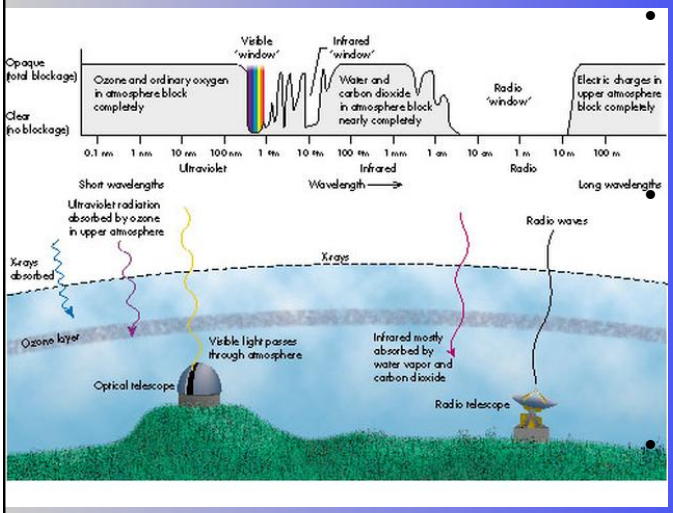
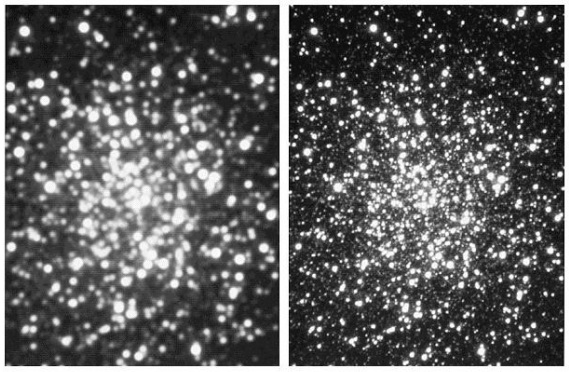
Earth's Atmosphere & Telescopes



- Whether light is absorbed by the atmosphere or not depends greatly on its wavelength.
- Earth's atmosphere can absorb certain wavelengths of light so much that astronomers can not observe them from the ground.
- UV light is strongly absorbed by ozone molecules.

1

Atmospheric Effects



Before correcting for atmospheric blurring

After correction

- The temperature variations in the atmosphere cause light from objects to be bent like passing through a lens
- Random bending of light causes stars to "twinkle" and blurs images in telescopes.
- These effects can be reduced but not eliminated by placing telescopes on mountains.

2

Light Pollution

North America at night

- Light from cities has greatly reduced everyone's ability to enjoy the night sky.
- The atmosphere scatters light from cities over long distances
- Astronomers must go to remote locations to make observations

3

Telescopes in Space

The Hubble Space Telescope

- All of these problems can be avoided by placing telescopes in space.
- However because of the expense, dangers and other difficulties of going into space most telescopes are going to remain ground-based.

