ASTRONOMY

Chapter 6 ASTRONOMICAL INSTRUMENTS

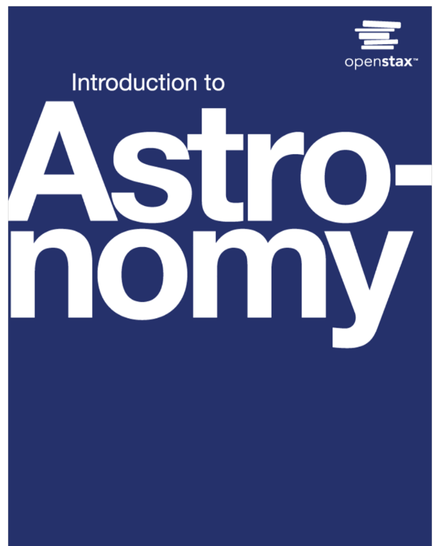
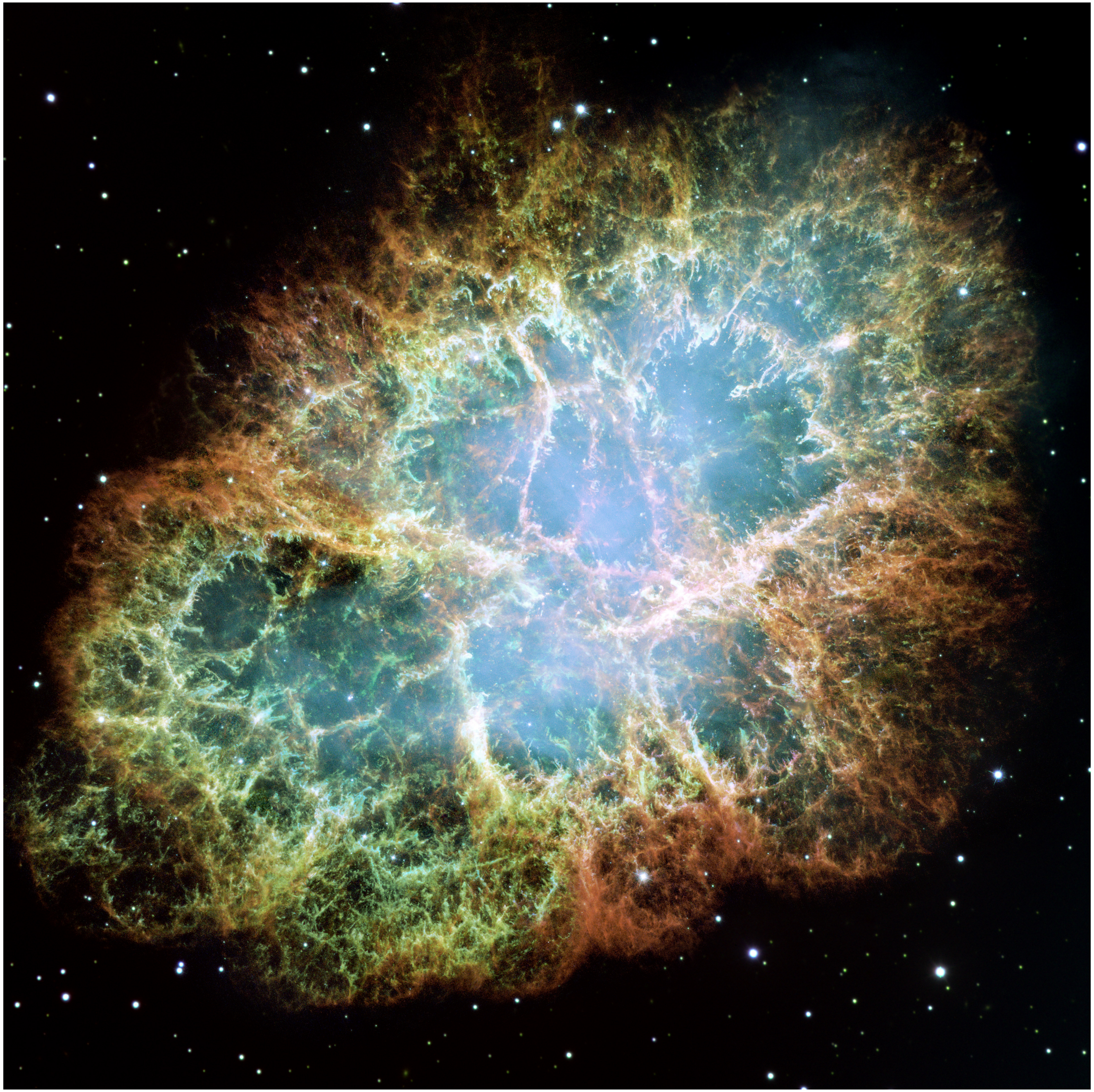
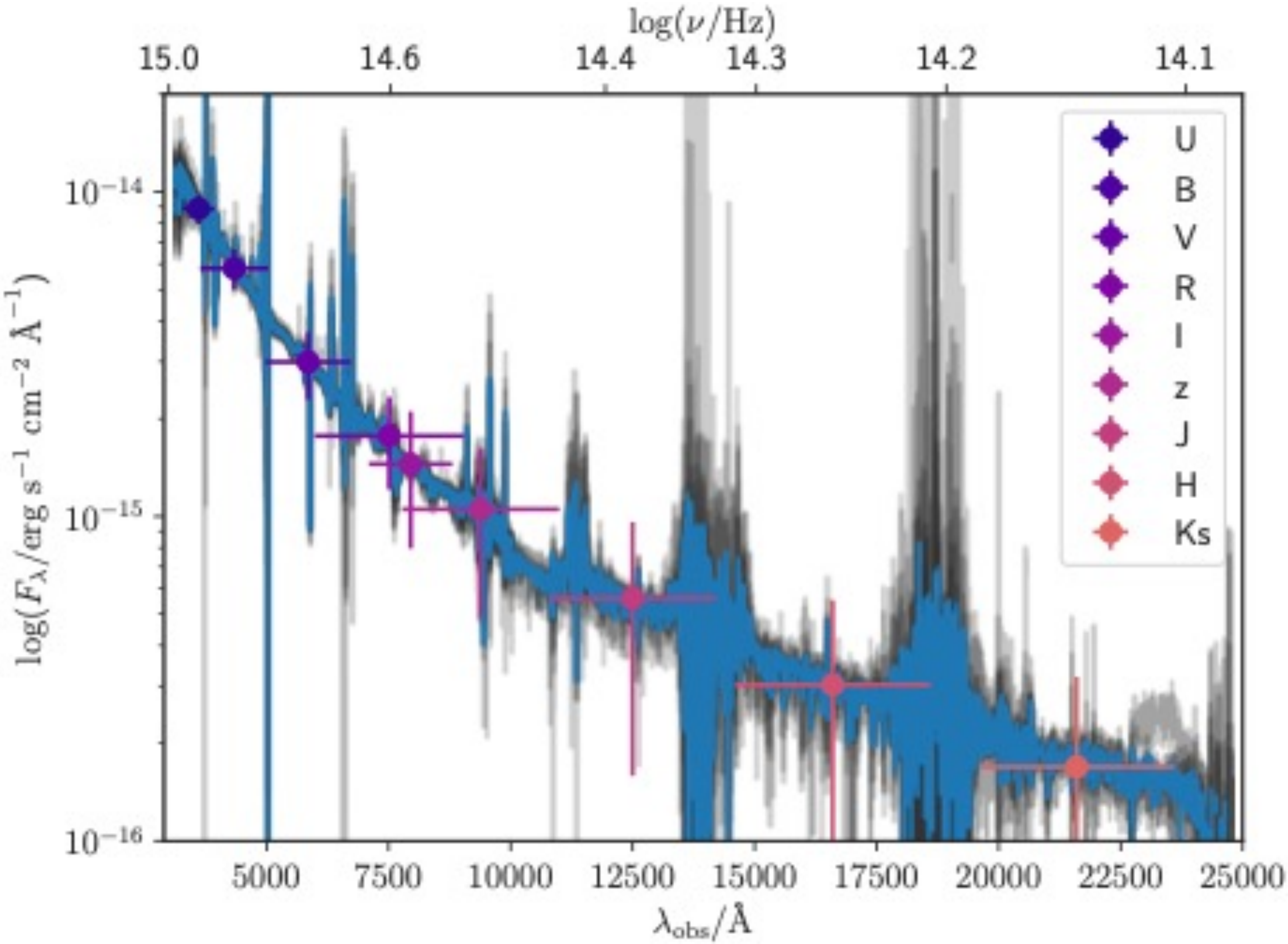


FIGURE 6.1

Hubble Space Telescope (HST). This artist’s impression shows the Hubble above Earth, with the rectangular solar panels that provide it with power seen to the left and right.

