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ASTRONOMY

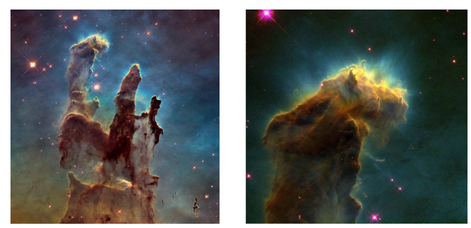
Chapter 21 THE BIRTH OF STARS

openstax

21.1 STAR FORMATION

- **Where Stars Are Born.** We see a close-up of part of the Carina Nebula taken with the Hubble Space Telescope. This image reveals jets powered by newly forming stars embedded in a great cloud of gas and dust. Parts of the clouds are glowing from the energy of very young stars recently formed within them. (credit: modification of work by NASA, ESA, and M. Livio and the Hubble 20th Anniversary Team (STScI))

Figure 21.2



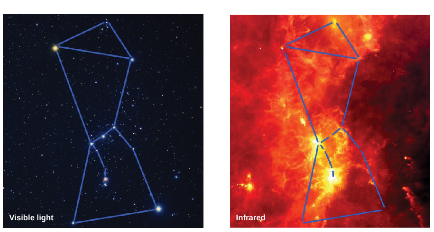
(a) (b)

- **Pillars of Dust and Dense Globules in M16.**

(a) This Hubble Space Telescope image of the central regions of M16 (also known as the Eagle Nebula) shows huge columns of cool gas and dust. The tallest pillar is about 1 light-year long, and the M16 region is about 7000 light-years away from us.

(b) This close-up view of one of the pillars shows some very dense globules, many of which harbor embryonic stars. Astronomers coined the term *evaporating gas globules* (EGGs) for these structures, in part so that they could say we found EGGs inside the Eagle Nebula

Figure 21.3



(a) (b)

- **Orion in Visible and Infrared.**

(a) The Orion star group was named after the legendary hunter in Greek mythology. Three stars close together in a link mark Orion's belt. The ancients imagined a sword hanging from the belt; the object at the end of the blue line in this sword is the Orion Nebula.

(b) This wide-angle, infrared view of the same area was taken with the Infrared Astronomical Satellite. Heated dust clouds dominate in this false-color image, and many of the stars that stood out on part (a) are now invisible

Figure 21.4

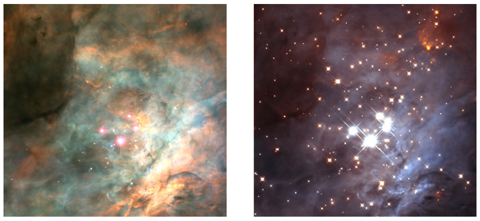
(a) (b)

- **Orion Nebula.**

(a) The Orion Nebula is shown in visible light.

(b) With near-infrared radiation, we can see more detail within the dusty nebula since infrared can penetrate dust more easily than can visible light. (credit a: modification of work by Filip Lolić; credit b: modification of work by NASA/JPL-Caltech/T. Megeath (University of Toledo, Ohio))

Figure 21.5



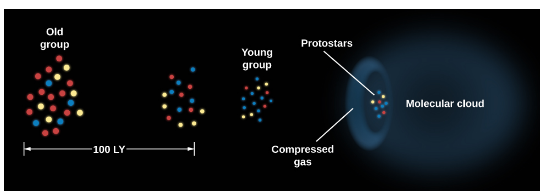
(a) (b)

- **Central Region of the Orion Nebula.** The Orion Nebula harbors some of the youngest stars in the solar neighborhood. At the heart of the nebula is the Trapezium cluster, which includes four very bright stars that provide much of the energy that causes the nebula to glow so brightly. In these images, we see a section of the nebula in (a) visible light and (b) infrared. The four bright stars in the center of the visible-light image are the Trapezium stars. Notice that most of the stars seen in the infrared are completely hidden by dust in the visible-light image.