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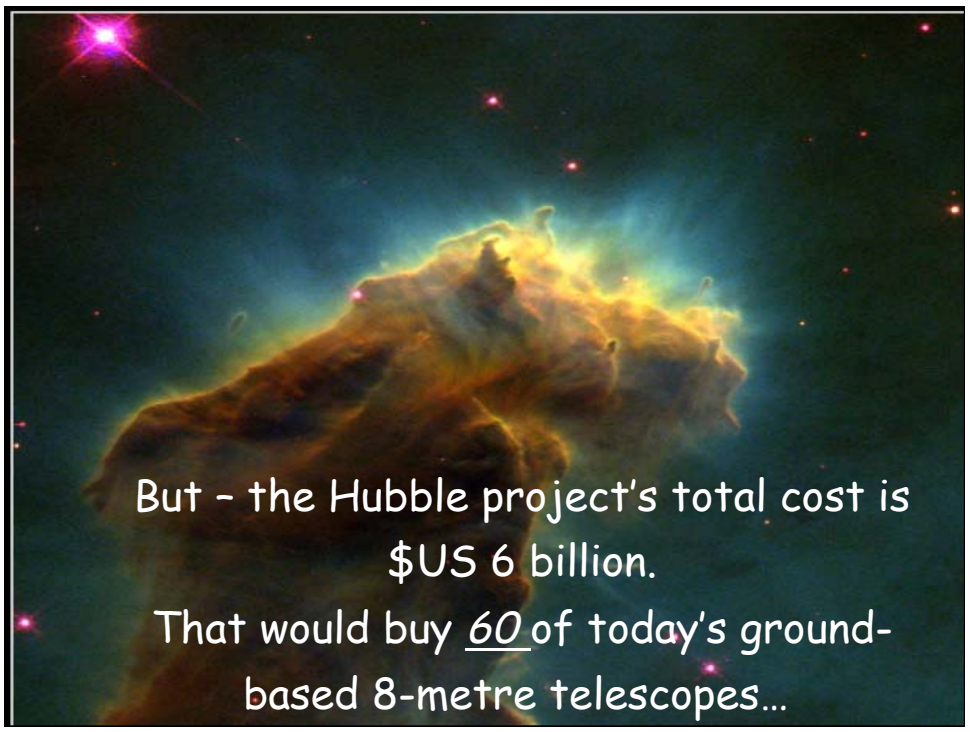
The Eagle Nebula—stellar birthplace



Hubble Space Telescope

- quick facts
- Video
- Launched in 1990
- **Hubble's Job Description**
- Explore the solar system.
- Measure the age and size of the universe.
- Search for our cosmic roots.
- Chart the evolution of the universe.
- Unlock the mysteries of galaxies, stars, planets, and life itself.

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Type of Telescopes

The Keck Telescope on top of an extinct volcano in Hawaii

- All telescopes are designed to focus electromagnetic radiation.
- The kind of telescope most people are familiar with are those that focus visible light.
- Telescopes have been built to observe in almost every form of electromagnetic radiation.

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Properties of Optical Telescopes

The Hale 200 inch diameter reflector on top of Mount Palomar in California.

- Optical Telescopes can focus light using lenses or mirrors.
- Telescopes that primarily use lenses to focus light are called **refractors**.
- Telescopes that primarily use mirrors to focus light are called **reflectors**.

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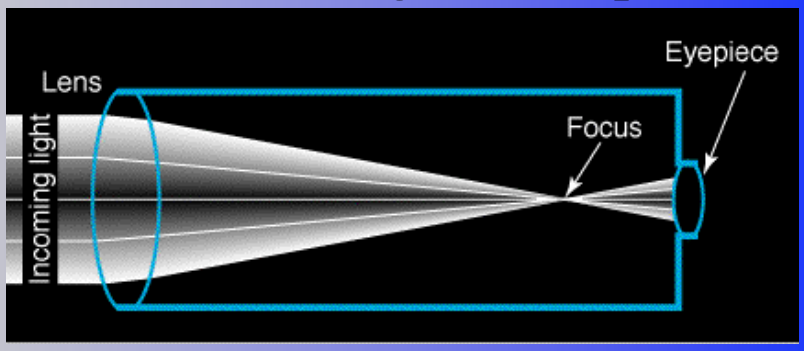
Refracting Telescopes



- Light enters a refractor through the Primary Lens. There is a secondary lens at the other end of the tube at the eyepiece.
- You see the image by looking through the eyepiece.