M16-"Pillars of Creation"





log(ν/Hz)
15.0
14.6
14.4
14.3
14.2
14.1
log(F_λ/erg s^-1 cm^-2 Å^-1)
10^-14
10^-15
10^-16
5000
7500
10000
12500
15000
17500
20000
22500
25000
λ_obs/Å
U
B
V
R
I
z
J
H
Ks

Star Cluster R136

A ‘star nursery’ gas cloud

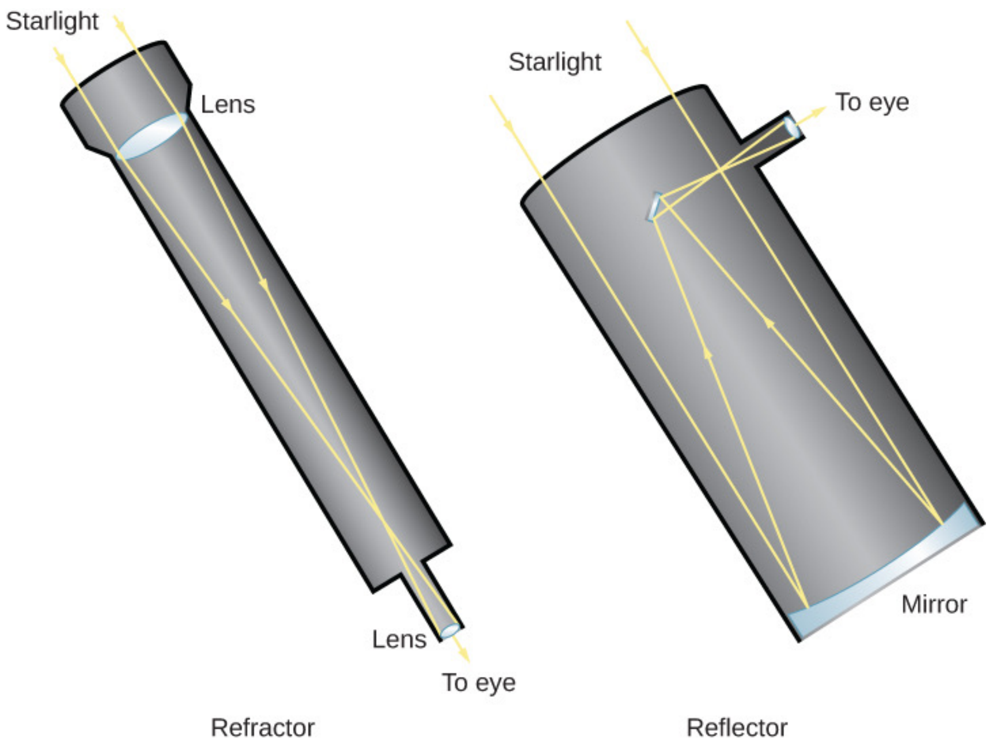
FUNCTIONS OF A TELESCOPE

Most people would say that the main function of a telescope is to make things look larger. But in fact, the most important function is to make things look *brighter!* This is called its *light-gathering power.*

Another important function of the telescope is *resolving power. This measures how well you can separate two objects, and of course this is related to how sharp the image looks.*

Courtesy Prof D. Gary

FIGURE 6.5



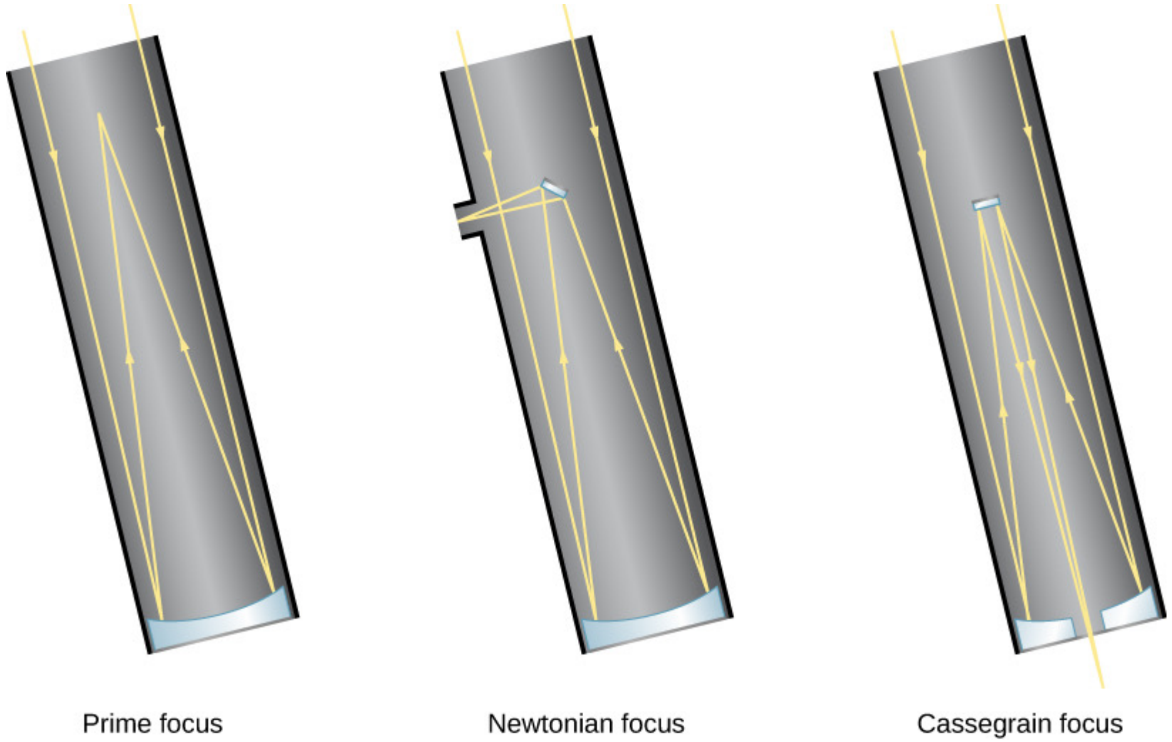
Refracting and Reflecting Telescopes. Light enters a refracting telescope through a lens at the upper end, which focuses the light near the bottom of the telescope. An eyepiece then magnifies the image so that it can be viewed by the eye, or a detector like a photographic plate can be placed at the focus. The upper end of a reflecting telescope is open, and the light passes through to the mirror located at the bottom of the telescope. The mirror then focuses the light at the top end, where it can be detected. Alternatively, as in this sketch, a second mirror may reflect the light to a position outside the telescope structure, where an observer can have easier access to it. Professional astronomers' telescopes are more complicated than this, but they follow the same principles of reflection and refraction.

ADVANTAGES OF REFLECTING TELESCOPE OVER A REFRACTING TELESCOPE:

A refracting telescope uses a lens, which bends red light more than blue light, so the image has color halos. This is called chromatic aberration.	*A reflecting telescope reflects all wavelengths of light at the same angle, so there are no color halos.*
A lens has two surfaces to be figured, which is more difficult to control its shape.	*A mirror has only one surface to be figured, so it is easier to control the shape.*
A lens passes light through, so the glass has to be very transparent and pure, and some wavelengths (infrared and ultraviolet) are absorbed by glass.	*A mirror reflects the light, so the material that it is made from does not have to be transparent, and infrared and ultraviolet light reflects equally well.*
A lens can only be mounted by its edges, so a large lens can sag under its own weight.	*A mirror can be supported from the back, so it is less subject to sagging. Also, a mirror can be hollow, to reduce weight.*

