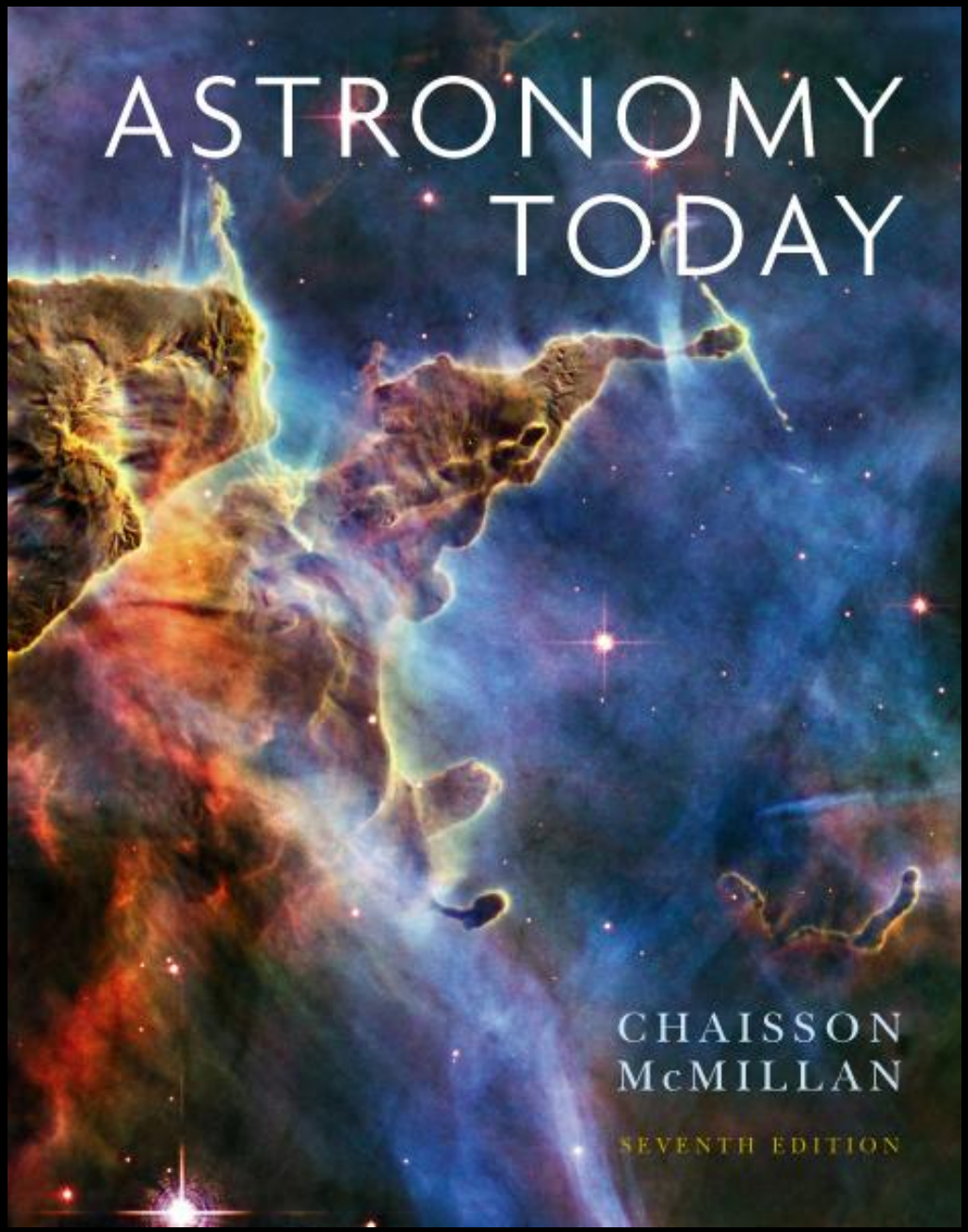


Lecture Outlines

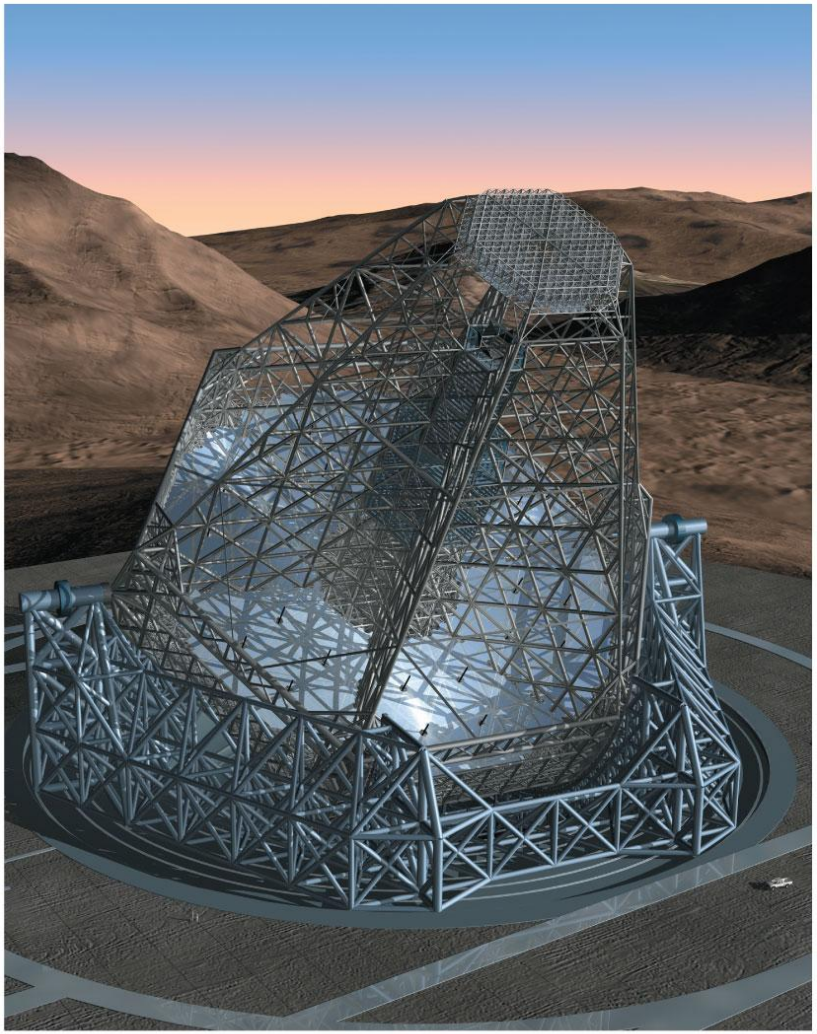
Chapter 5

Astronomy Today

7th Edition

Chaisson/McMillan

Chapter 5
Telescopes



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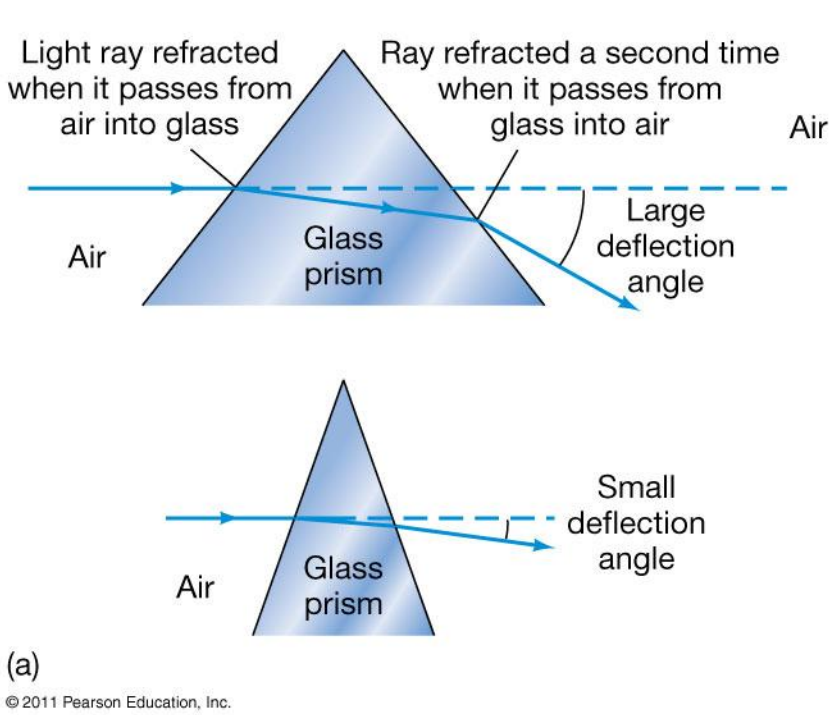
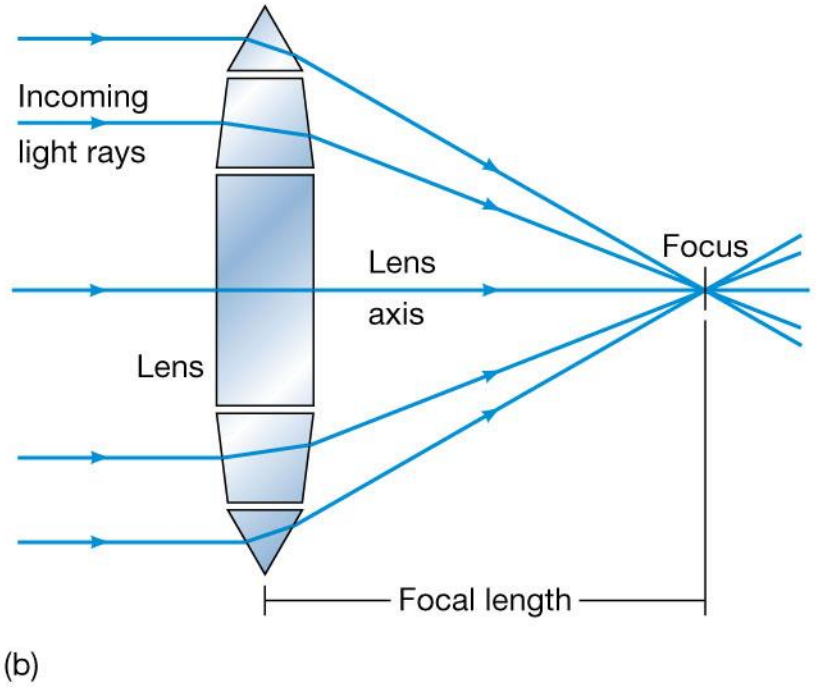
Units of Chapter 5

