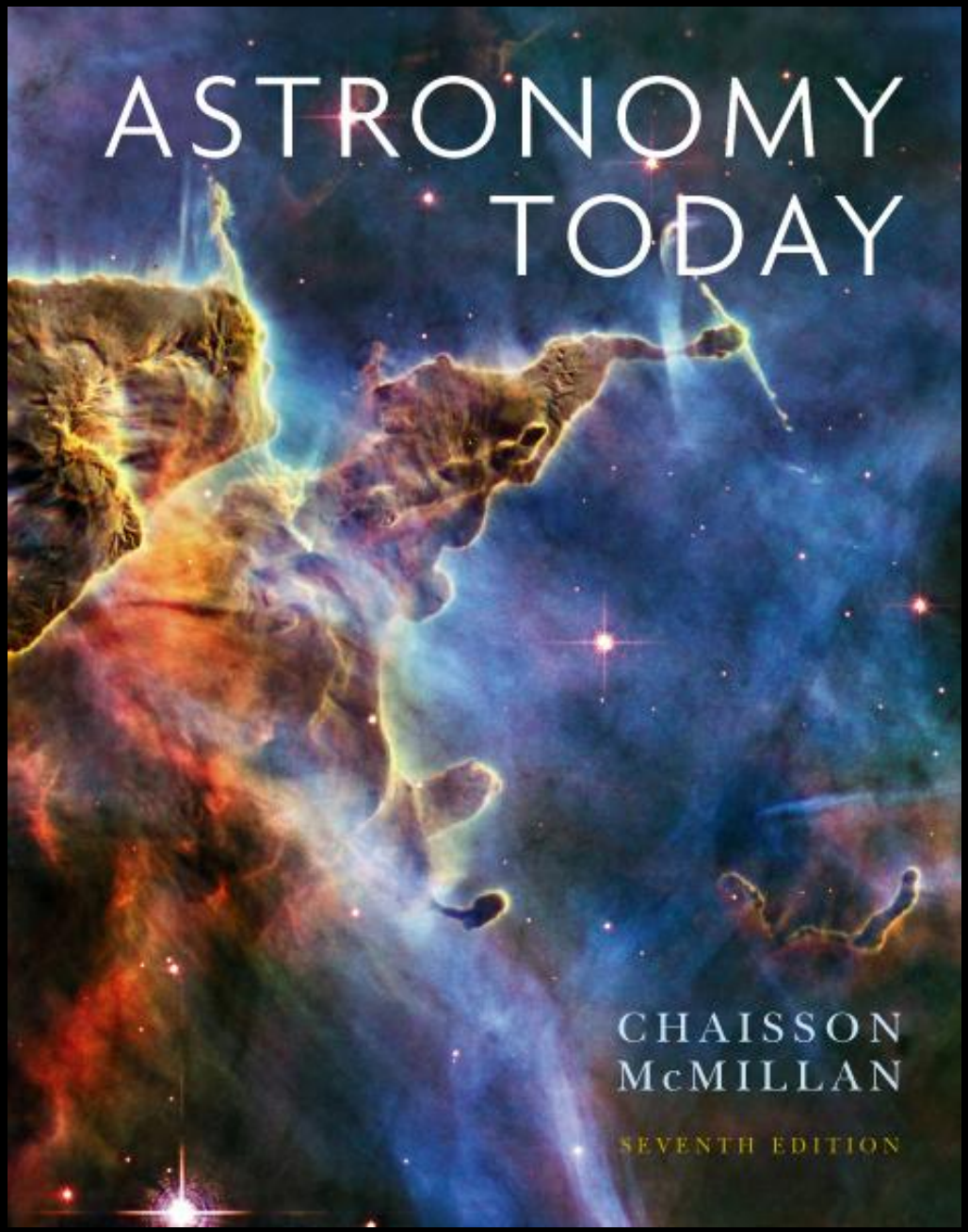


Lecture Outlines

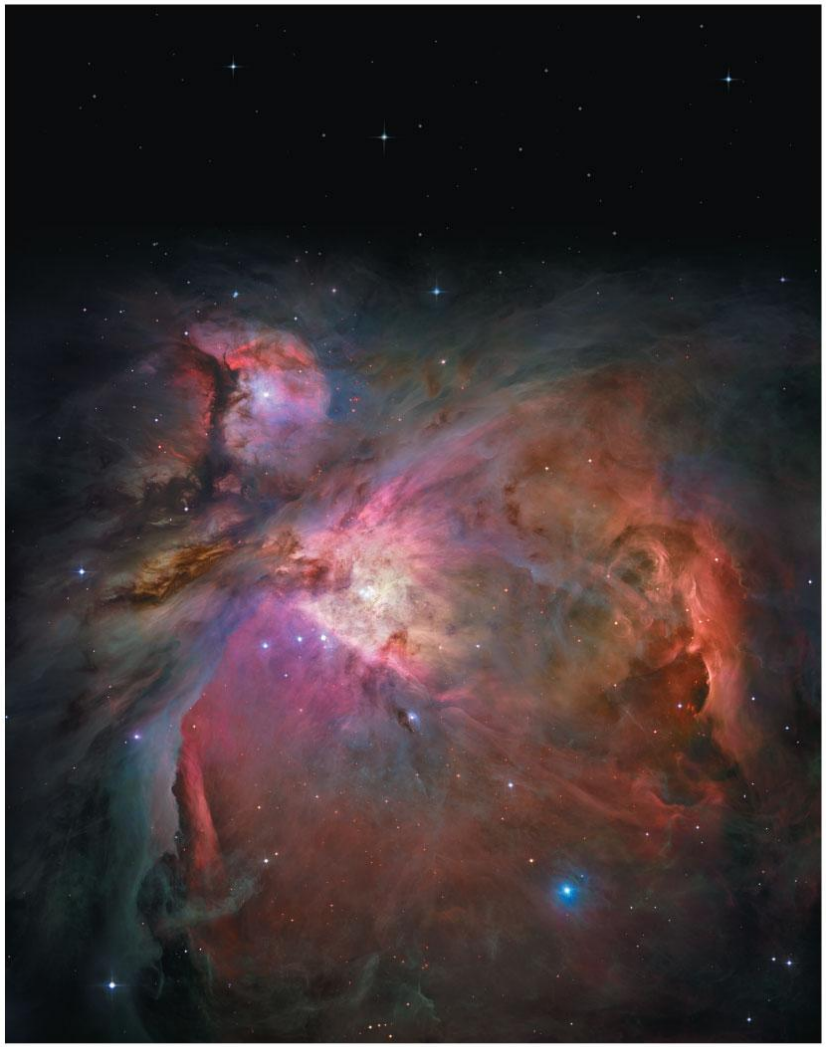
Chapter 18

Astronomy Today

7th Edition

Chaisson/McMillan

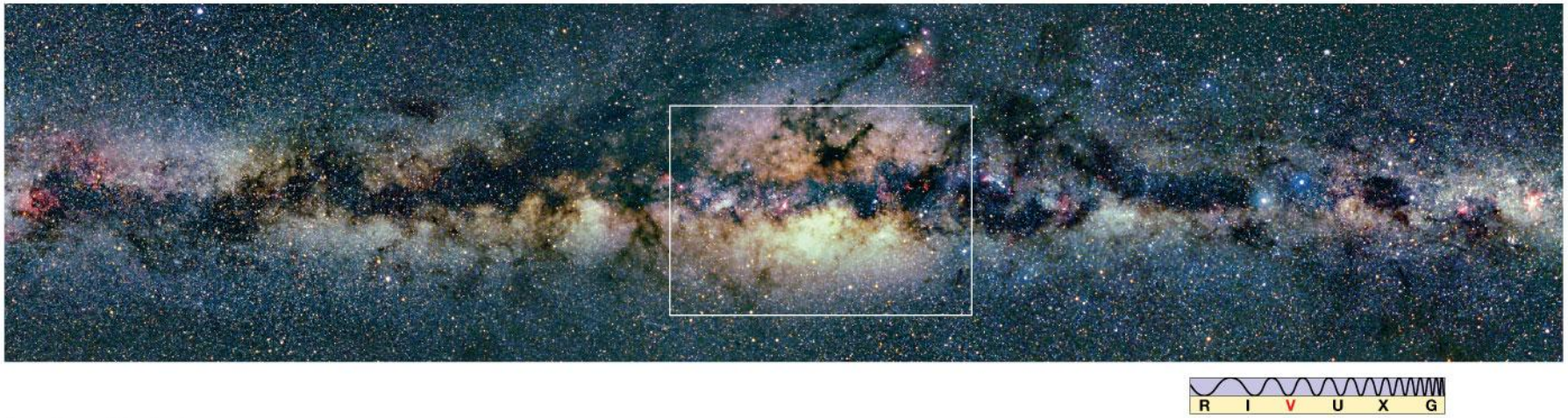
Chapter 18