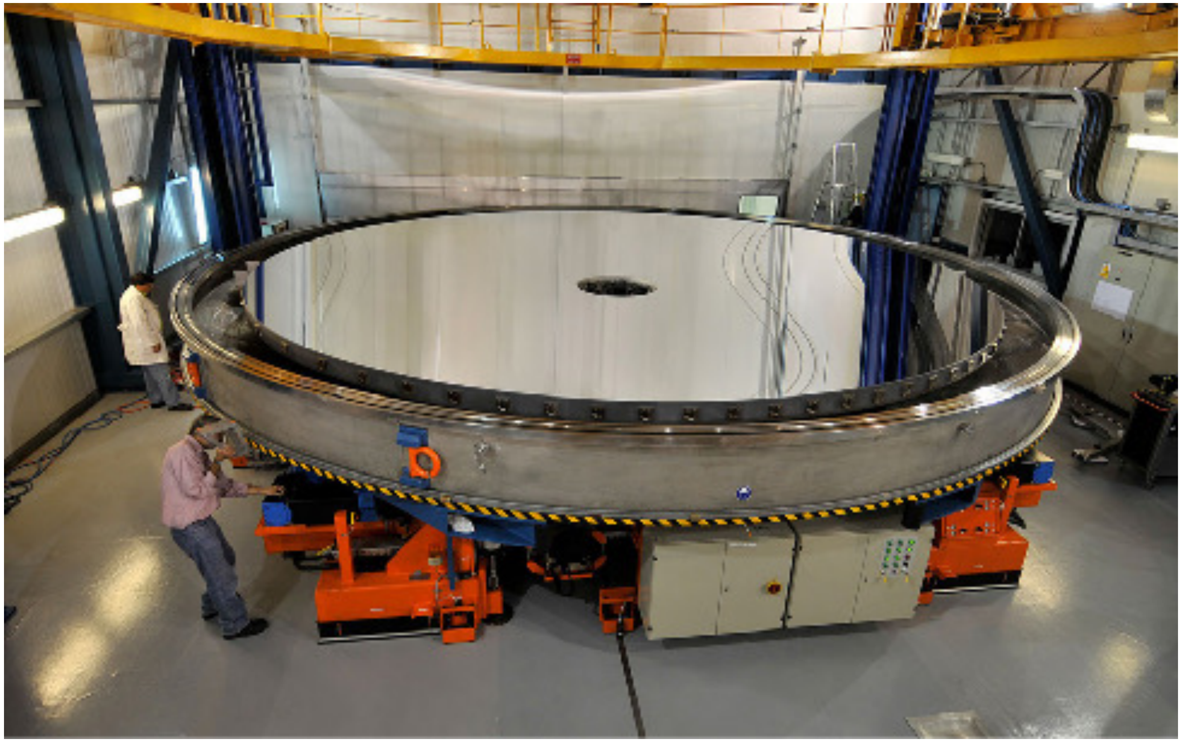
Courtesy Prof D. Gary

FIGURE 6.6



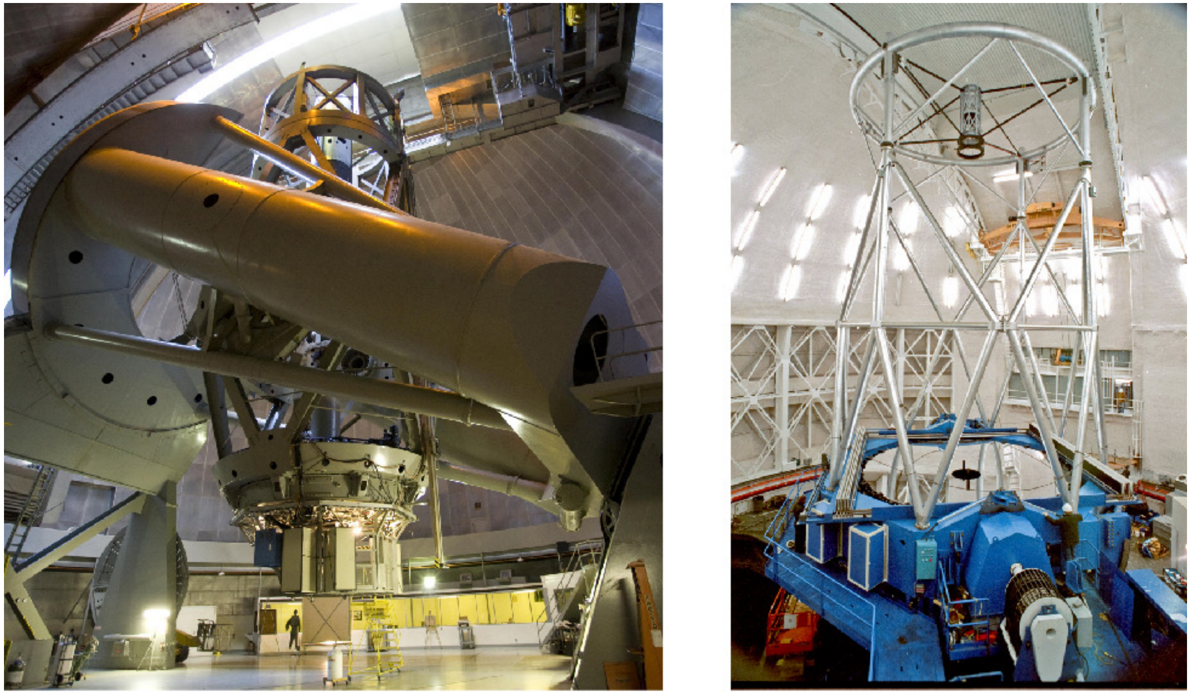
Focus Arrangements for Reflecting Telescopes. Reflecting telescopes have different options for where the light is brought to a focus. With prime focus, light is detected where it comes to a focus after reflecting from the primary mirror. With Newtonian focus, light is reflected by a small secondary mirror off to one side, where it can be detected (see also Figure 6.5). Most large professional telescopes have a Cassegrain focus in which light is reflected by the secondary mirror down through a hole in the primary mirror to an observing station below the telescope.

FIGURE 6.7



Large Telescope Mirror. This image shows one of the primary mirrors of the European Southern Observatory's Very Large Telescope, named Yepun, just after it was recoated with aluminum. The mirror is a little over 8 meters in diameter. (credit: ESO/G. Huedepohl)

FIGURE 6.8



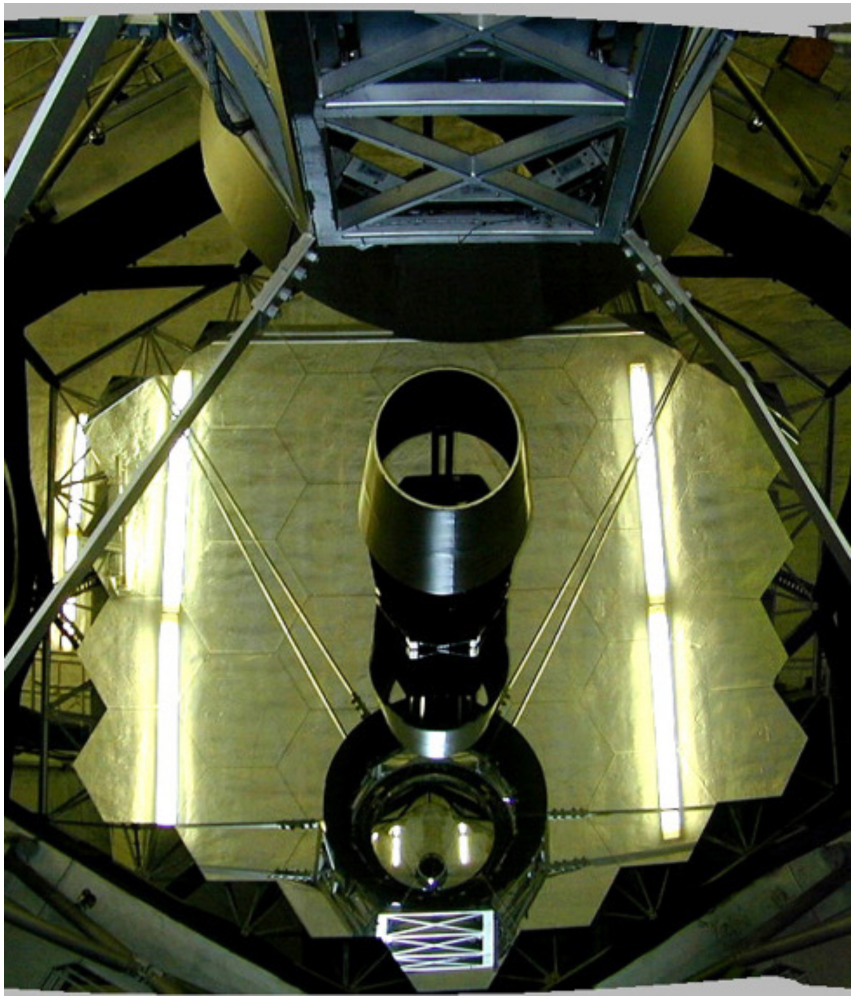
(a) (b)

Modern Reflecting Telescopes.

(a) The Palomar 5-meter reflector: The Hale telescope on Palomar Mountain has a complex mounting structure that enables the telescope (in the open “tube” pointing upward in this photo) to swing easily into any position.

(b) The Gemini North 8-meter telescope: The Gemini North mirror has a larger area than the Palomar mirror, but note how much less massive the whole instrument seems. (credit a: modification of work by Caltech/Palomar Observatory; credit b: modification of work by Gemini Observatory/AURA)