5.1 Optical Telescopes

Refracting lens

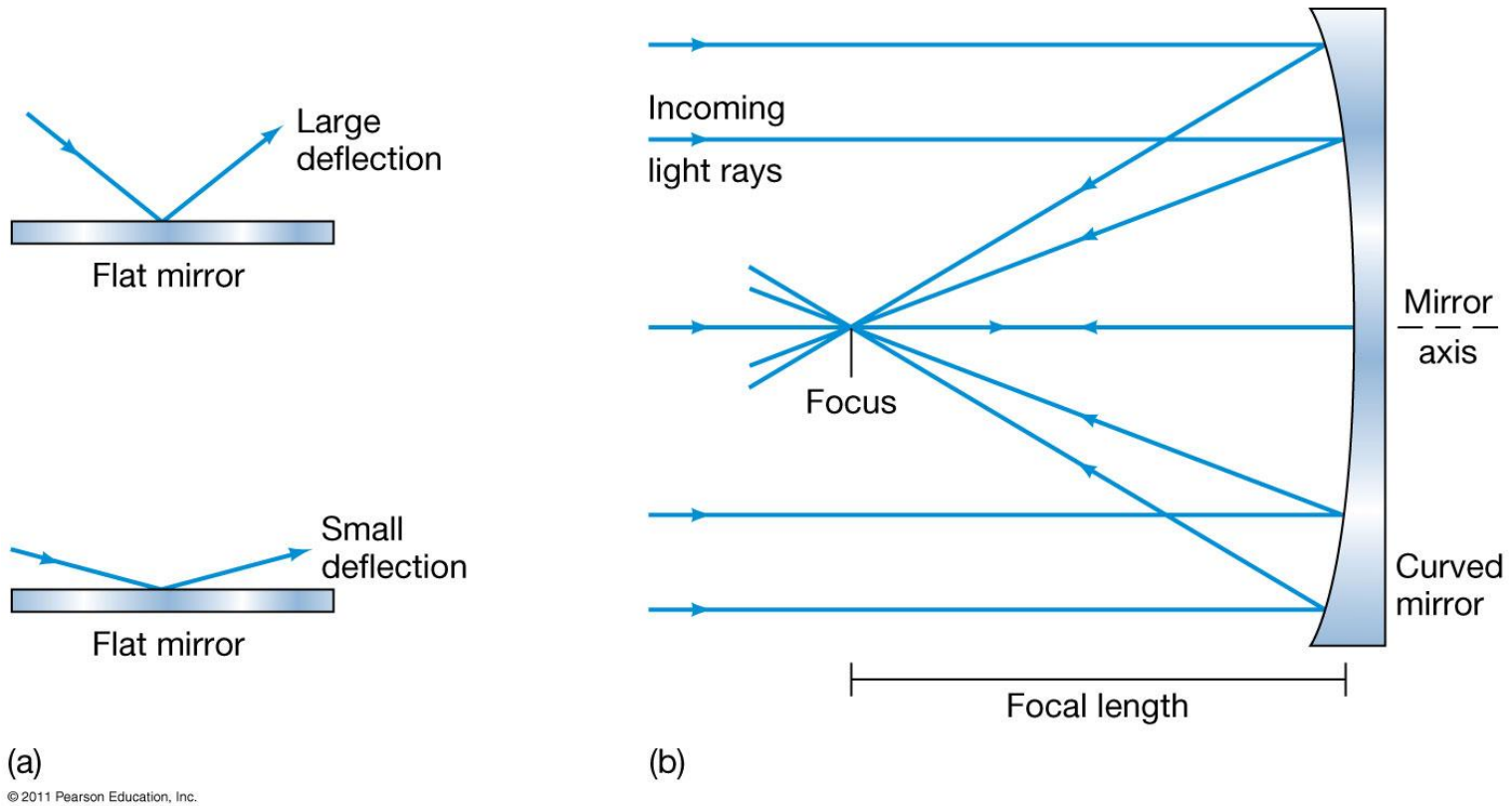




5.1 Optical Telescopes

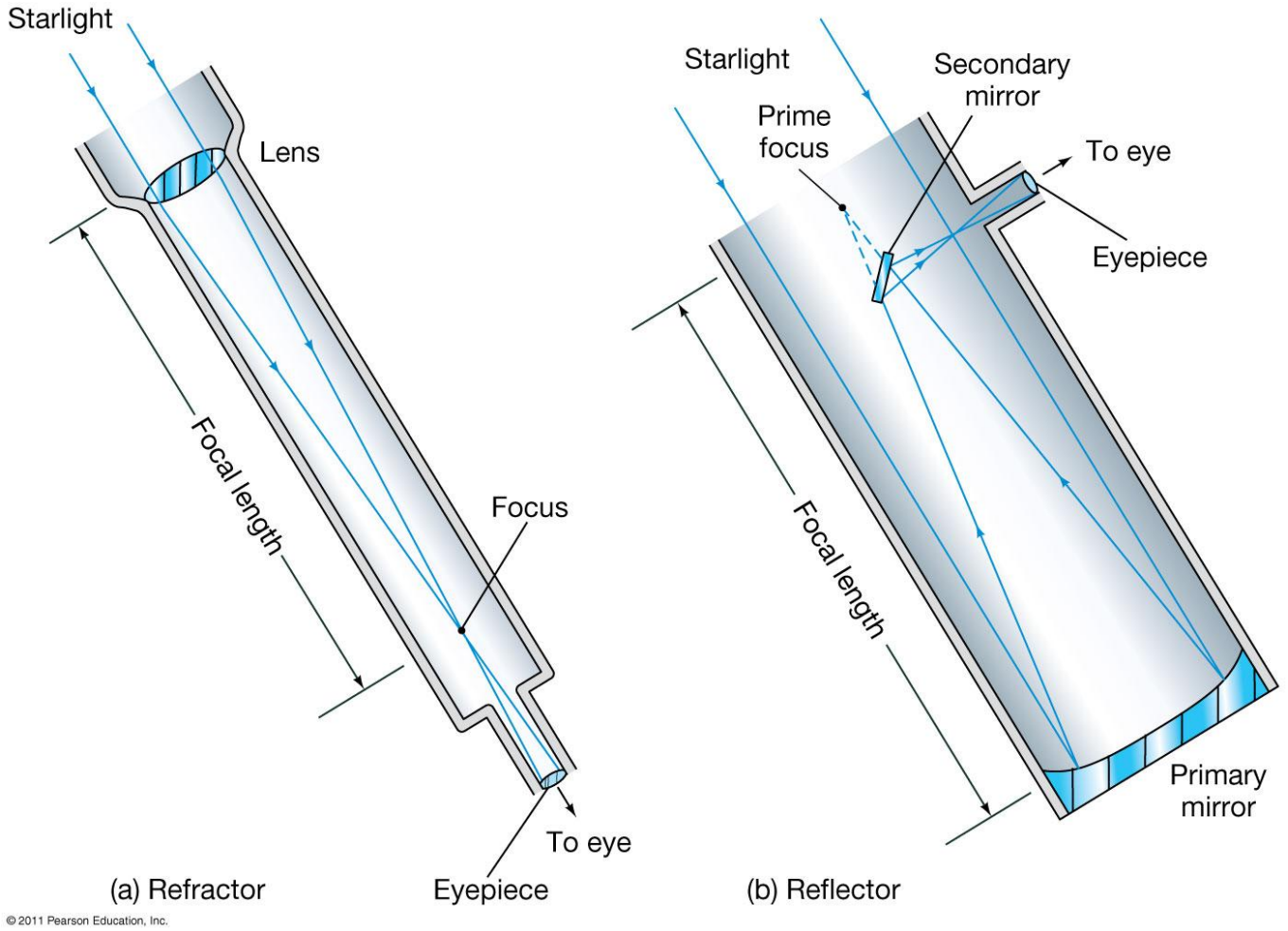
Images can be formed through reflection or refraction

Reflecting mirror



5.1 Optical Telescopes

Reflecting and refracting telescopes



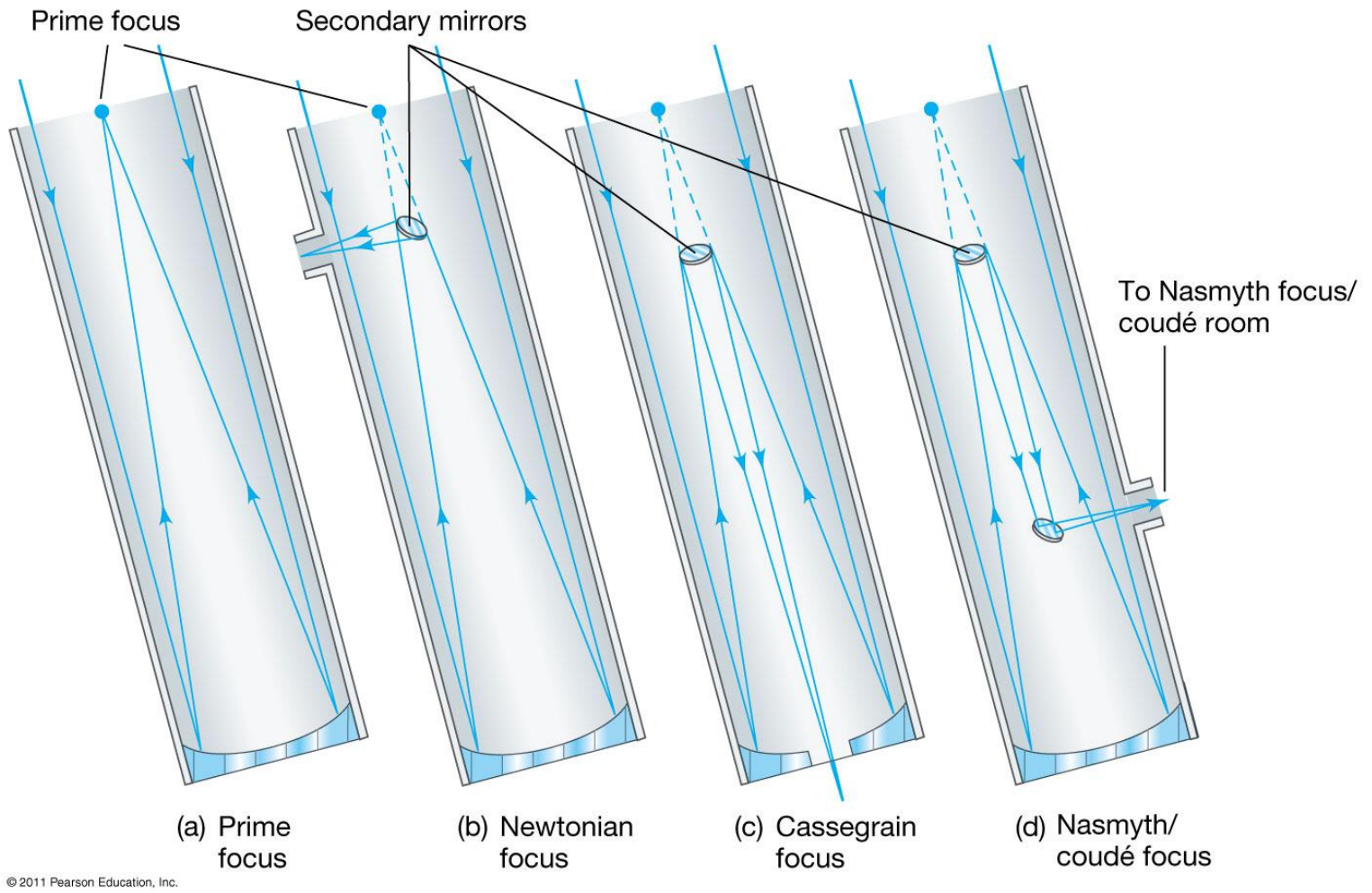
5.1 Optical Telescopes

Modern telescopes are all reflectors:

- **Light traveling through lens is refracted differently depending on wavelength**
- **Some light traveling through lens is absorbed**
- **Large lens can be very heavy, and can only be supported at edge**
- **A lens needs two optically acceptable surfaces; mirror needs only one**