The Interstellar Medium



Units of Chapter 18

18.1 Interstellar Matter

A wide-angle view of the Milky Way—the dark regions are dust clouds, blocking light from the stars beyond



18.1 Interstellar Matter

The interstellar medium consists of gas and dust.

Gas is atoms and small molecules, mostly hydrogen and helium.

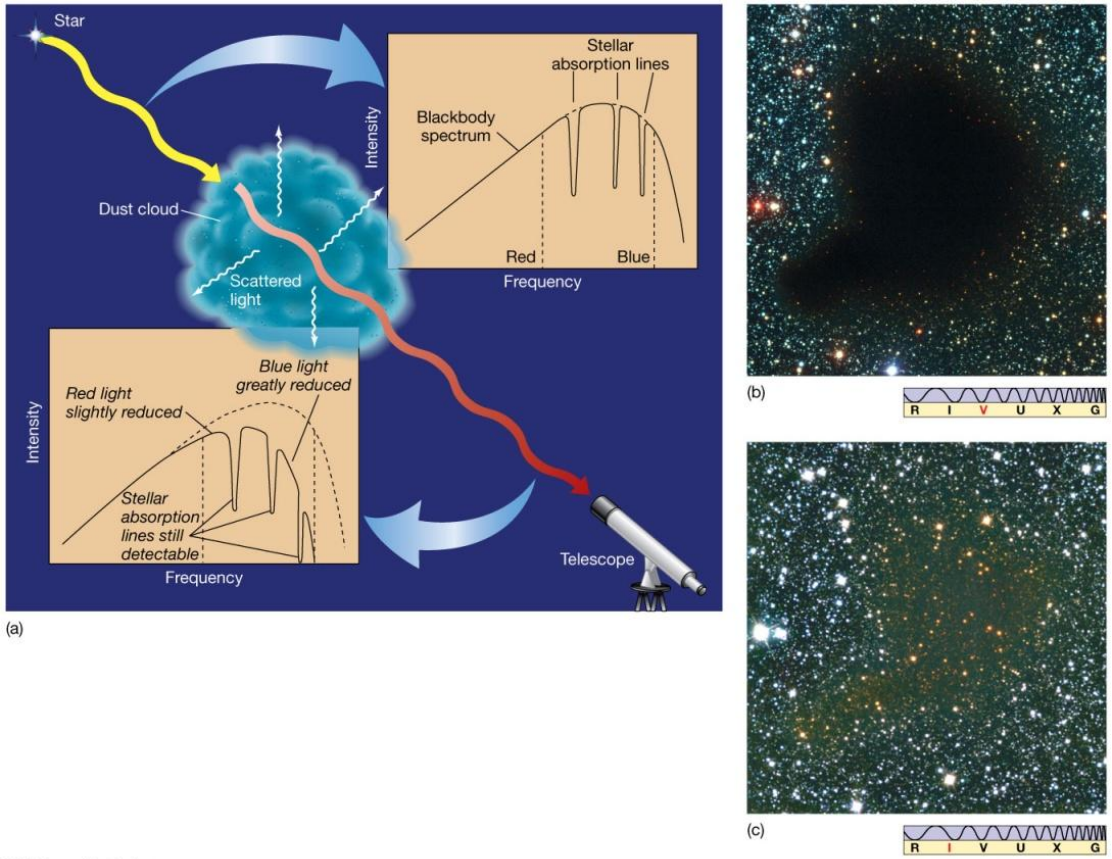
Dust is more like soot or smoke; larger clumps of particles.