FIGURE 6.9

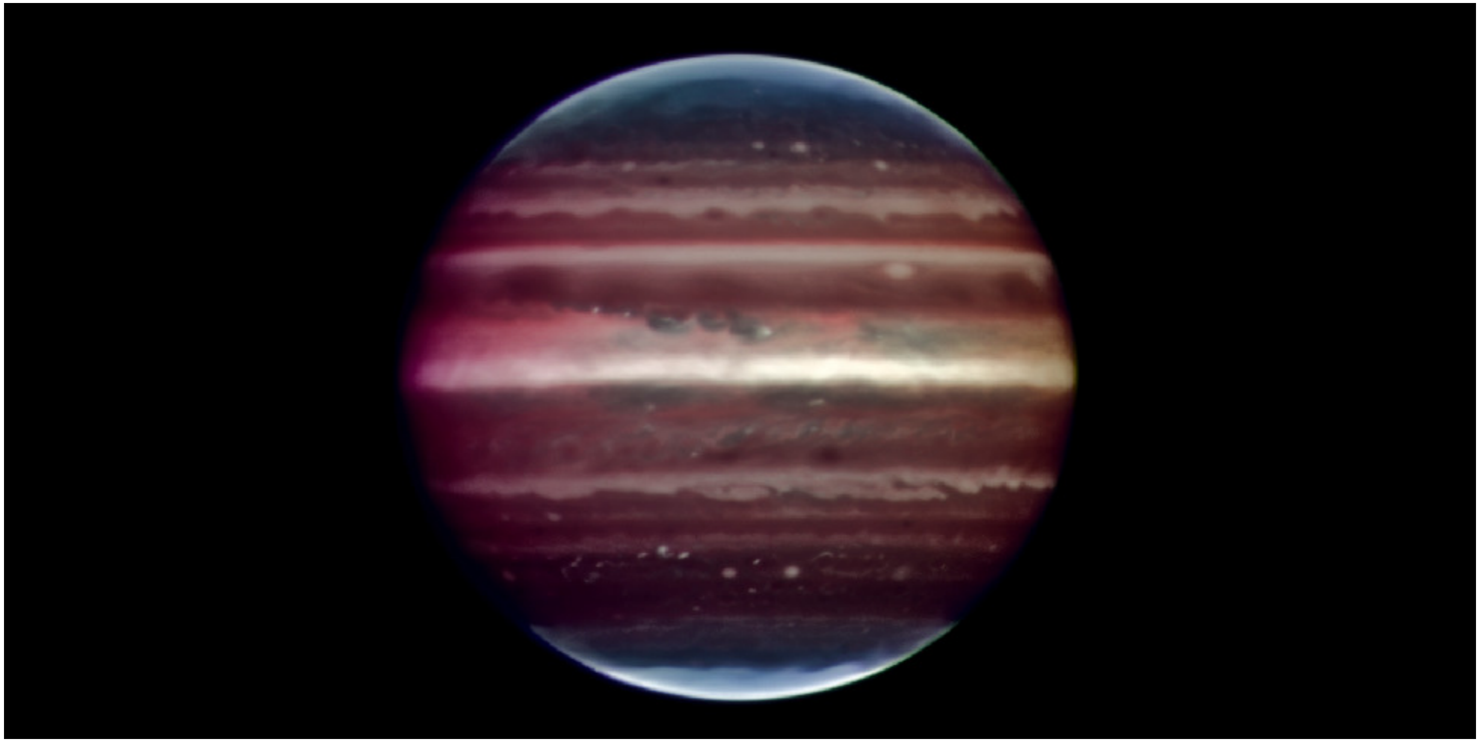


Thirty-Six Eyes Are Better Than One. The mirror of the 10-meter Keck telescope is composed of 36 hexagonal sections. (credit: NASA)

FIGURE 6.11

World's Largest Refractor. The Yerkes 40-inch (1-meter) telescope.

FIGURE 6.13



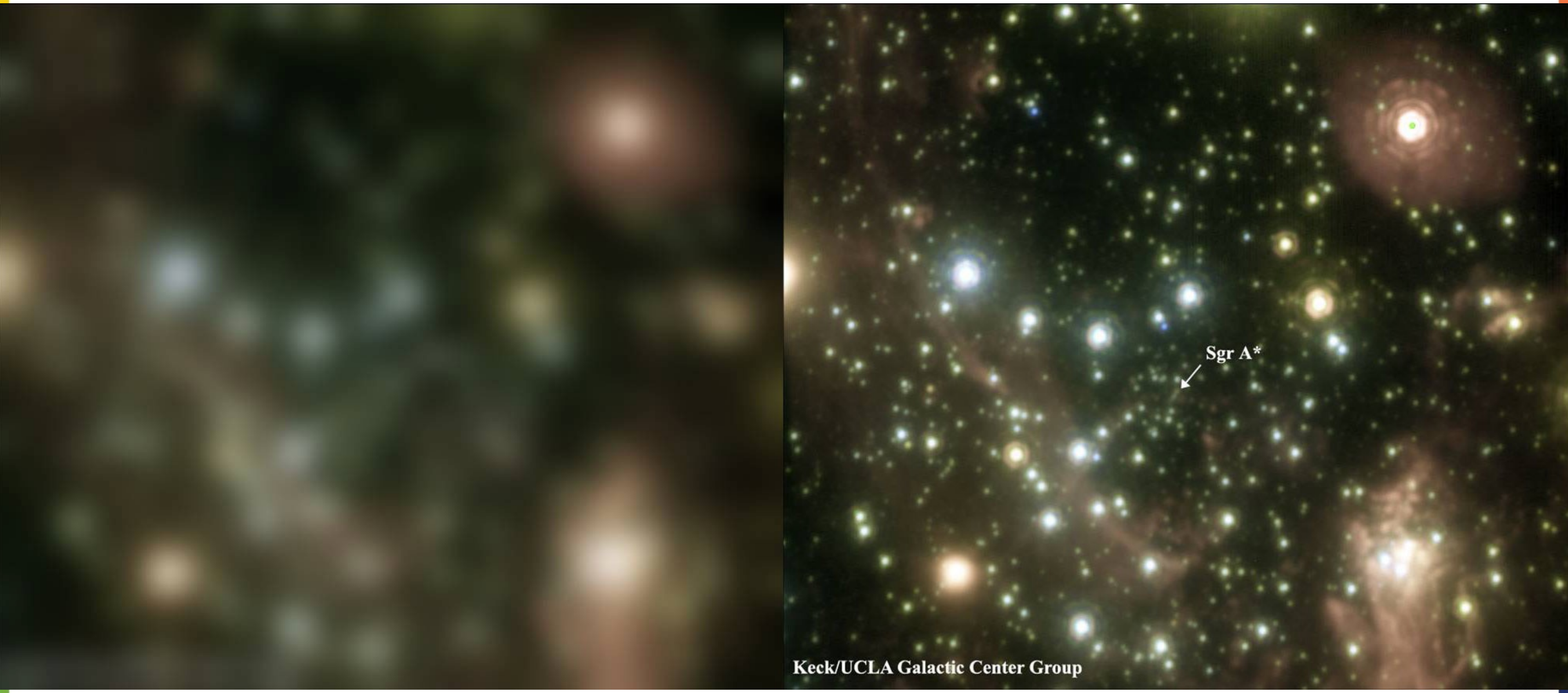
Power of Adaptive Optics. One of the clearest pictures of Jupiter ever taken from the ground, this image was produced with adaptive optics using an 8-meter-diameter telescope at the Very Large Telescope in Chile. Adaptive optics uses infrared wavelengths to remove atmospheric blurring, resulting in a much clearer image. (credit: modification of work by ESO, F.Marchis, M.Wong (UC Berkeley); E.Marchetti, P.Amico, S.Tordo (ESO))

LASER "GUIDE STAR" & ADAPTIVE OPTICS

53/76 The moon, which has risen high in the sky, leaves a soft glow on the twin Keck domes. - Image Credit: Joey Stein

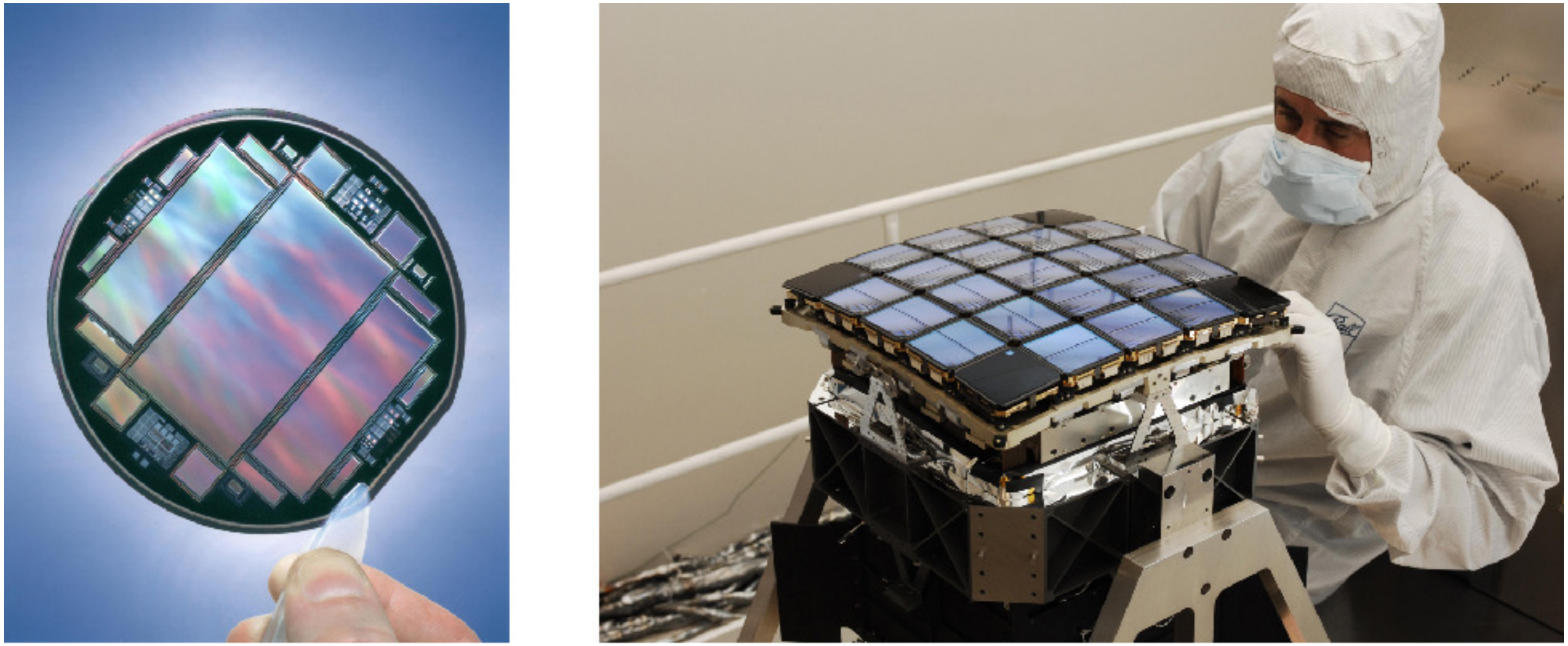
http://www.keckobservatory.org/gallery#prettyPhoto[pp_gal]/52/

KECK ADAPTIVE OPTICS IMAGE OF THE GALACTIC CENTER



http://keckobservatory.org/cosmicmatters/archive/category/winter_2007_spring_2008