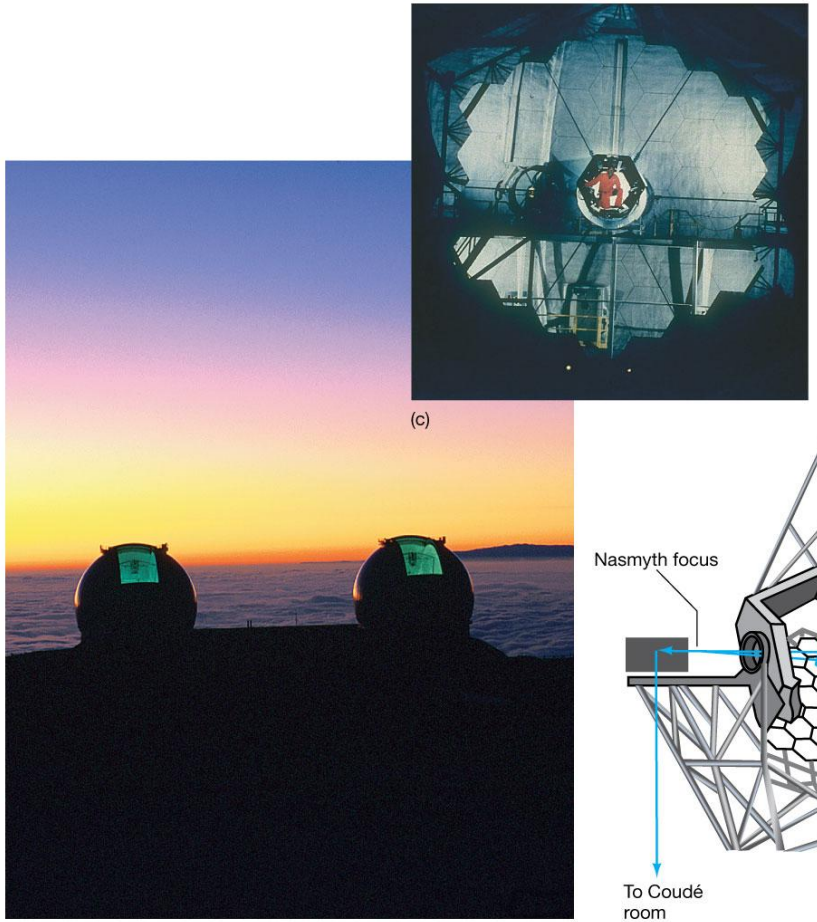
5.1 Optical Telescopes

Types of reflecting telescopes



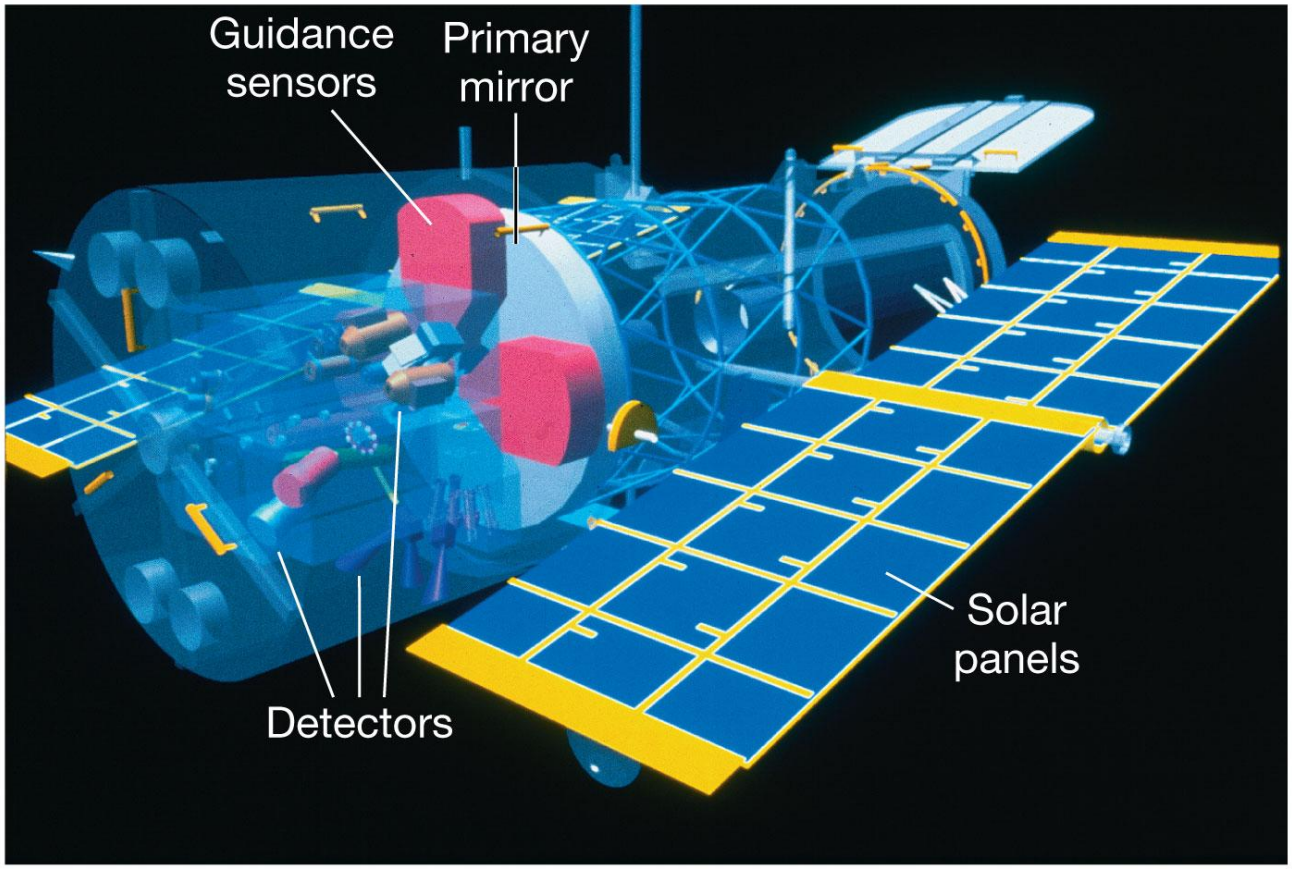
5.1 Optical Telescopes

The Keck telescope, a modern research telescope



Discovery 5-1: The *Hubble Space Telescope*

The *Hubble Space Telescope* has a variety of detectors

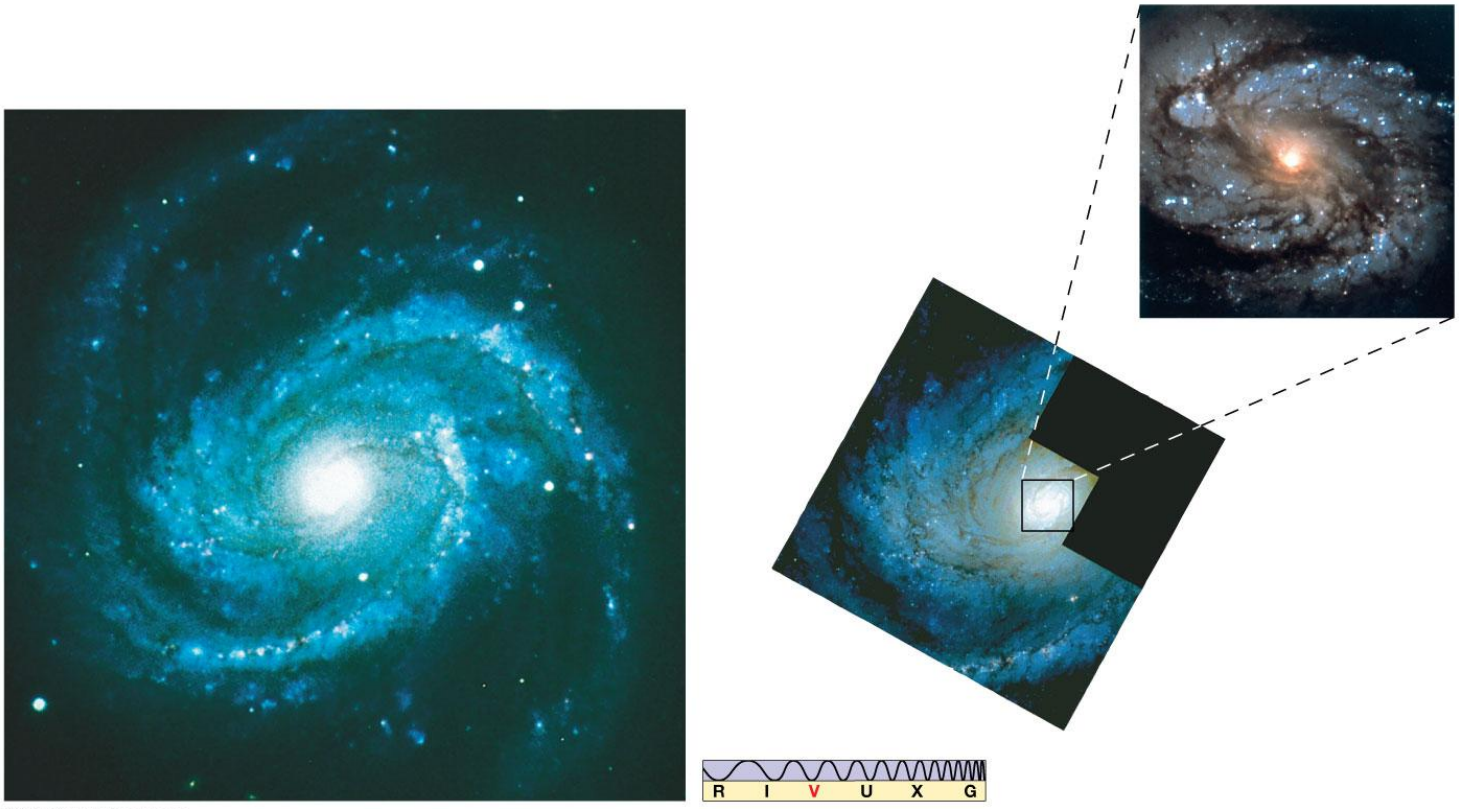


Discovery 5-1: The *Hubble Space Telescope*

The *Hubble Space Telescope's* main mirror is 2.4 m in diameter and is designed for visible, infrared, and ultraviolet radiation

Discovery 5-1: The *Hubble Space Telescope*

Here we compare the best ground-based image of M100, on the left, with the *Hubble* images on the right



5.2 Telescope Size

Light-gathering power: Improves detail

Brightness proportional to square of radius of mirror

Photo (b) was taken with a telescope twice the size of the telescope that took photo (a)