Dust absorbs light, and reddens light that gets through.

Reddening can interfere with blackbody temperature measurement, but spectral lines do not shift.

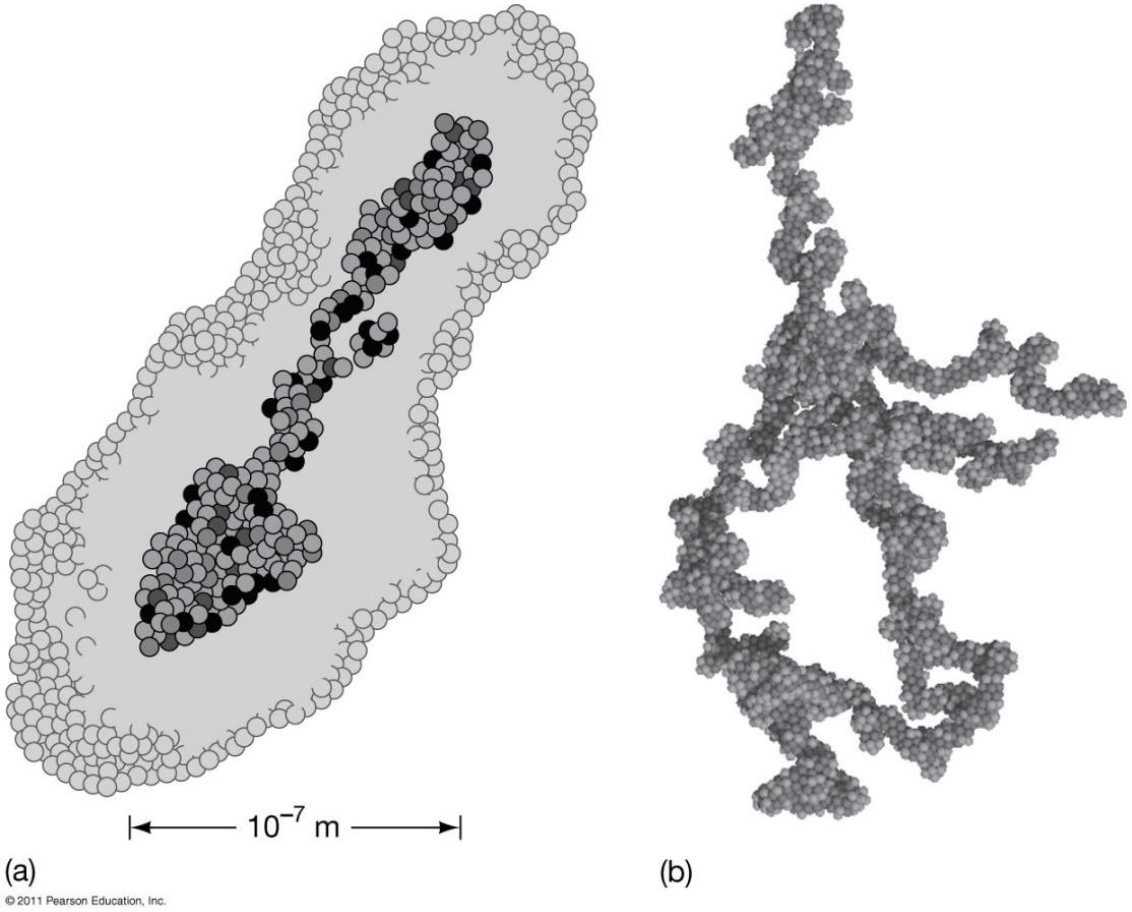
18.1 Interstellar Matter

This image illustrates how reddening works. On the right, the upper image was made using visible light; the lower was made using infrared.