FIGURE 6.14



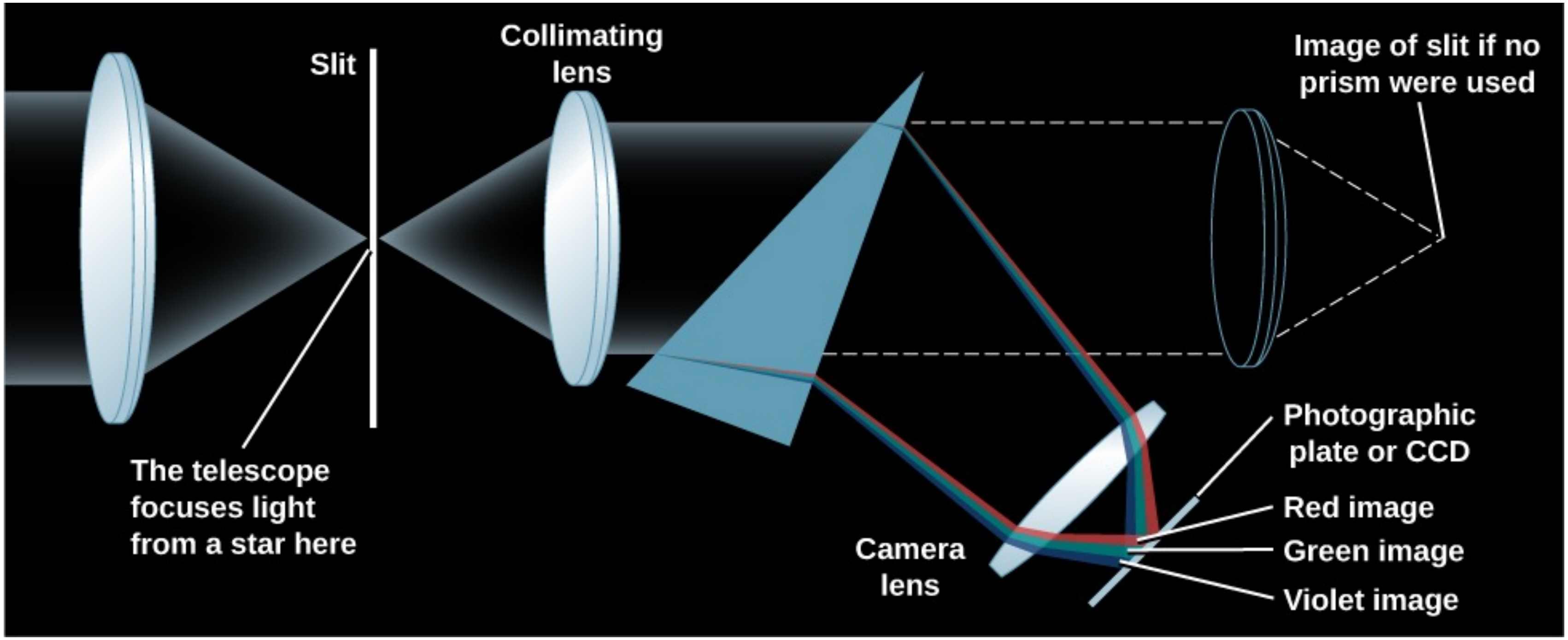
(a) (b)

Charge-Coupled Devices (CCDs).

(a) This CCD is a mere 300-micrometers thick (thinner than a human hair) yet holds more than 21 million pixels.

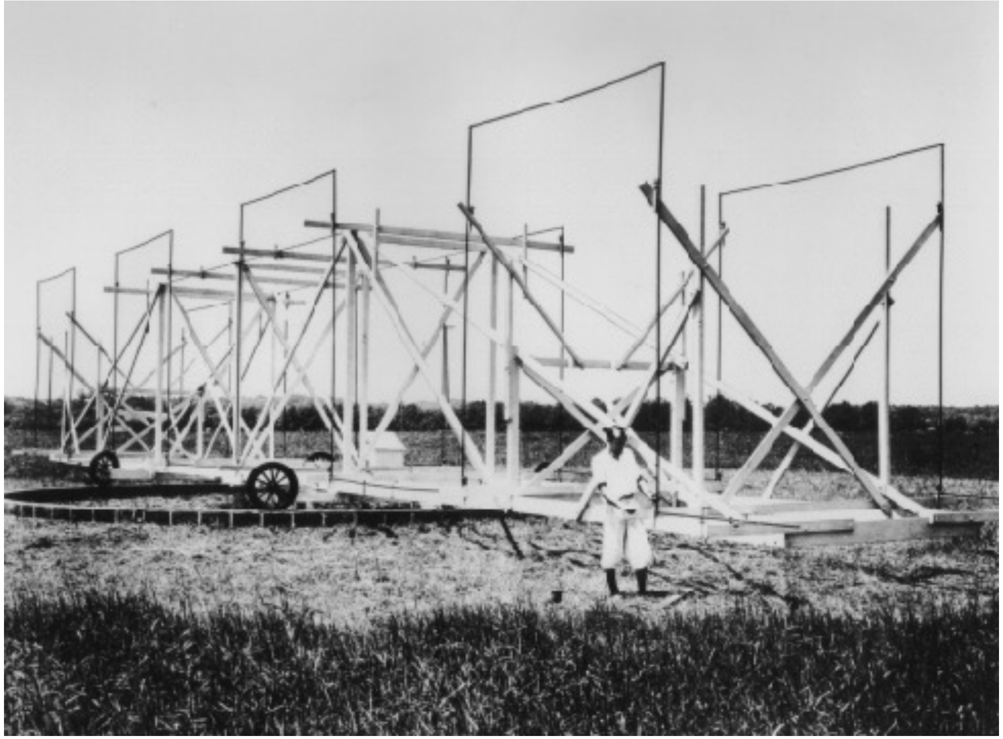
(b) This matrix of 42 CCDs serves the Kepler telescope. (credit a: modification of work by US Department of Energy; credit b: modification of work by NASA and Ball Aerospace)

FIGURE 6.16



Prism Spectrometer. The light from the telescope is focused on a slit. A prism (or grating) disperses the light into a spectrum, which is then photographed or recorded electronically.

FIGURE 6.17

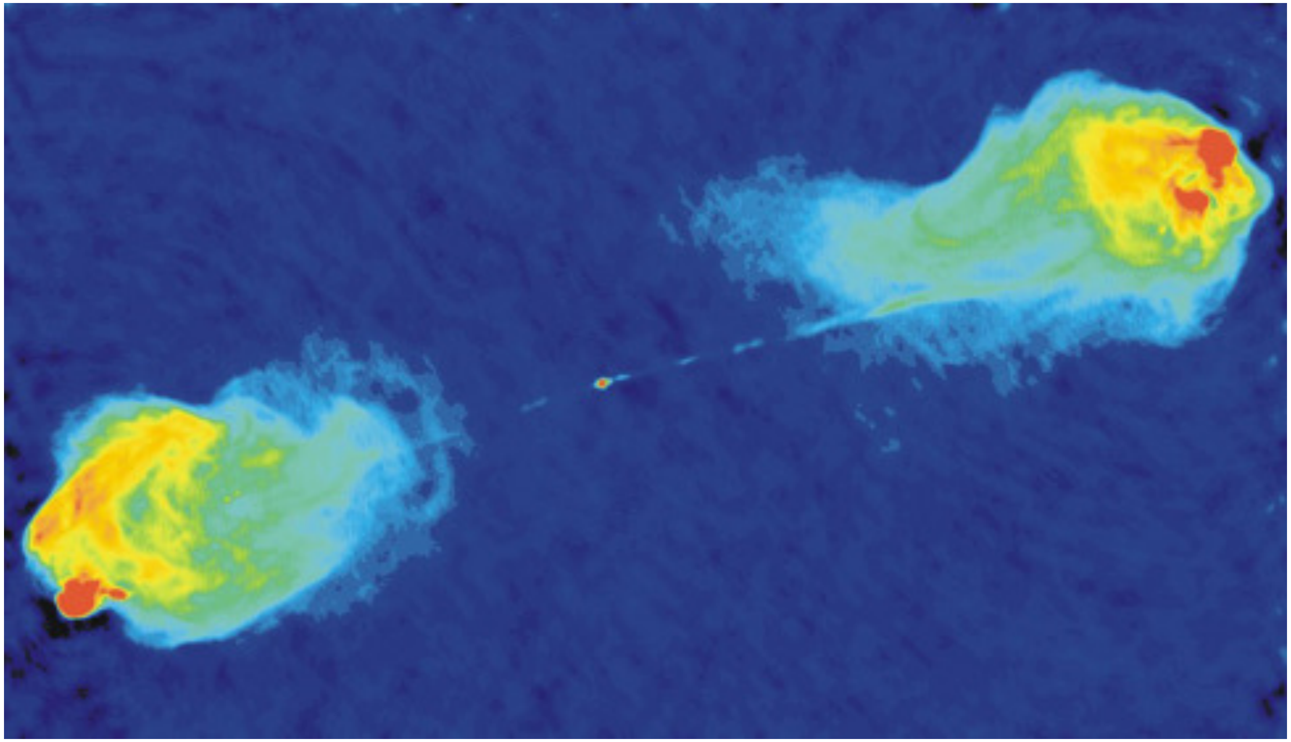


First Radio Telescope. This rotating radio antenna was used by Jansky in his serendipitous discovery of radio radiation from the Milky Way.