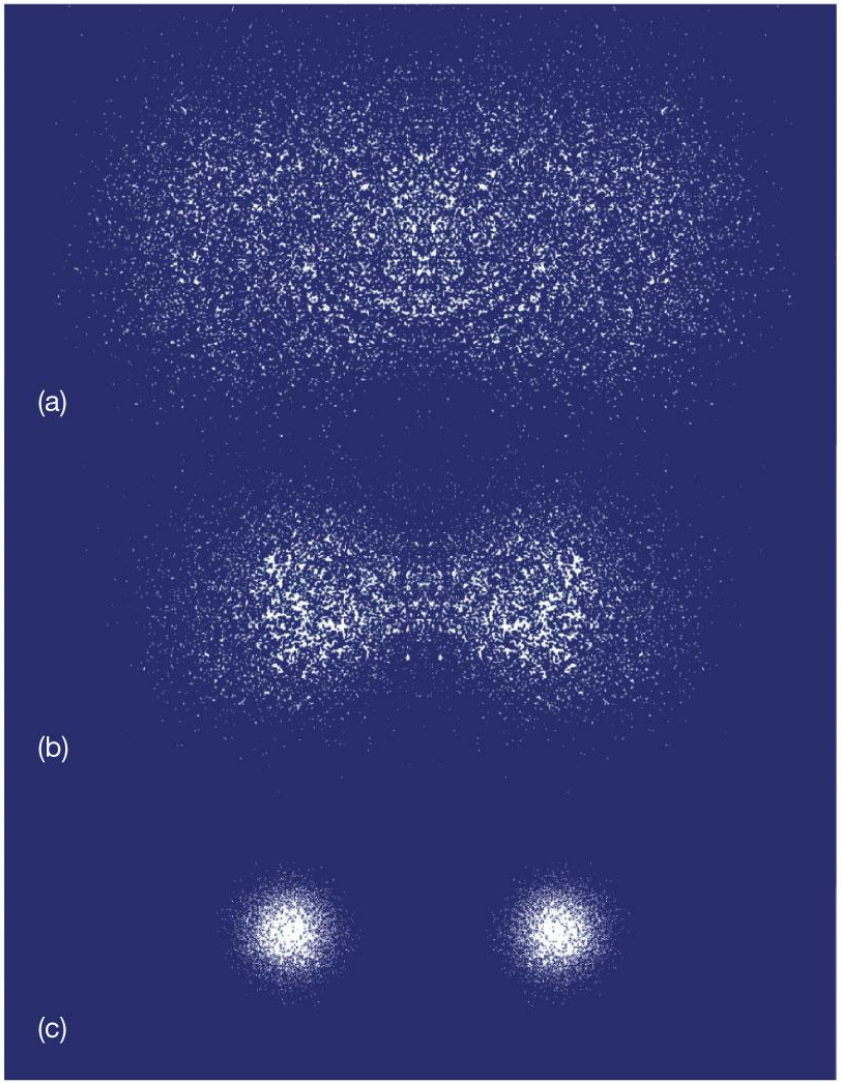
(a)

(b)

5.2 Telescope Size

Resolving power: When better, can distinguish objects that are closer together

Resolution is proportional to wavelength and inversely proportional to telescope size—bigger is better!



5.2 Telescope Size

Effect of improving resolution:

(a) 10′; (b) 1′; (c) 5″; (d) 1″

(a)

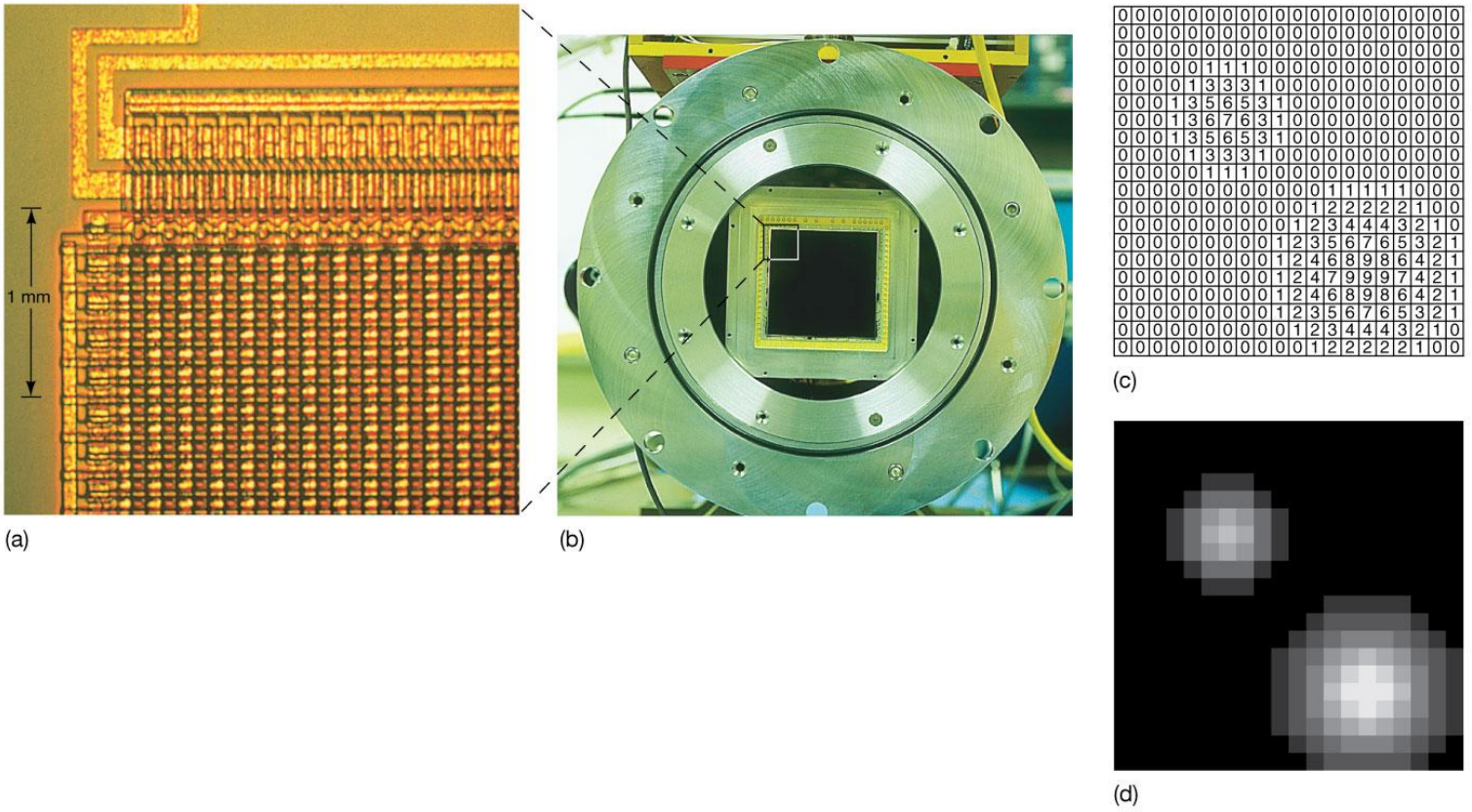
(b)

(c)

(d)

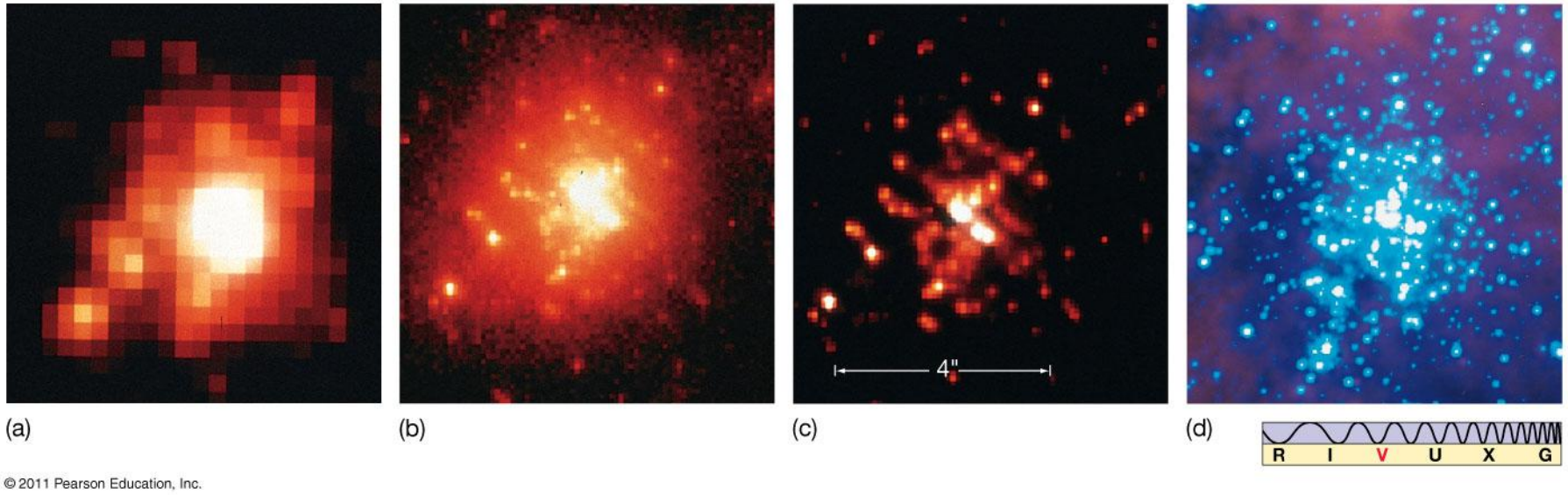
5.3 Images and Detectors

Image acquisition: Charge-coupled devices (CCDs) are electronic devices, which can be quickly read out and reset



