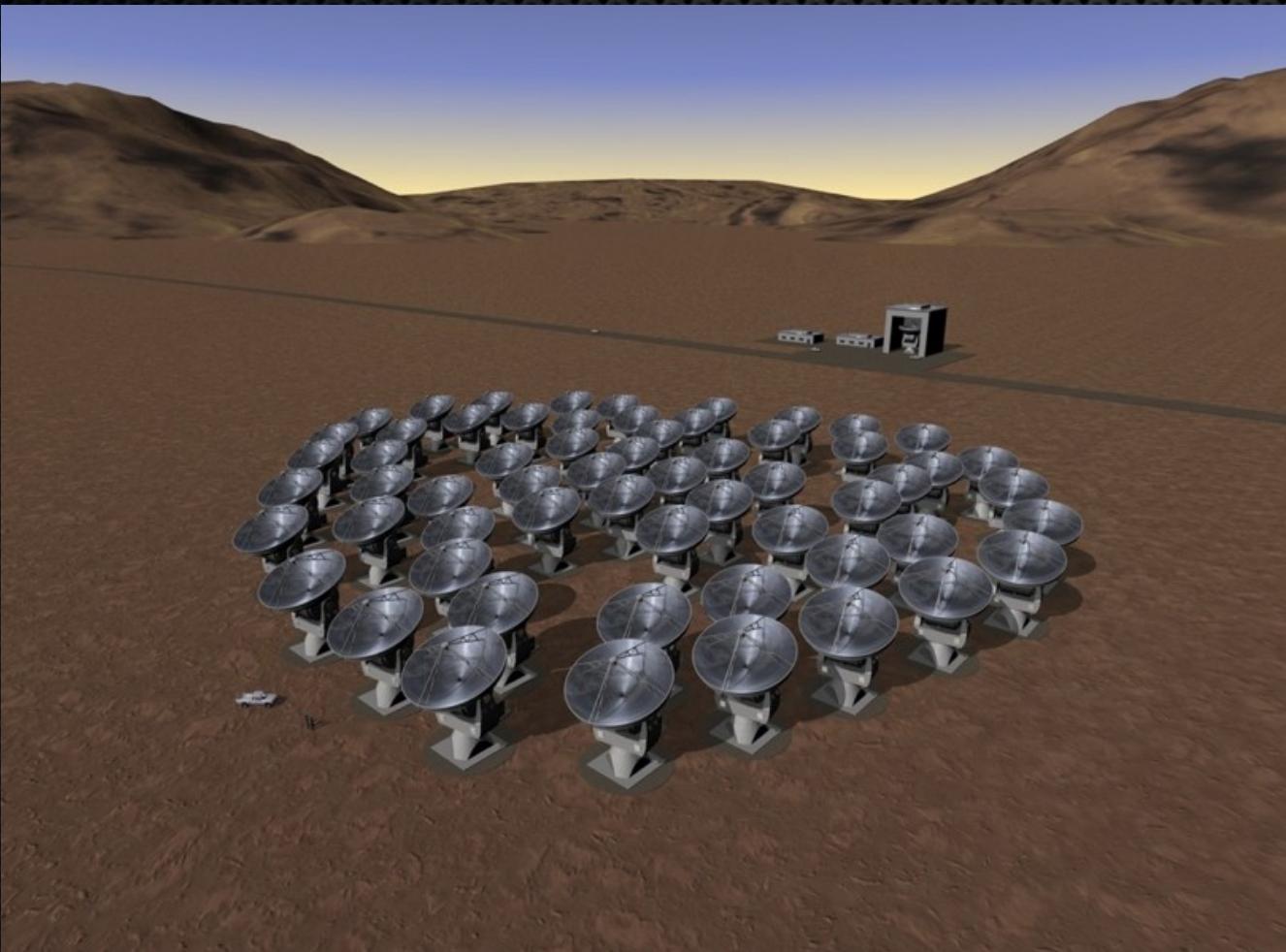


Aperture Synthesis



Aperture Synthesis

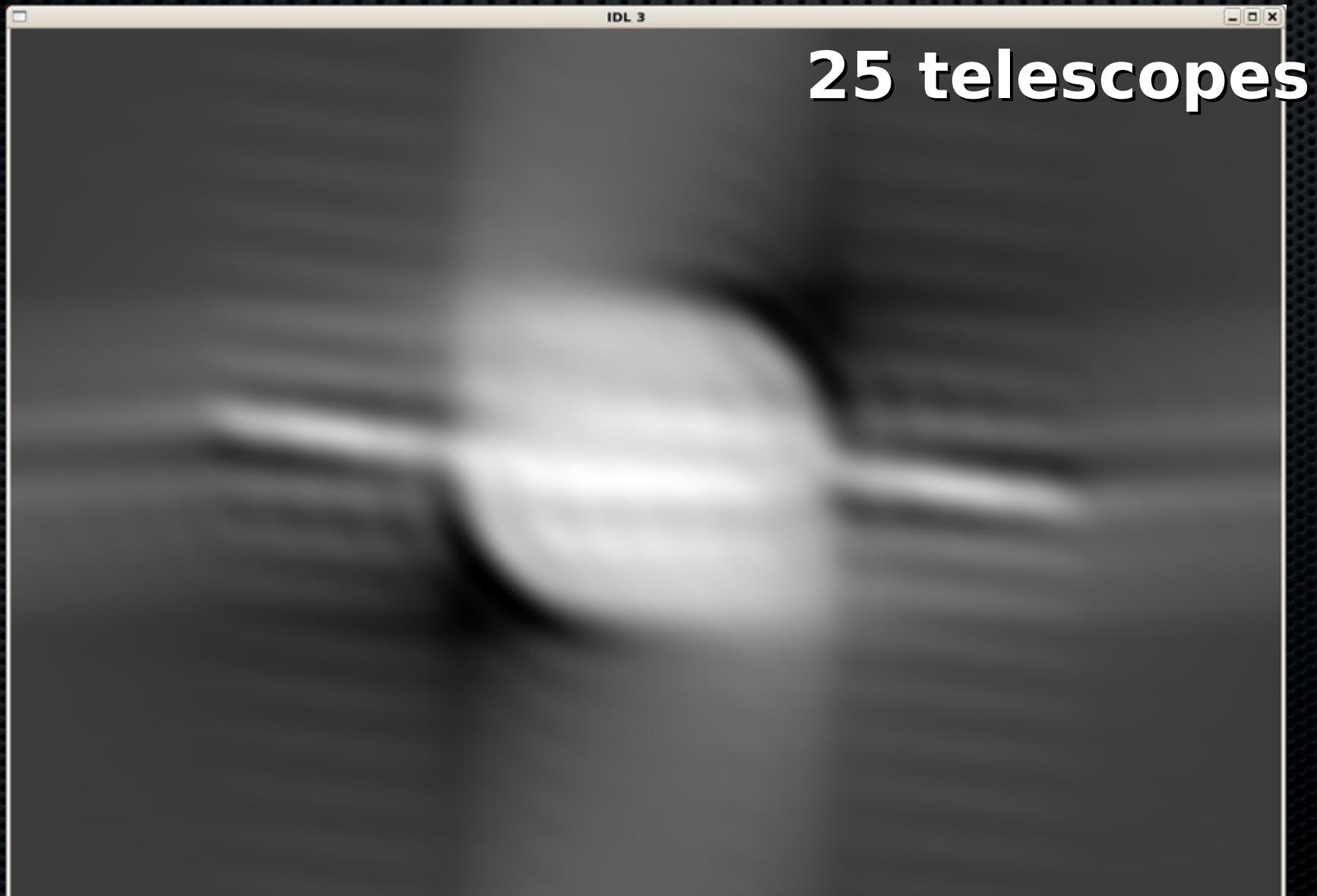
Atacama Large Millimeter Array (ALMA)



Aperture Synthesis



Aperture Synthesis



Aperture Synthesis



Aperture Synthesis