FIGURE 6.19

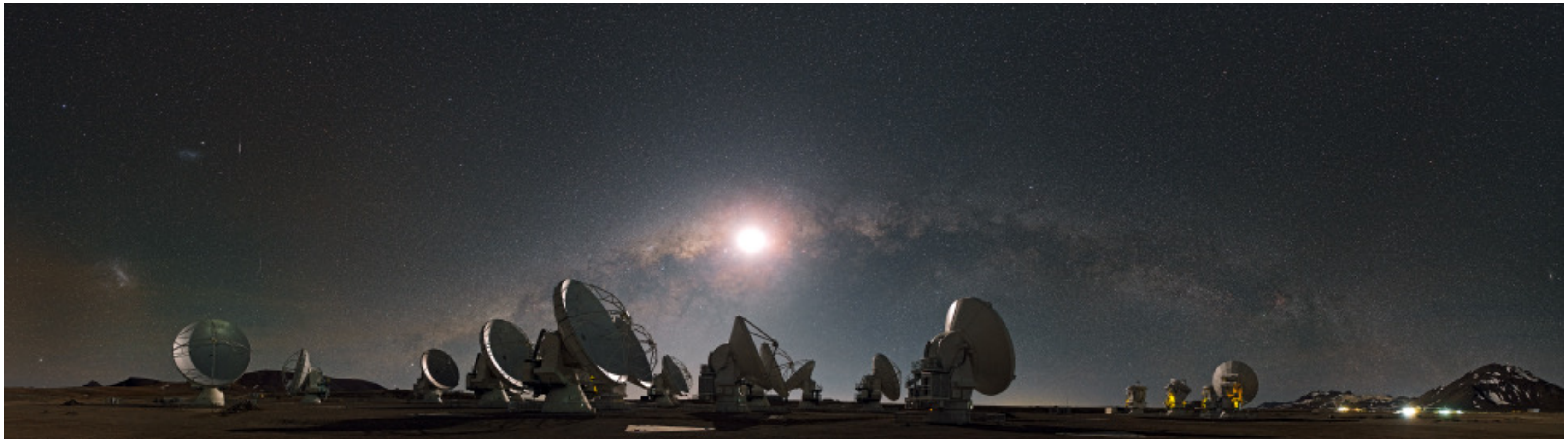
Robert C. Byrd Green Bank Telescope. This fully steerable radio telescope in West Virginia went into operation in August 2000. Its dish is about 100 meters across. (credit: modification of work by “b3nscott”/Flickr)

FIGURE 6.18



Radio Image. This image has been constructed of radio observations at the Very Large Array of a galaxy called Cygnus A. Colors have been added to help the eye sort out regions of different radio intensities. Red regions are the most intense, blue the least. The visible galaxy would be a small dot in the center of the image. The radio image reveals jets of expelled material (more than 160,000 light-years long) on either side of the galaxy. (credit: NRAO/AUI)

FIGURE 6.20



Atacama Large Millimeter/Submillimeter Array (ALMA). Located in the Atacama Desert of Northern Chile, ALMA currently provides the highest resolution for radio observations. (credit: ESO/S. Guisard)

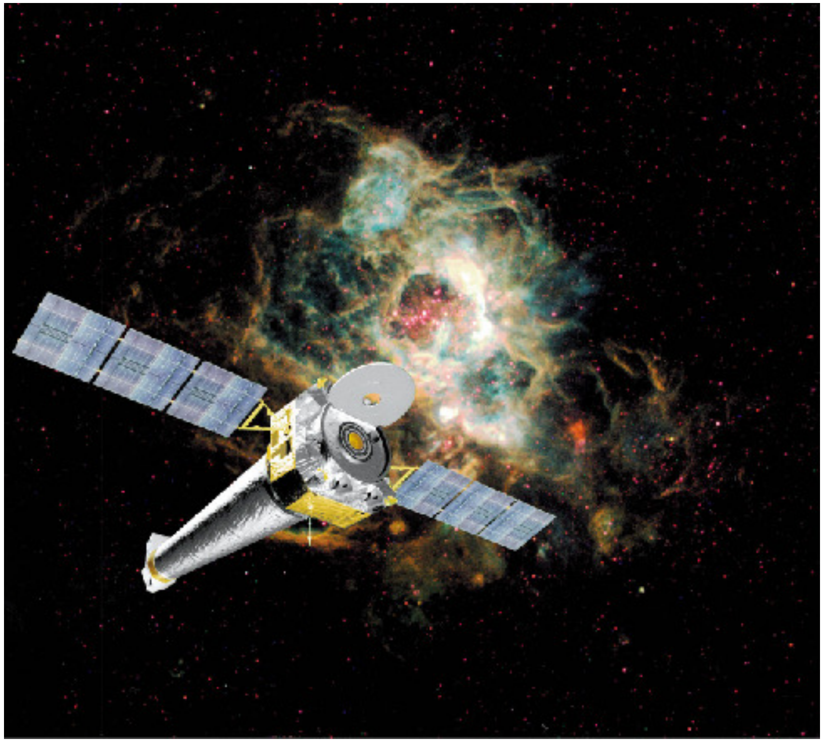
FIGURE 6.21

Very Long Baseline Array. This map shows the distribution of 10 antennas that constitute an array of radio telescopes stretching across the United States and its territories.

FIGURE 6.22

Largest Radio and Radar Dish. The Arecibo Observatory, with its 1000-foot radio dish-filling valley in Puerto Rico, is part of the National Astronomy and Ionosphere Center, operated by SRI International, USRA, and UMET under a cooperative agreement with the National Science Foundation. (credit: National Astronomy and Ionosphere Center, Cornell U., NSF)

FIGURE 6.26



Chandra X-Ray Satellite. Chandra, the world’s most powerful X-ray telescope, was developed by NASA and launched in July 1999. (credit: modification of work by NASA)

FIGURE 6.26

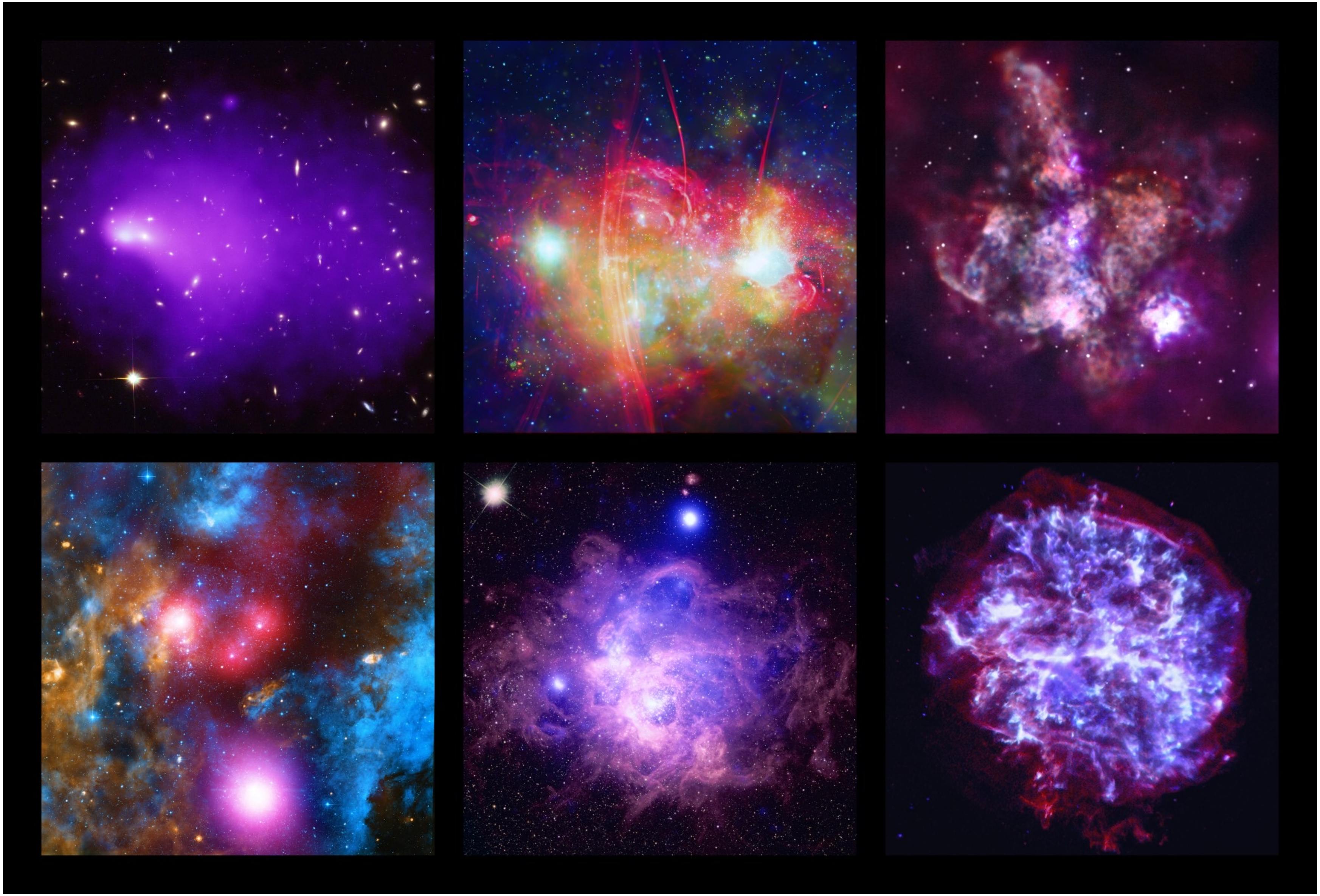
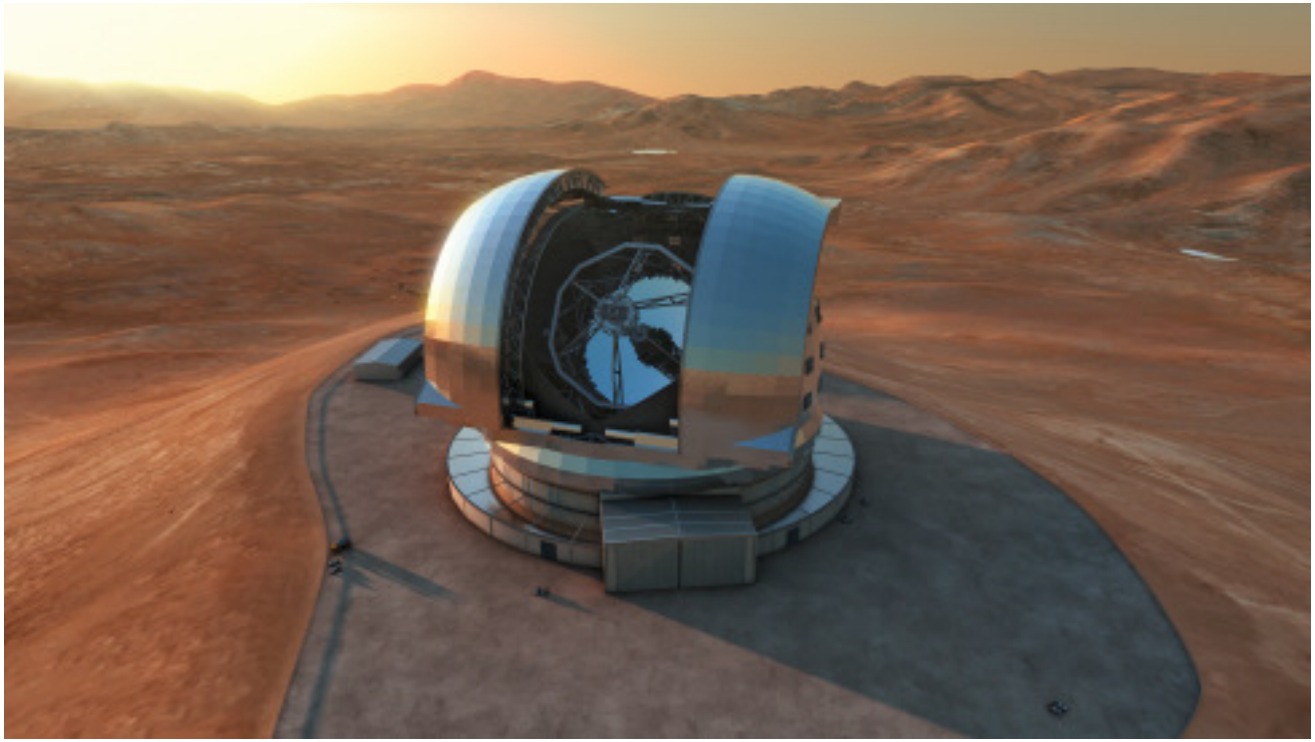