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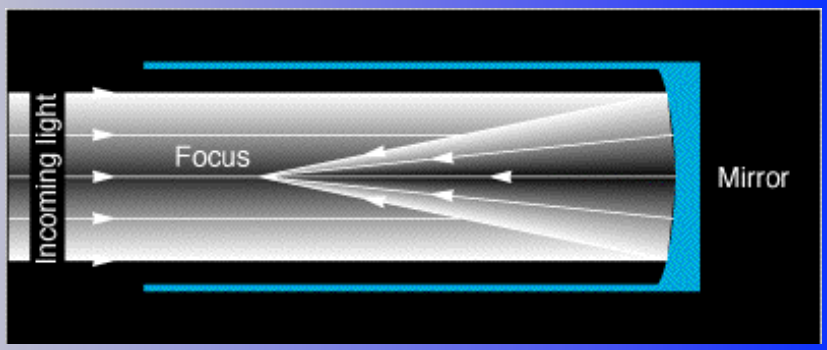
Reflecting Telescopes



- In a reflector the light enters the tube and is reflected off of the Primary Mirror mounted at the back.
- The light is then focused towards a secondary mirror which then sends the light to the eyepiece.

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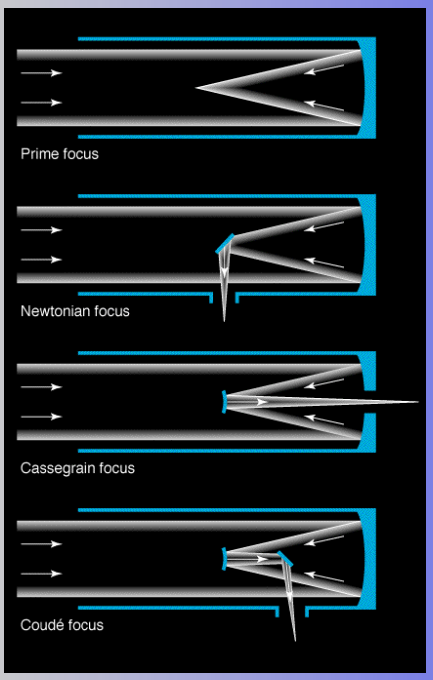

Types of Reflectors

- The eyepiece can be in many different locations depending on the type of reflector.
- Sometimes the reason why one location is chosen over another has to do with the type of detector you are using with this telescope.
- Some telescopes may have several locations for an eyepiece.

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Advantages of Reflectors Over Refractors

- The glass lens in a refractor must be supported on its edge. (Mirrors in a reflector can be supported from the back)
- When glass gets too heavy it may sag causing images to lose focus. (Proper support of mirrors in a reflector prevents this problem)
- Lenses often focus different colors of light differently. (Mirrors can focus all colors equally well)
- Generally reflectors are less expensive than refractors of similar size for these reasons.

The World's Largest Refractor. The 40 inch diameter telescope at Yerkes Observatory built in 1897.

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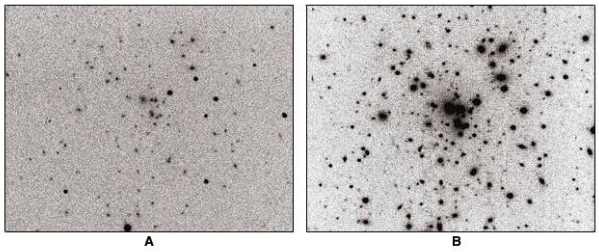
Detectors on Telescopes



Short time exposure

Long time exposure

- The ability to record information obtained through telescopes is very important.
- At first people wrote or drew what they saw
- With photography they could record observations more accurately and see fainter objects by taking long time exposures

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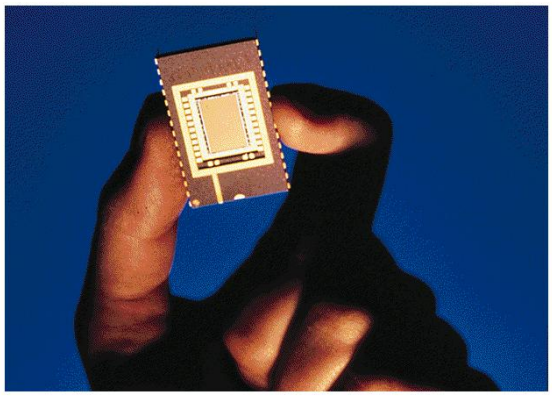
Detectors and Computers



- Most modern optical observations are made using CCD detectors and computer processing.
- Charge-Coupled Devices (CCDs) have the ability to record even fainter objects than photographs using the same exposure time.
- They also take digital images so they can easily be studied using computers.