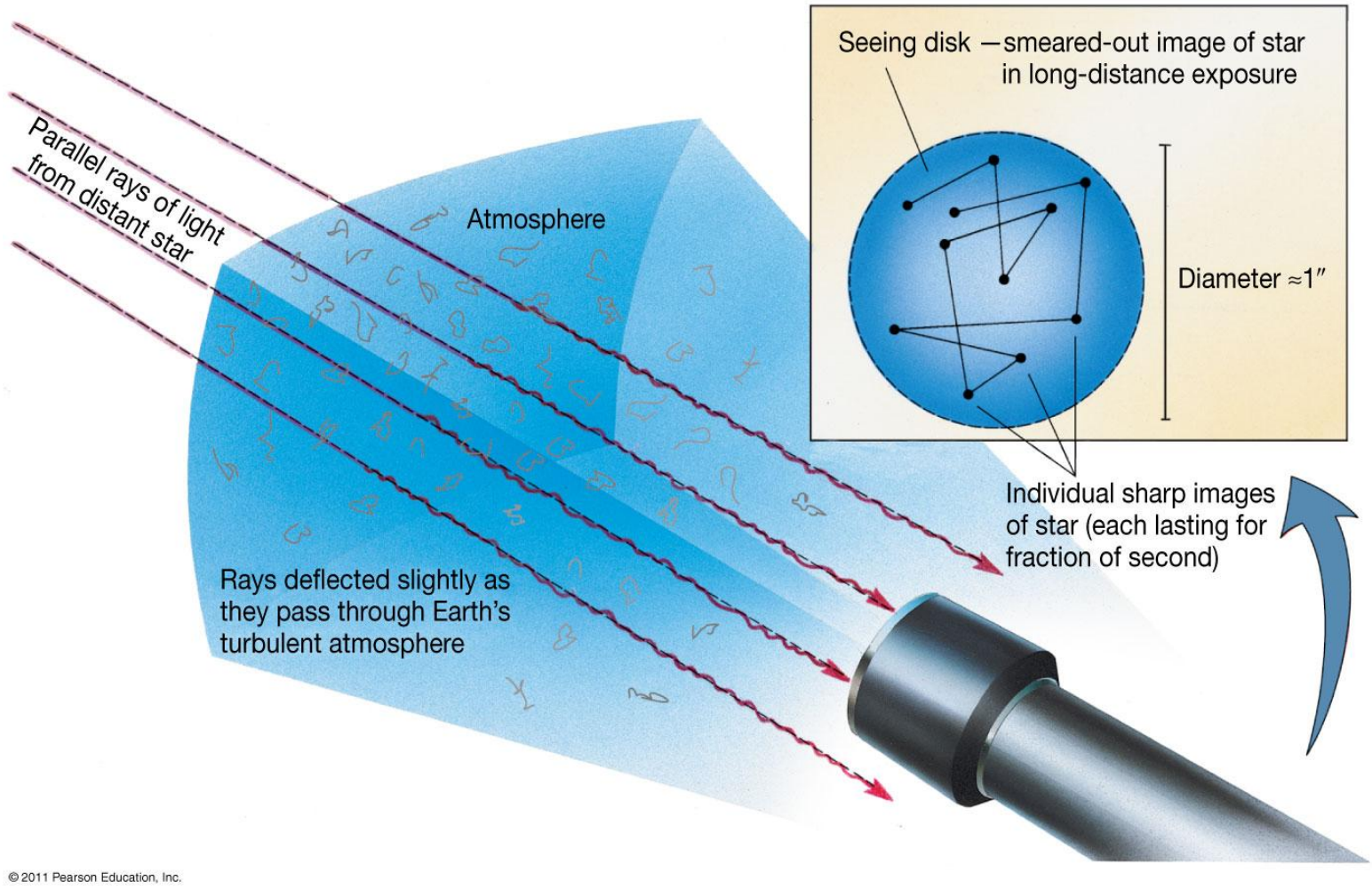
5.3 Images and Detectors

Image processing by computers can sharpen images



5.4 High-Resolution Astronomy

Atmospheric blurring is due to air movements



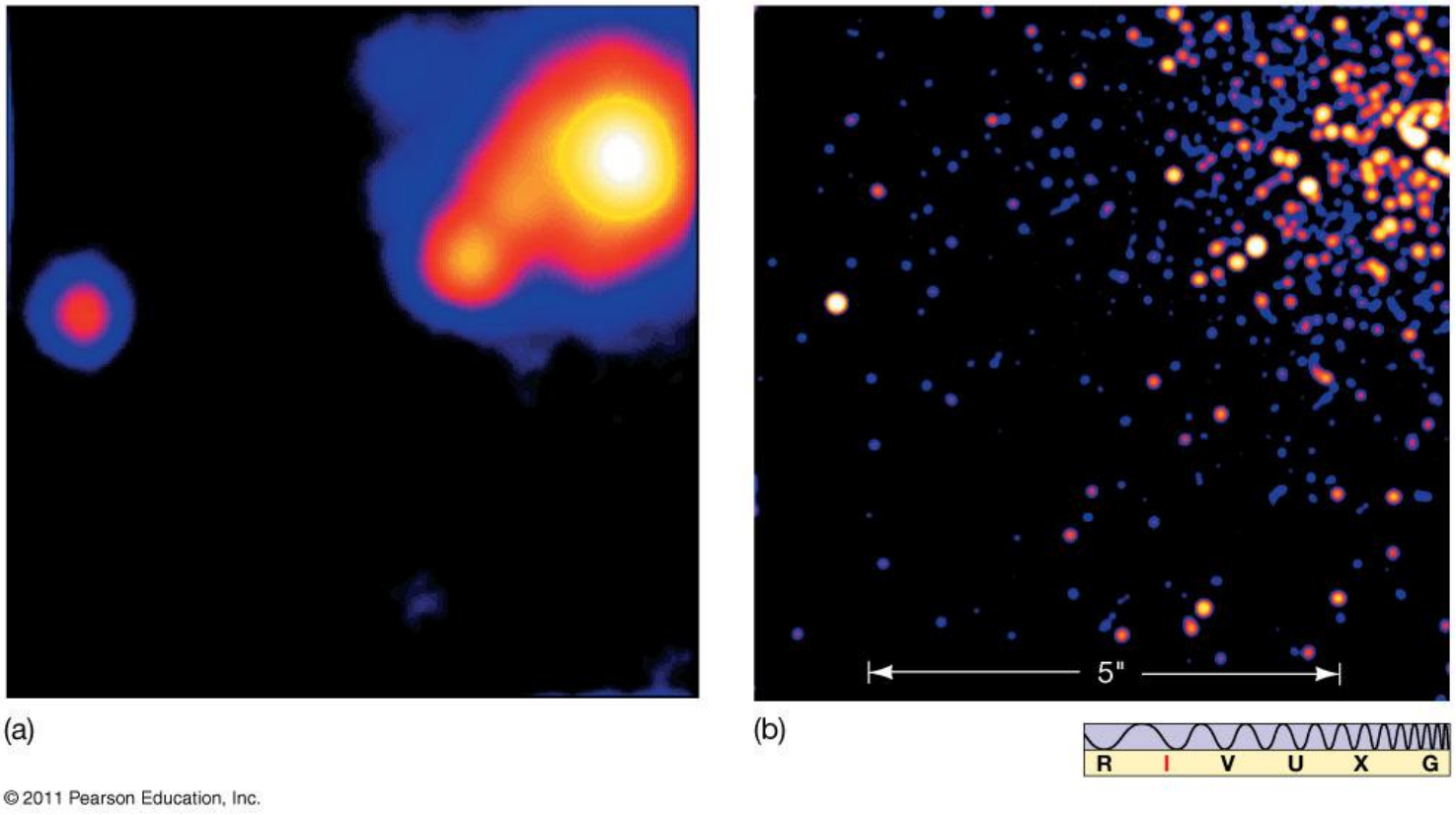
5.4 High-Resolution Astronomy

Solutions:

- **Put telescopes on mountaintops, especially in deserts**
- **Put telescopes in space**