FIGURE 6.27

James Webb Space Telescope (JWST). This image shows some of the mirrors of the JWST as they underwent cryogenic testing. The mirrors were exposed to extreme temperatures in order to gather accurate measurements on changes in their shape as they heated and cooled. (credit: NASA/MSFC/David Higginbotham/Emmett Given)

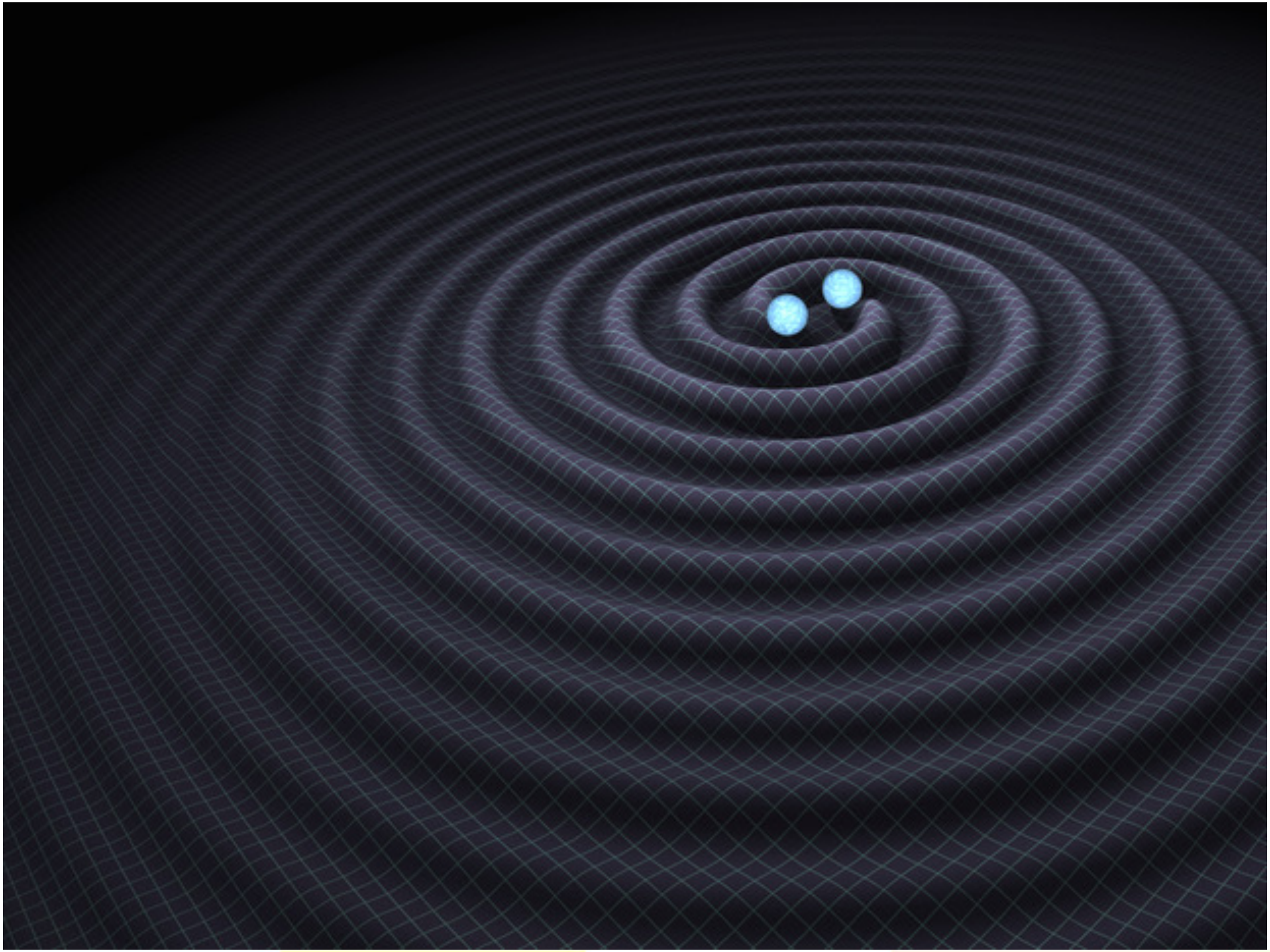
FIGURE 6.28



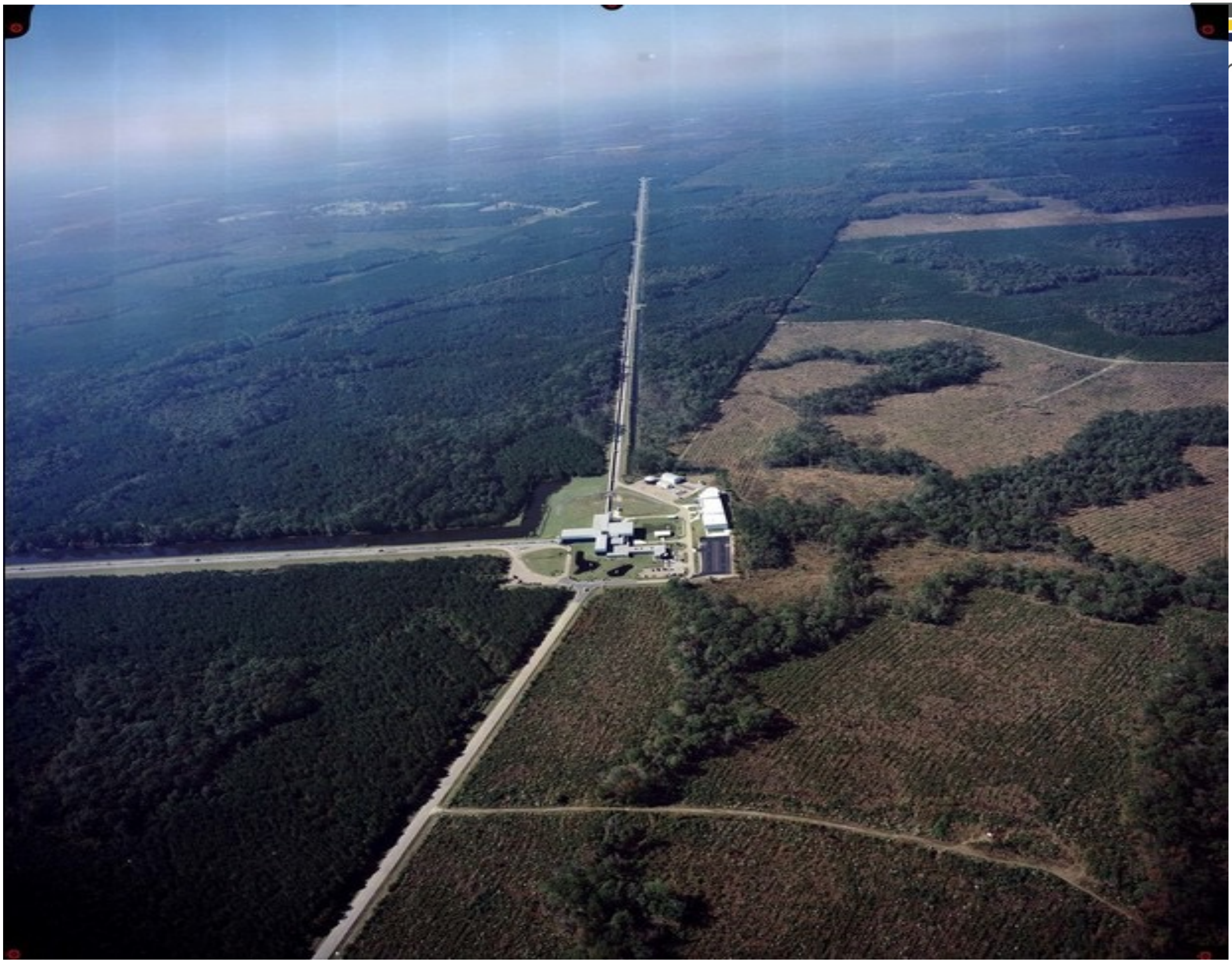
Artist's Conception of the European Extremely Large Telescope. The primary mirror in this telescope is 39.3 meters across. The telescope is under construction in the Atacama Desert in Northern Chile. (credit: ESO/L. Calçada)

(European Extremely Large Telescope Credit: EarthSky)

(LIGO Site, Credit: R. Hurt (Caltech-IPAC))

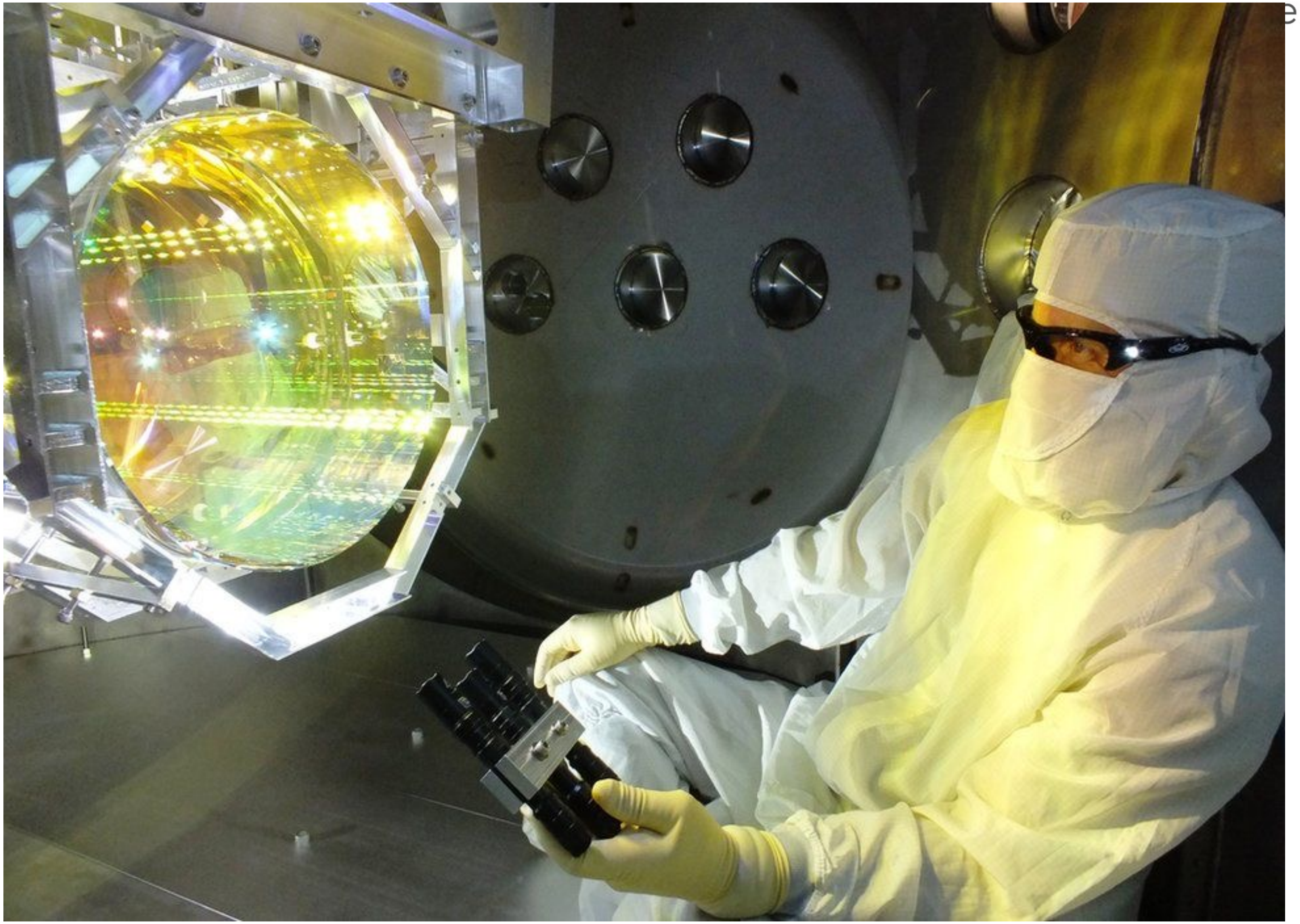


(LIGO Site, Credit: Caltech/MIT/LIGO Lab)



(LIGO Site, Credit: Caltech/MIT/LIGO Lab)

(LIGO Optics, Credit: Caltech/MIT/LIGO Lab)



FROM THE PHYS 202 SYLLABUS: LEARNING OBJECTIVES AND OUTCOMES

Comprehend our place in the universe.

Analyze the changes in the sky from different locations on the Earth.

Describe the changes in perspective that led to the Copernican revolution.

Apply Kepler's laws to explain observations of planetary motion.

Describe Newton's model of the universe, including Newton's laws and Newton's theory of gravitation.

Comprehend atomic theory, including subatomic particles.

Use the Doppler effect to analyze redshifts and blueshifts.

READ CHAPTER 5+6

Homework Problems on Canvas

Due by Tuesday night

No Late Submissions

IN CLASS EXAM

WEDNESDAY, SEPTEMBER 23, 2020

On Canvas

11:00 AM to 12:20 PM

WHEN AN ELECTRON IN AN ATOM JUMPS FROM A HIGHER ENERGY LEVEL TO A LOWER ENERGY LEVEL, IT