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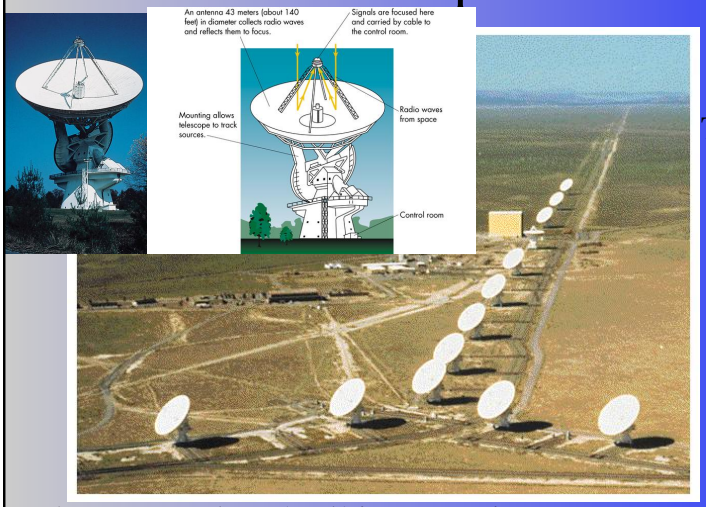
Radio Telescopes



Radio waves can be observed using radio telescopes.

To obtain high-resolution (fine detail) images, data from several widely spaced radio telescopes are often combined together.

The Very Large Array (VLA) in New Mexico.
Signals from 27 dishes each 81 feet in diameter
are combined to simulate the resolution of a telescope 22 miles across!

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X-Ray Telescopes

The Chandra
X-ray Observatory

- All X-ray telescopes have to be put into space since the atmosphere blocks X-rays from reaching the ground.
- X-rays are very difficult to focus because they can so easily pass through most materials.
- X-ray telescopes do not generate X-rays they only detect the X-rays generated by stars, planets, galaxies, black holes, etc.

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Characteristics of astronomy today

- Highly comprehensive range of instrumentation
- Infinite computing power
- Access to every part of the electromagnetic spectrum:
  γ-rays, X-rays, UV, visible (optical), IR, mm-wave, radio
- Not to mention particles, gravitational waves…
  (So we won't.)

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What's so good about optical astronomy?

- Visible light is emitted by 'ordinary matter' in the Universe—i.e. stars
- The visible spectrum is rich in the 'bar-code' of atomic and molecular features
- Optical observations bridge long and short wavebands
- You can do it with your feet on the ground

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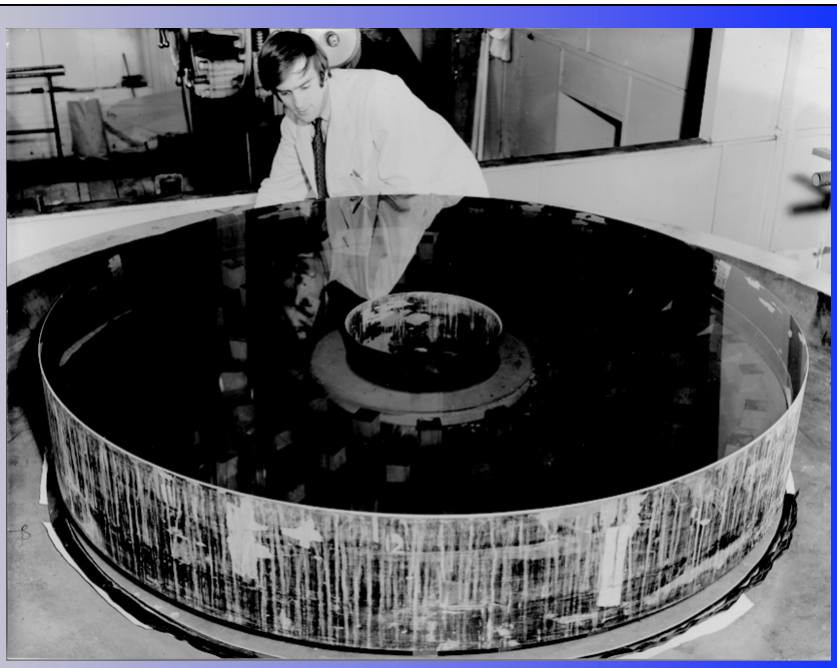