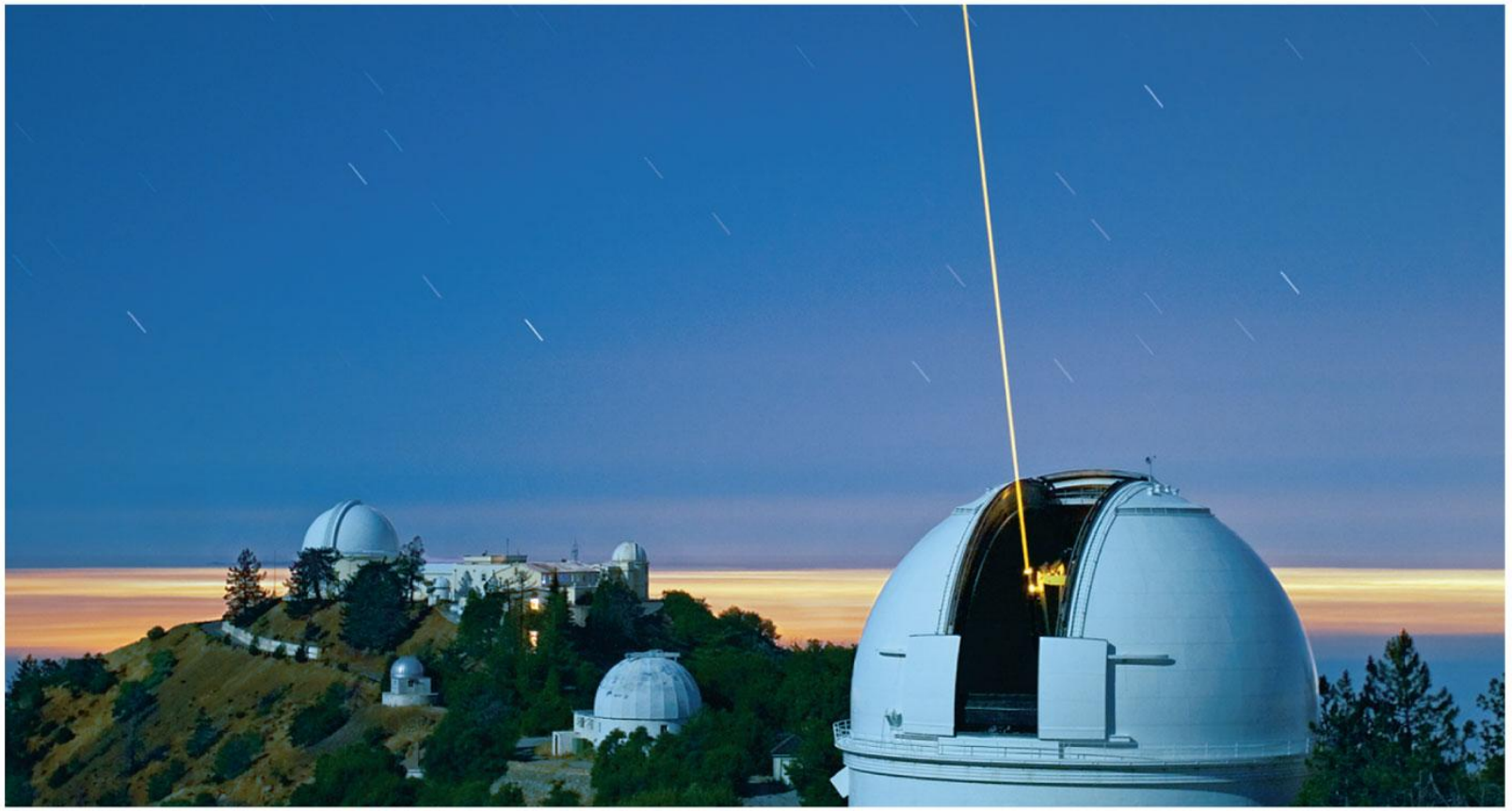
5.4 High-Resolution Astronomy

Active optics: Control mirrors based on temperature and orientation



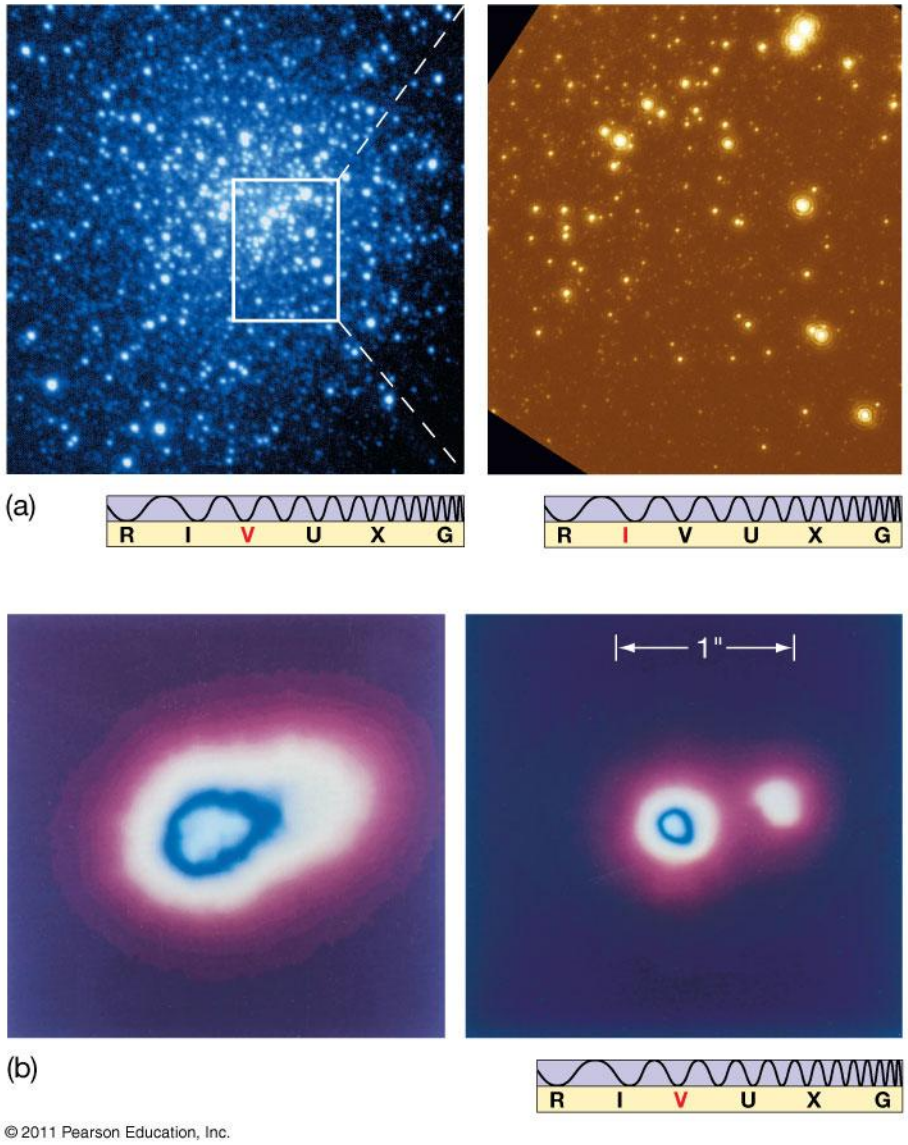
5.4 High-Resolution Astronomy

Adaptive optics: Track atmospheric changes with laser; adjust mirrors in real time



5.4 High-Resolution Astronomy

These images show the improvements possible with adaptive optics

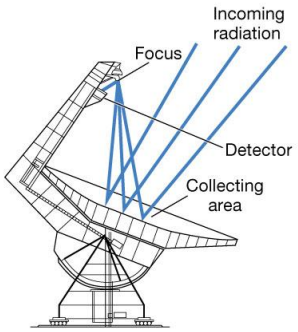


5.5 Radio Astronomy

Radio telescopes

- **Similar to optical reflecting telescopes**
- **Prime focus**
- **Less sensitive to imperfections (due to longer wavelength); can be made very large**

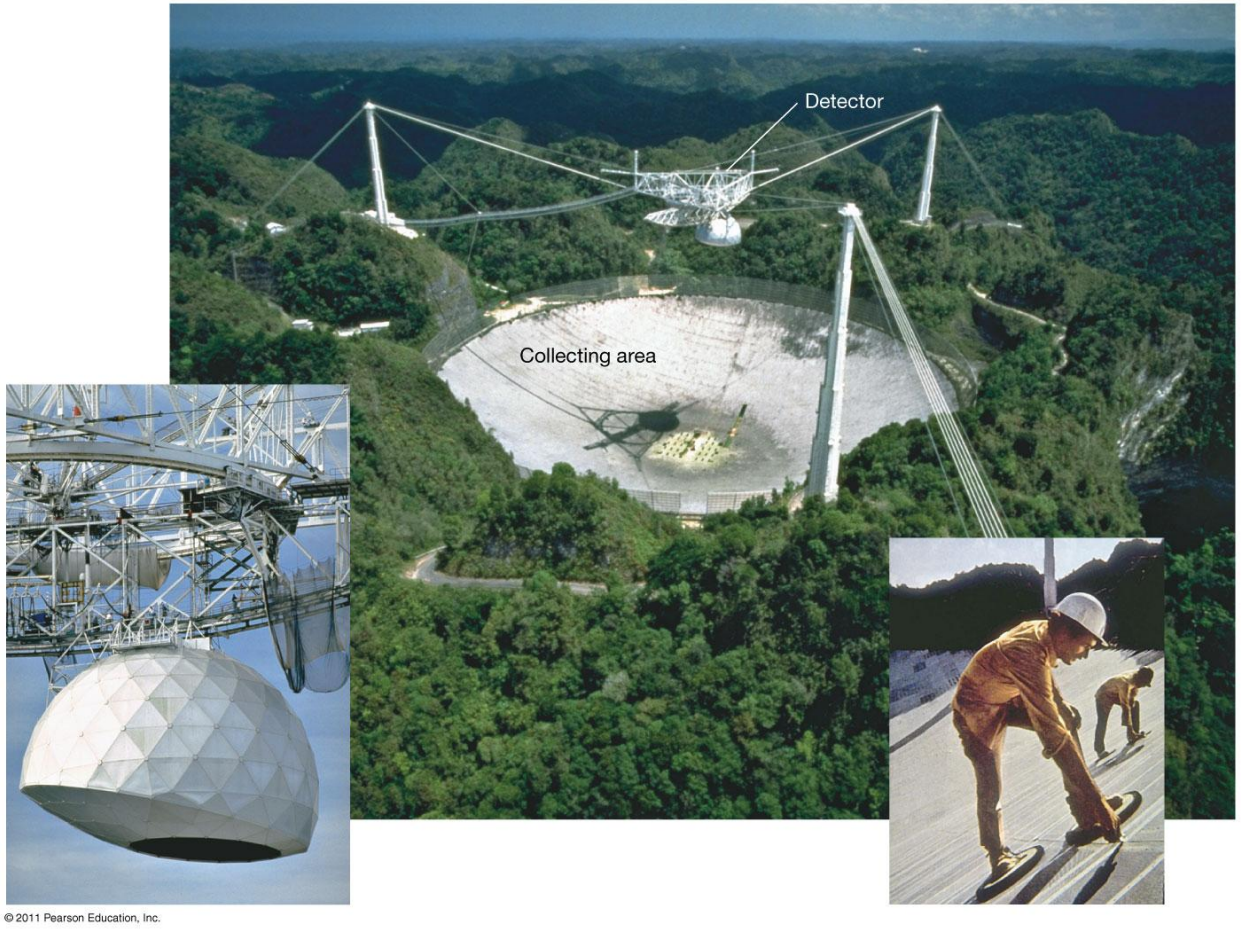
(a)



(b)

5.5 Radio Astronomy

Largest radio telescope is the 300-m dish at Arecibo

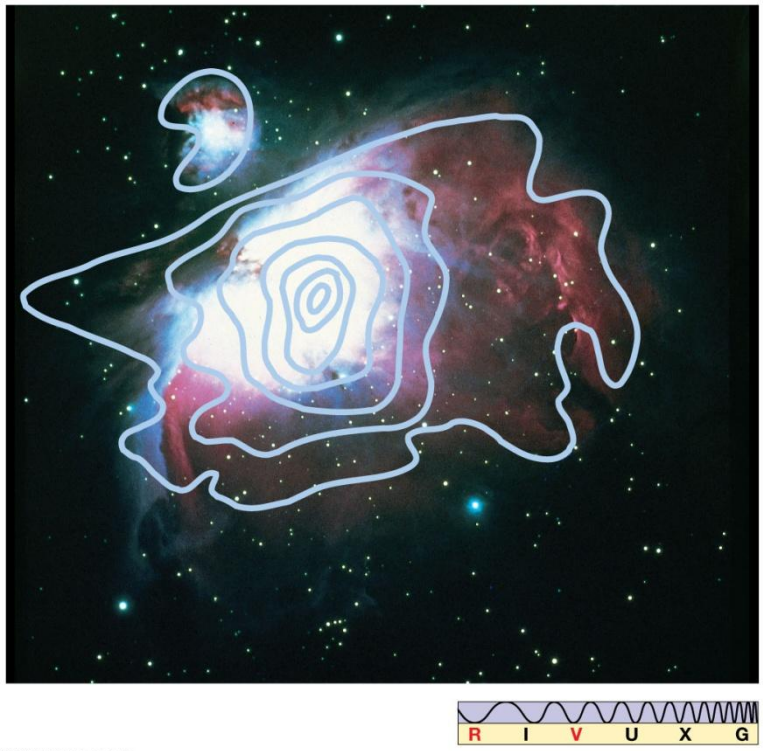


5.5 Radio Astronomy

Longer wavelength means poor angular resolution

Advantages of radio astronomy:

- **Can observe 24 hours a day**
- **Clouds, rain, and snow don't interfere**
- **Observations at an entirely different frequency; get totally different information**



5.6 Interferometry

Interferometry:

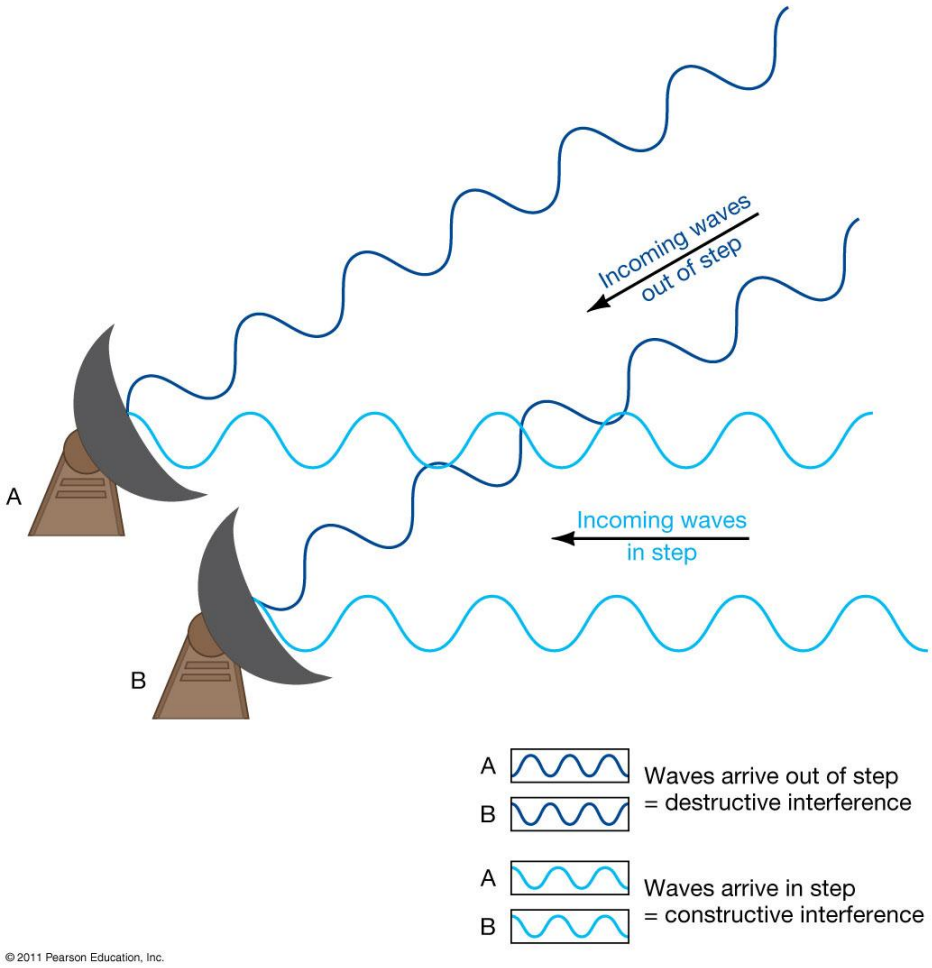
- **Combines information from several widely spread radio telescopes as if it came from a single dish**
- **Resolution will be that of dish whose diameter = largest separation between dishes**