(a) emits a photon of a specific frequency.

(b) absorbs a photon of a specific frequency.

(c) absorbs several photons of a specific frequency.

(d) can emit a photon of any frequency.

(e) can absorb a photon of any frequency.

THE FACT THAT THE FREQUENCY OF ANY WAVE SHIFTS WHEN THE SOURCE OF THAT WAVE IS MOVING TOWARD OR AWAY FROM A DETECTOR IS CALLED

(a) the Doppler effect.

(b) the photoelectric effect.

(c) redshift.

(d) Newton’s Second Law.

(e) Kepler’s Second Law.

ACCORDING TO *NEWTON'S THEORY OF GRAVITATION*, IF YOU DOUBLE THE DISTANCE BETWEEN TWO OBJECTS, THEN THE GRAVITATIONAL FORCE BETWEEN THEM WILL

(a) strengthen by a factor of 2.

(b) weaken by a factor of 2.

(c) remain unchanged.

(d) strengthen by a factor of 4.

(e) weaken by a factor of 4.

NEWTON'S SECOND LAW OF MOTION TELLS US THAT THE NET FORCE APPLIED TO AN OBJECT EQUALS ITS

(a) mass times energy.

(b) momentum times velocity.

(c) mass times velocity.

(d) energy times acceleration.

(e) mass times acceleration.

WHICH OF THE FOLLOWING IS NOT TRUE DURING NORTHERN HEMISPHERE SUMMER?

(a) Sunlight strikes the ground at a steeper angle in the Northern Hemisphere than it does in the Southern Hemisphere.

(b) The Sun follows a longer and higher path through the Northern Hemisphere sky than it does through the Southern Hemisphere sky.

(c) Noontime shadows are longer in the Northern Hemisphere than in the Southern Hemisphere.

WHICH OF THE FOLLOWING IS *TRUE*?

(a) Two negative charges will attract each other.

(b) Two positive charges will attract each other.

(c) A positive charge and a negative charge will repel each other.

(d) A positive charge and a negative charge will attract each other.