Large Telescope Mirror, 1969

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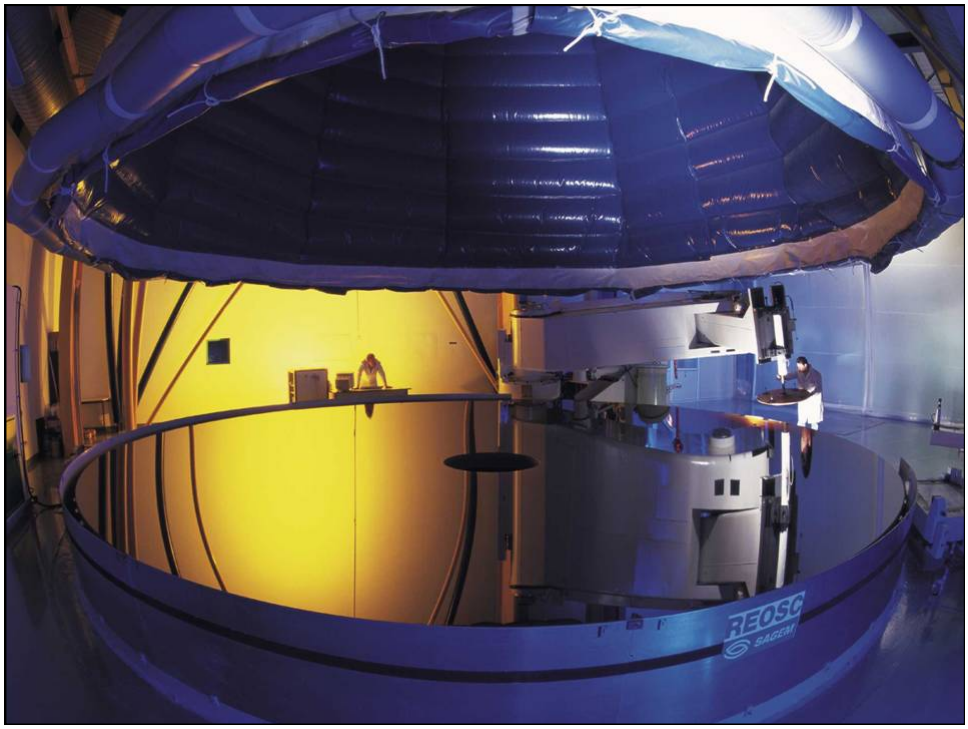
