Physics." When energy is added to an atom that is at a lower energy state, the atom can be excited to a higher energy state. These *excited* atoms then release their excess energy in the form of electromagnetic radiation when they return to their original, lower energy states.

When light of a certain wavelength is applied to excited atoms, the atoms can be induced to release light waves that have the same properties. After one atom spontaneously releases its energy in the form of a light wave, this initial wave can cause other energized atoms to release their excess energy as light waves with the same wavelength, phase, and direction as the initial wave, as shown in **Figure 24(b).** This process is called *stimulated emission.*

Most of the light produced by stimulated emission escapes out the sides of the glass tube. However, some of the light moves along the length of the tube, producing more stimulated emission as it goes. Mirrors on the ends of the material return these coherent light waves into the active medium, where they stimulate the emission of more coherent light waves, as shown in **Figure 24(c).** As the light passes back and forth through the active medium, it becomes more and more intense. One of the mirrors is slightly transparent, which allows the intense coherent light to be emitted by the laser.

APPLICATIONS OF LASERS

There are a wide variety of laser types, with wavelengths ranging from the far infrared to the X-ray region of the spectrum. Scientists have also created *masers,* devices similar to lasers but operate in the microwave region of the spectrum. Lasers are used in many ways, from common household uses to a wide variety of industrial uses and very specialized medical applications.

Lasers are used to measure distances with great precision

Of the properties of laser light, the one that is most evident is that it emerges from the laser as a narrow beam. Unlike the light from a light bulb or even the light that is focused by a parabolic reflector, the light from a laser undergoes very little spreading with distance. One reason is that all the light waves emitted by the laser have the same direction. As a result, a laser can be used to measure large distances, because it can be pointed at distant reflectors and the reflected light can be detected.

As shown in **Figure 25,** astronomers direct laser light at particular points on the moon's surface to determine the Earth-to-moon distance. A pulse of light is directed toward one of several 0.25 m^2 reflectors that were placed on the moon's surface by astronauts during the *Apollo* missions. By knowing the speed of light and measuring the time the light takes to travel to the moon and back, scientists have measured the Earth-to-moon distance to be about 3.84×10^5 km. Geologists use repeated measurements to record changes in the height of Earth's crust from geological processes. Lasers can be used for these measurements even when the height changes by only a few centimeters.

Figure 25
A laser beam is fired at reflectors on the moon, which is more than 380 000 km away.