(a)

(b)

5.6 Interferometry

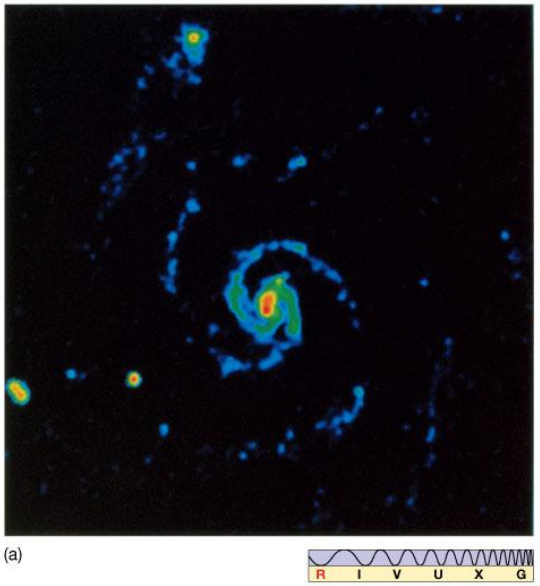
Interferometry involves combining signals from two receivers; the amount of interference depends on the direction of the signal



5.6 Interferometry

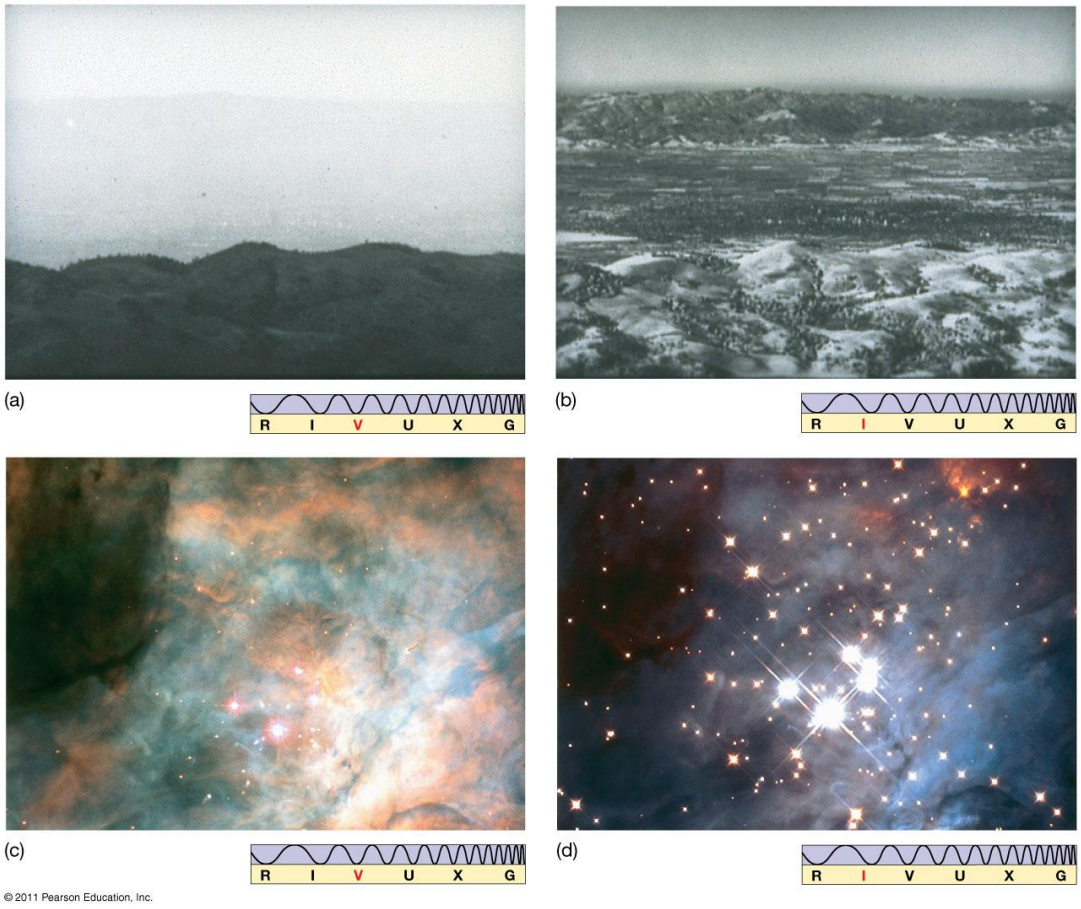
Can get radio images whose resolution is close to optical

Interferometry can also be done with visible light but is much more difficult due to shorter wavelengths



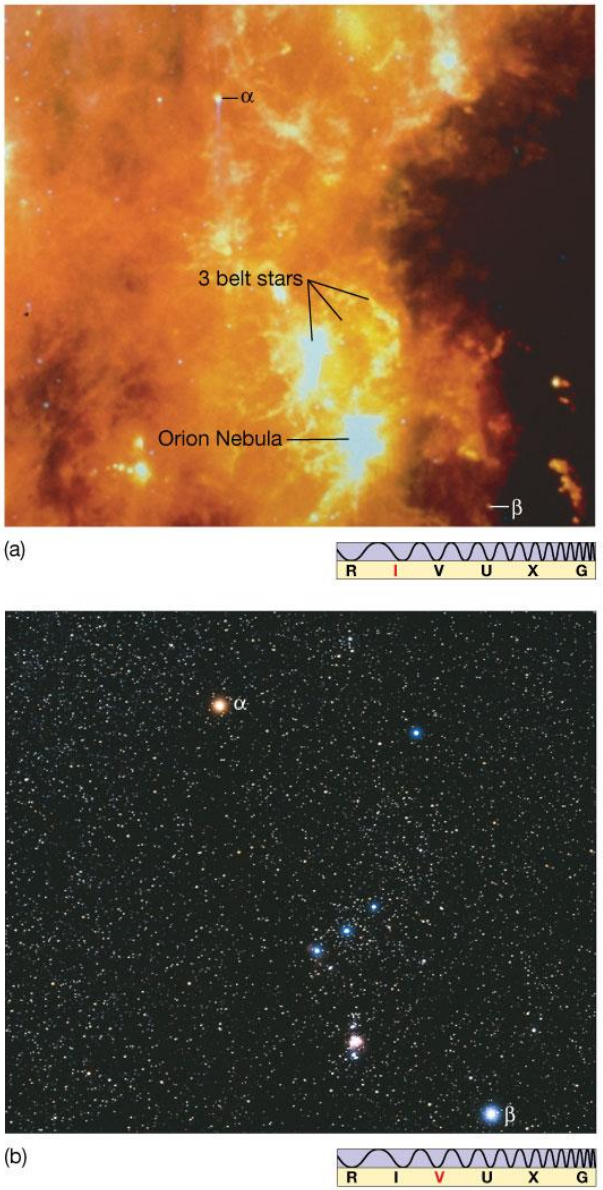
5.7 Space-Based Astronomy

Infrared radiation can produce an image where visible radiation is blocked; generally can use optical telescope mirrors and lenses



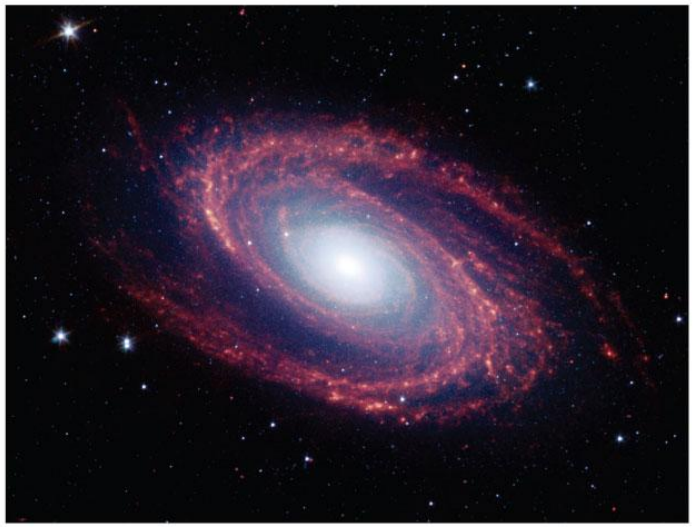
5.7 Space-Based Astronomy

Infrared telescopes
can also be in space; the image on the top is from the Infrared Astronomy Satellite



5.7 Space-Based Astronomy

The *Spitzer Space Telescope*, an infrared telescope, is in orbit around the Sun. These are some of its images.

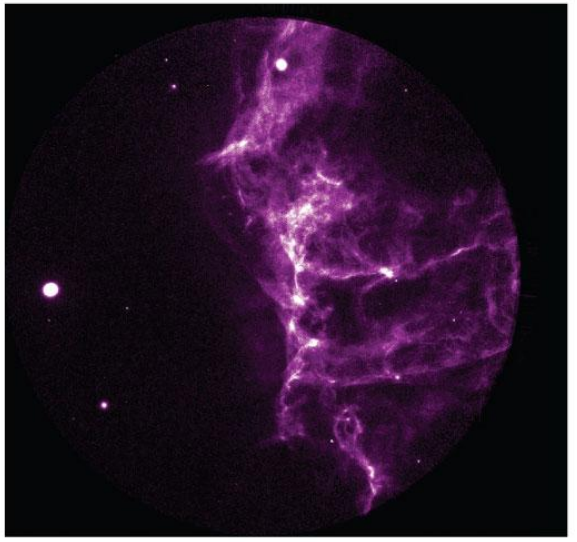


(a)

(b)

5.7 Space-Based Astronomy

Ultraviolet observing must be done in space, as the atmosphere absorbs almost all ultraviolet rays.