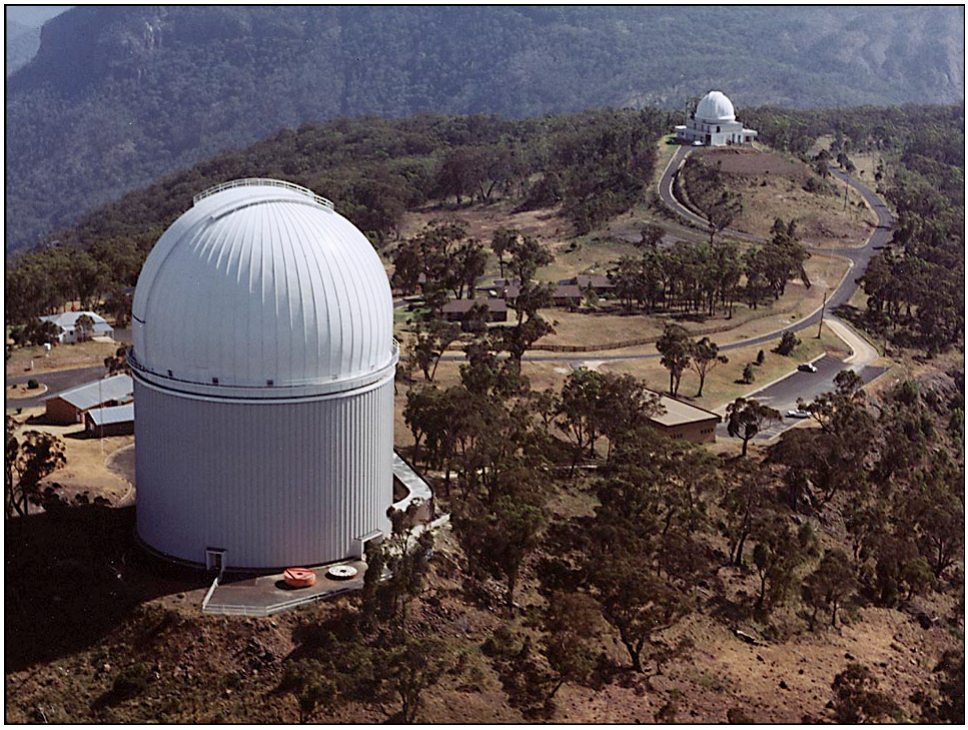
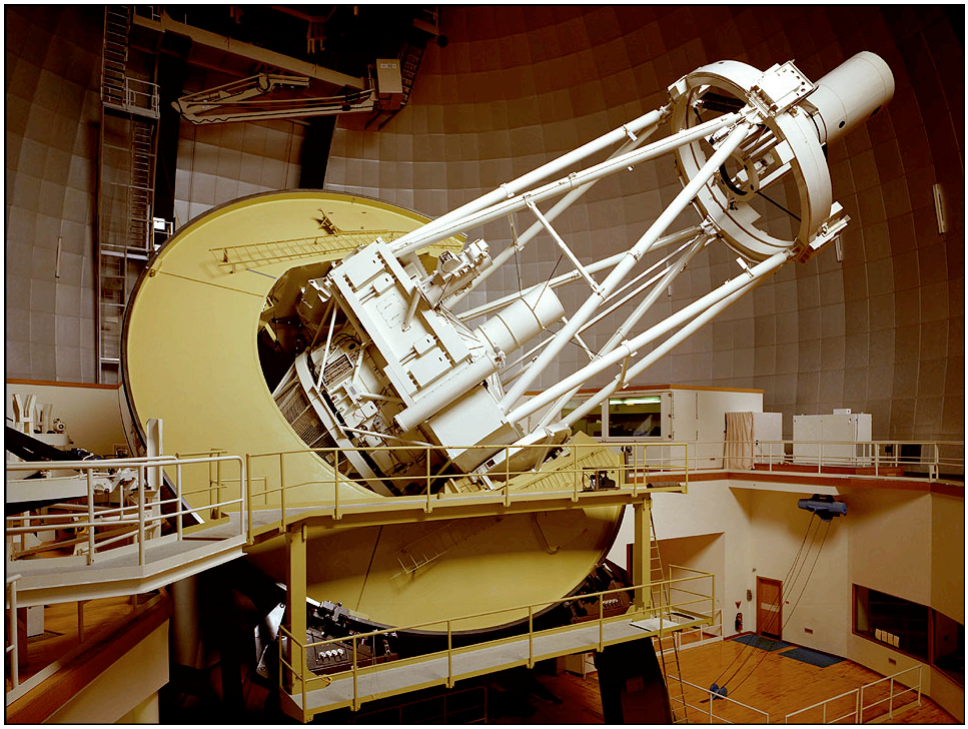
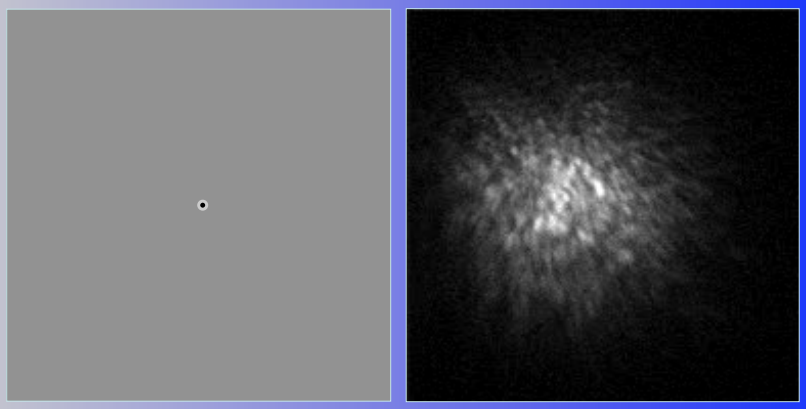