Figure 21.6

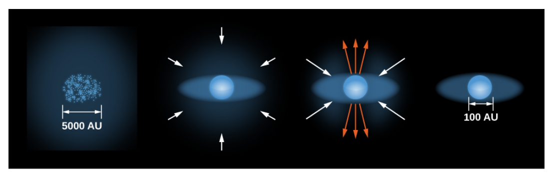
- **Westerlund 2.** This young cluster of stars known as Westerlund 2 formed within the Carina star-forming region about 2 million years ago. Stellar winds and pressure produced by the radiation from the hot stars within the cluster are blowing and sculpting the surrounding gas and dust. The nebula still contains many globules of dust. Stars are continuing to form within the denser globules and pillars of the nebula. This Hubble Space Telescope image includes near-infrared exposures of the star cluster and visible-light observations of the surrounding nebula. Colors in the nebula are dominated by the red glow of hydrogen gas, and blue-green emissions from glowing oxygen.

Figure 21.7



- **Propagating Star Formation.** Star formation can move progressively through a molecular cloud. The oldest group of stars lies to the left of the diagram and has expanded because of the motions of individual stars. Eventually, the stars in the group will disperse and no longer be recognizable as a cluster. The youngest group of stars lies to the right, next to the molecular cloud. This group of stars is only 1 to 2 million years old. The pressure of the hot, ionized gas surrounding these stars compresses the material in the nearby edge of the molecular cloud and initiates the gravitational collapse that will lead to the formation of more stars.

Birth of a Star



(a) (b) (c) (d)

- **Formation of a Star.**

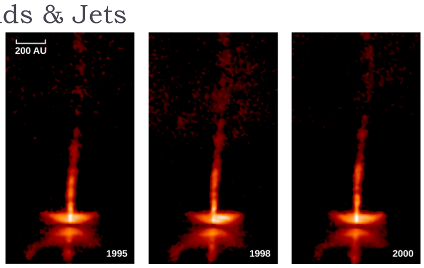
(a) Dense cores form within a molecular cloud.

(b) A protostar with a surrounding disk of material forms at the center of a dense core, accumulating additional material from the molecular cloud through gravitational attraction.

(c) A stellar wind breaks out but is confined by the disk to flow out along the two poles of the star.

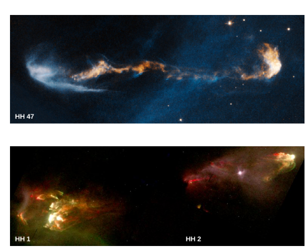
(d) Eventually, this wind sweeps away the cloud material and halts the accumulation of additional material, and a newly formed star, surrounded by a disk, becomes observable. These sketches are not drawn to the same scale. The diameter of a typical envelope that is supplying gas to the newly forming star is about 5000 AU. The typical diameter of the disk is about 100 AU or slightly larger than the diameter of the orbit of Pluto.

Winds & Jets



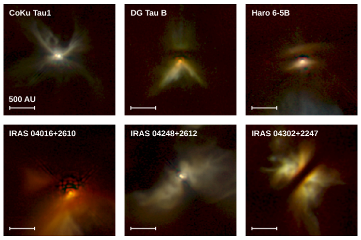
- **Gas Jets Flowing away from a Protostar.** Here we see the neighborhood of a protostar, known to us as HH 34 because it is a Herbig-Haro object. The star is about 450 light-years away and only about 1 million years old. Light from the star itself is blocked by a disk, which is larger than 60 billion kilometers in diameter and is seen almost edge-on. Jets are seen emerging perpendicular to the disk. The material in these jets is flowing outward at speeds up to 580,000 kilometers per hour. The series of three images shows changes during a period of 5 years.. The changes in the brightness of the disk may be due to motions of clouds within the disk that alternately block some of the light and then let it through. This image corresponds to the stage in the life of a

Figure 21.10



- **Outflows from Protostars.** These images were taken with the Hubble Space Telescope and show jets flowing outward from newly formed stars. In the HH47 image, a protostar 1500 light-years away (invisible inside a dust disk at the left edge of the image) produces a very complicated jet. The star may actually be wobbling, perhaps because it has a companion.

Figure 21.11



- **Disks around Protostars.** These Hubble Space Telescope infrared images show disks around young stars in the constellation of Taurus, in a region about 450 light-years away. In some cases, we can see the central star (or stars—some are binaries). In other cases, the dark, horizontal bands indicate regions where the dust disk is so thick that even infrared radiation from the star embedded within it cannot make its way through. The brightly glowing regions are starlight reflected from the upper and lower surfaces of the disk, which are less dense than the central, dark regions.

Links

Reading

- 21.1