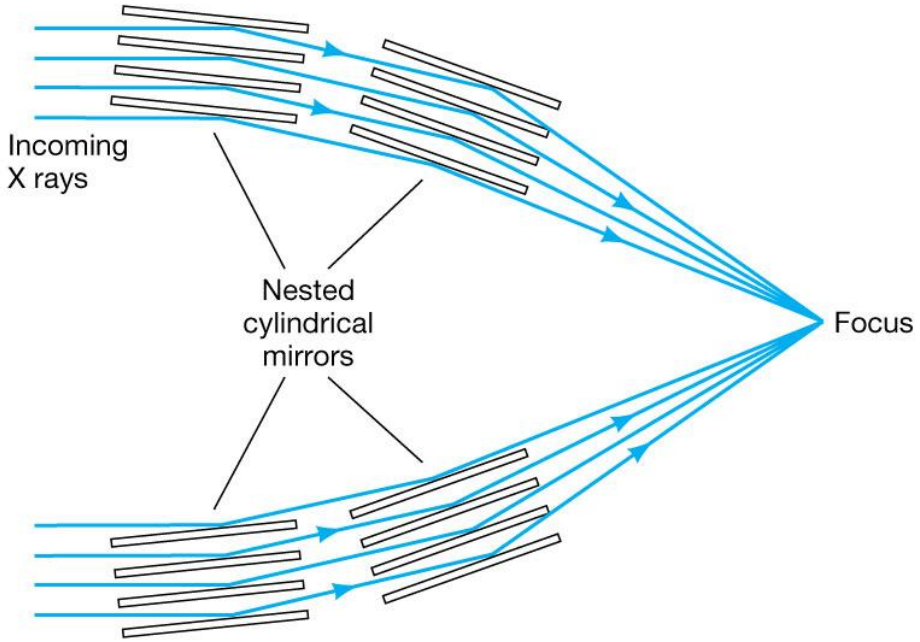
(a)

(b)

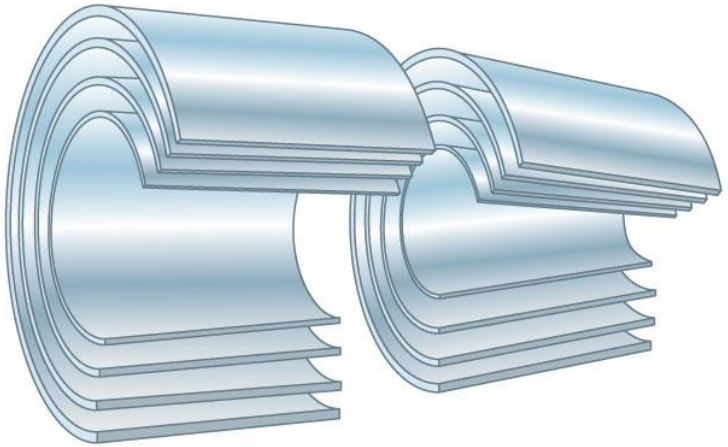
5.7 Space-Based Astronomy

X rays and gamma rays will not reflect off mirrors as other wavelengths do; need new techniques

X rays will reflect at a very shallow angle and can therefore be focused



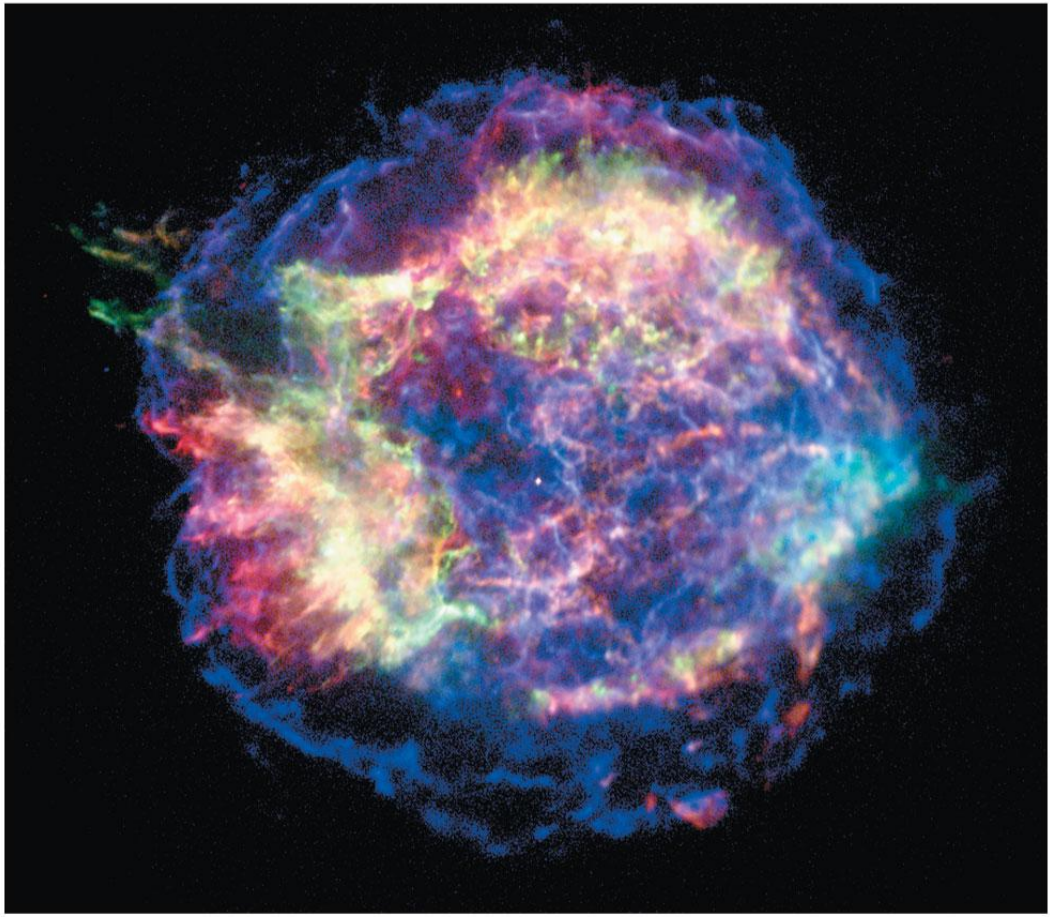
(a)

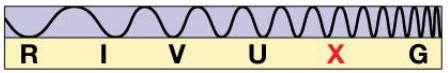


(b)

5.7 Space-Based Astronomy

X-ray image of supernova remnant

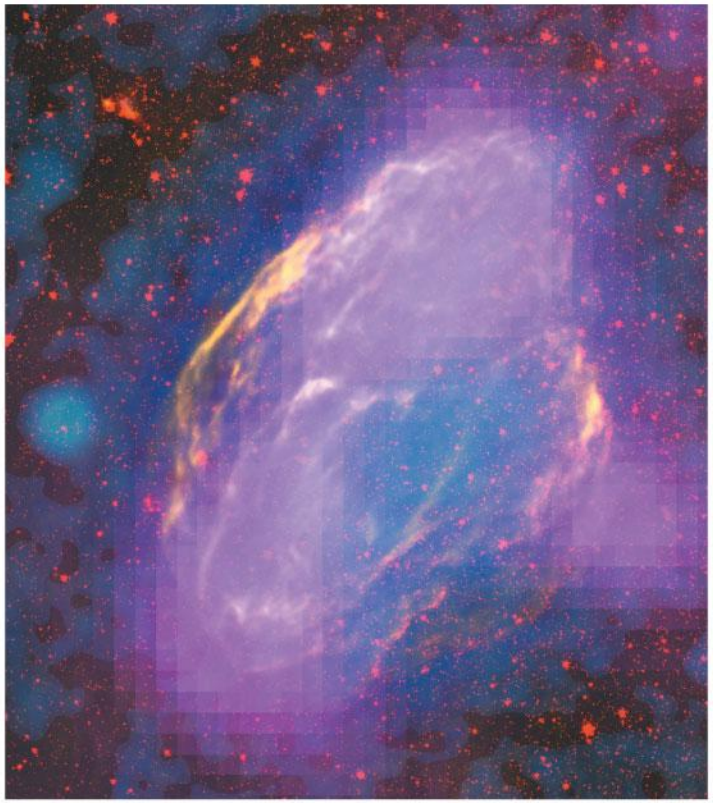




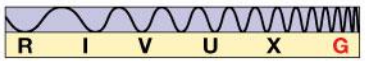
5.7 Space-Based Astronomy

Gamma rays cannot be focused at all; images are therefore coarse

(a)

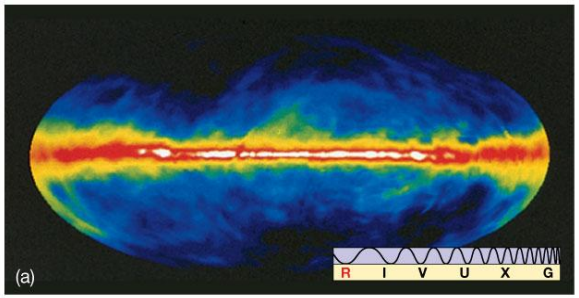


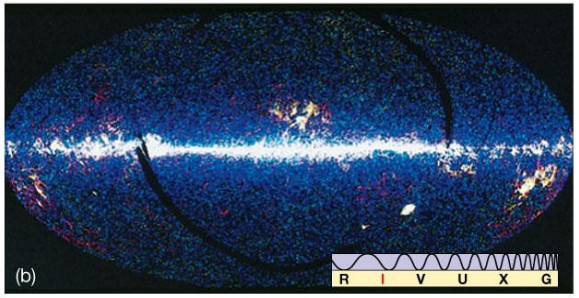
(b)

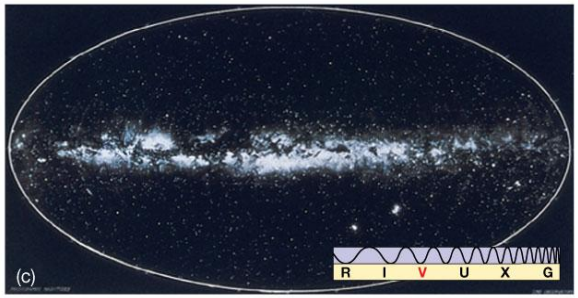


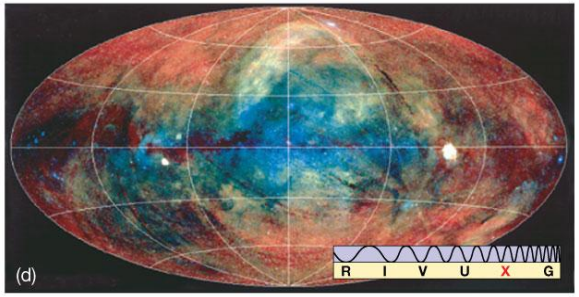
5.8 Full-Spectrum Coverage

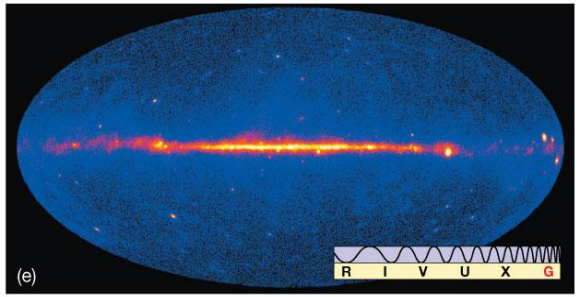
Much can be learned from observing the same astronomical object at many wavelengths. Here is the Milky Way.











Summary of Chapter 5

- **Refracting telescopes make images with a lens**
- **Reflecting telescopes make images with a mirror**
- **Modern research telescopes are all reflectors**
- **CCDs are used for data collection**
- **Data can be formed into image, analyzed spectroscopically, or used to measure intensity**
- **Large telescopes gather much more light, allowing study of very faint sources**
- **Large telescopes also have better resolution**

Summary of Chapter 5 (cont.)

- **Resolution of ground-based optical telescopes is limited by atmospheric effects**
- **Resolution of radio or space-based telescopes is limited by diffraction**
- **Active and adaptive optics can minimize atmospheric effects**
- **Radio telescopes need large collection area; diffraction limited**
- **Interferometry can greatly improve resolution**

Summary of Chapter 5 (cont.)

- **Infrared and ultraviolet telescopes are similar to optical**
- **Ultraviolet telescopes must be above atmosphere**
- **X rays can be focused, but very differently than visible light**
- **Gamma rays can be detected but not imaged**