The end-product is…



1 arcsecond

This is very depressing indeed ☹

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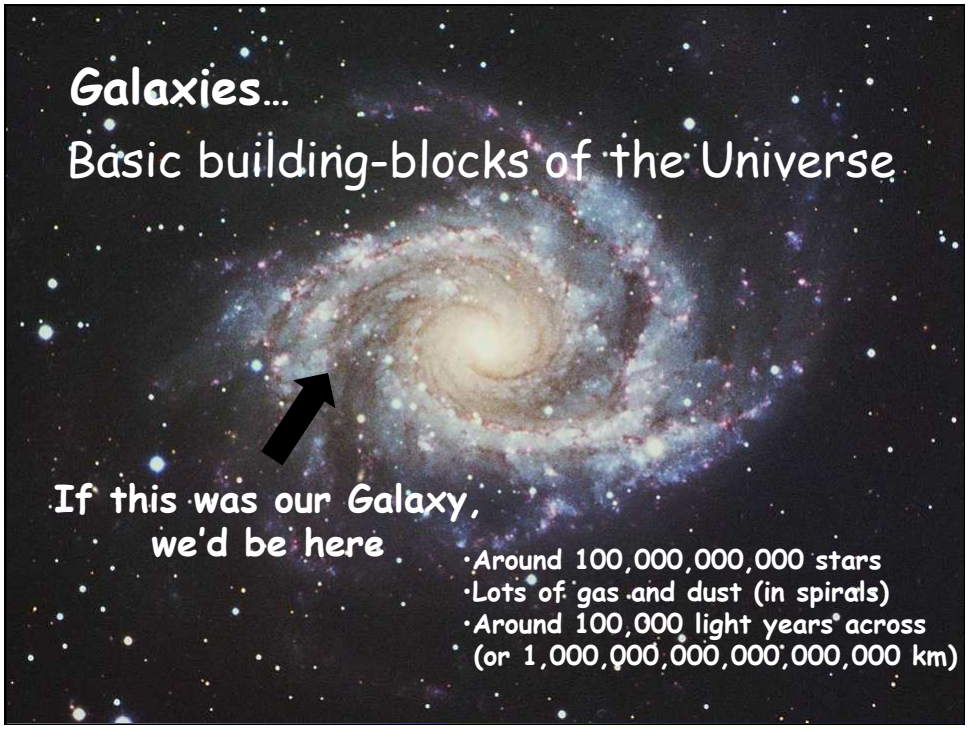

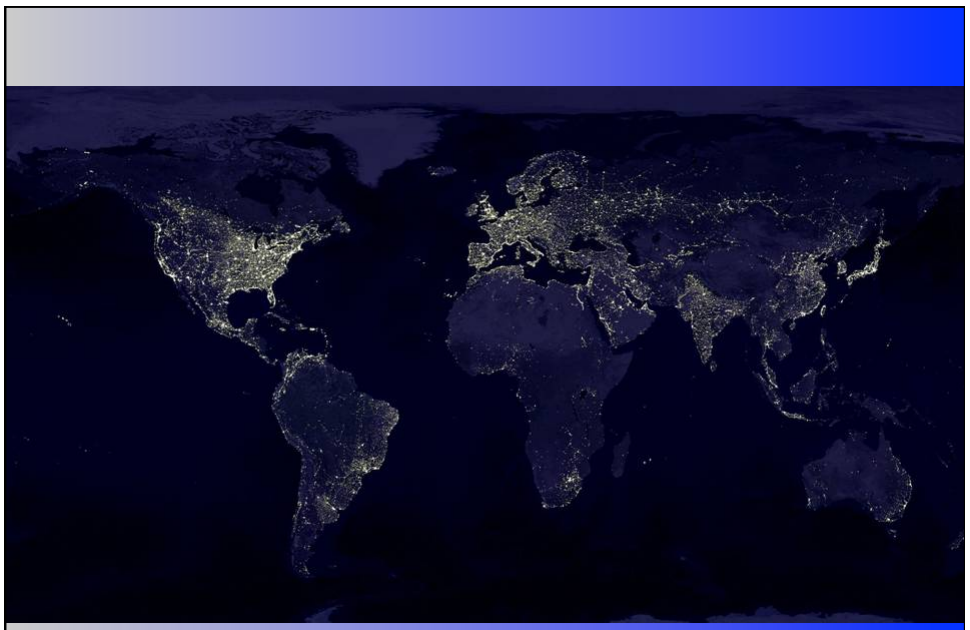

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The crowded summit of Mauna Kea

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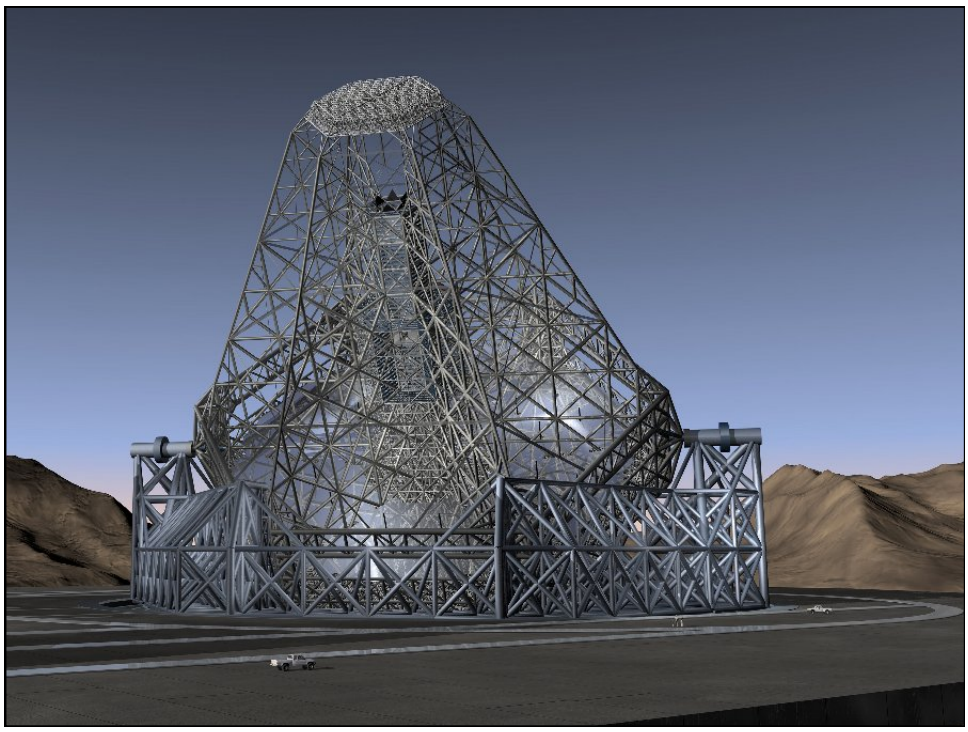
Antu, Kueyen, Melipal and Yepun



Beyond Hubble:
The James Webb Space Telescope

- Set to be deployed in 2014, it will replace Hubble. The size of a tennis court, it will orbit far beyond the moon and be able to look into our Universe as no other telescope has been able to do.

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