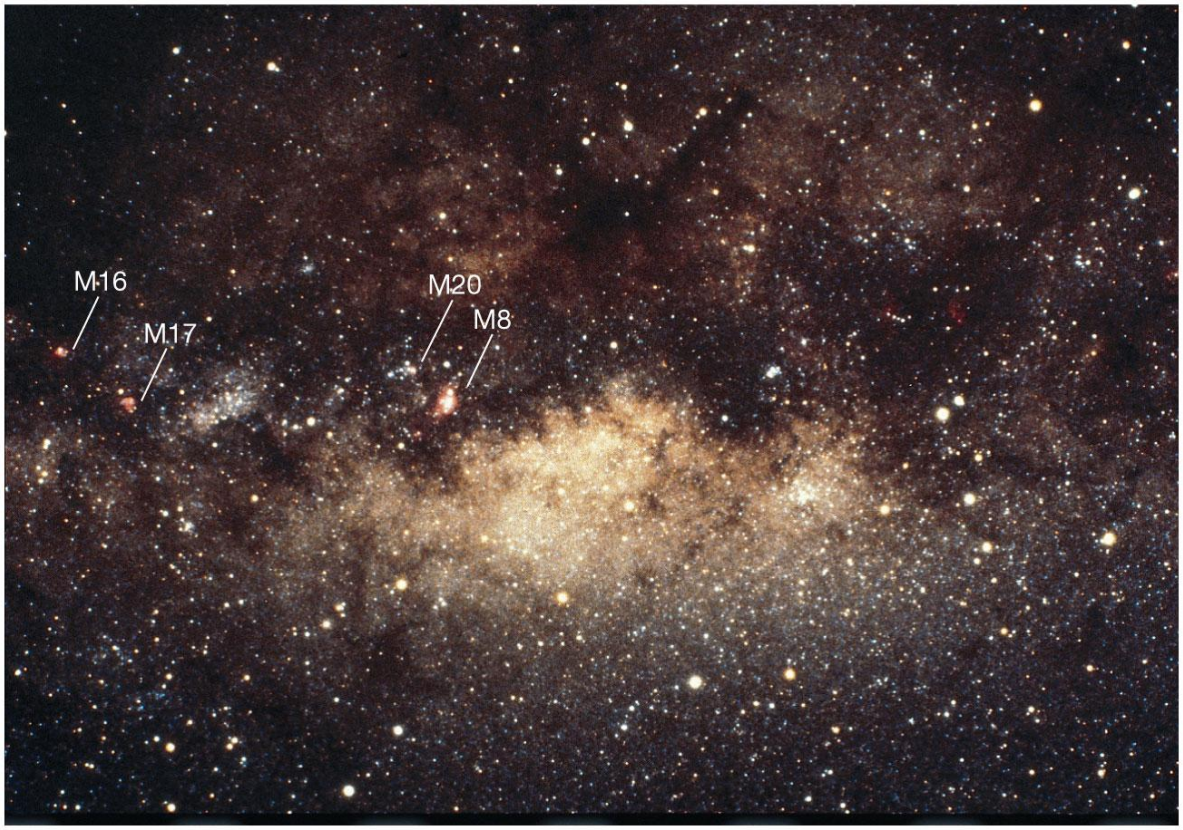
18.1 Interstellar Matter

Interstellar dust grains are complex in shape (left); on the right is the result of computer modeling of how a dust grain might grow.



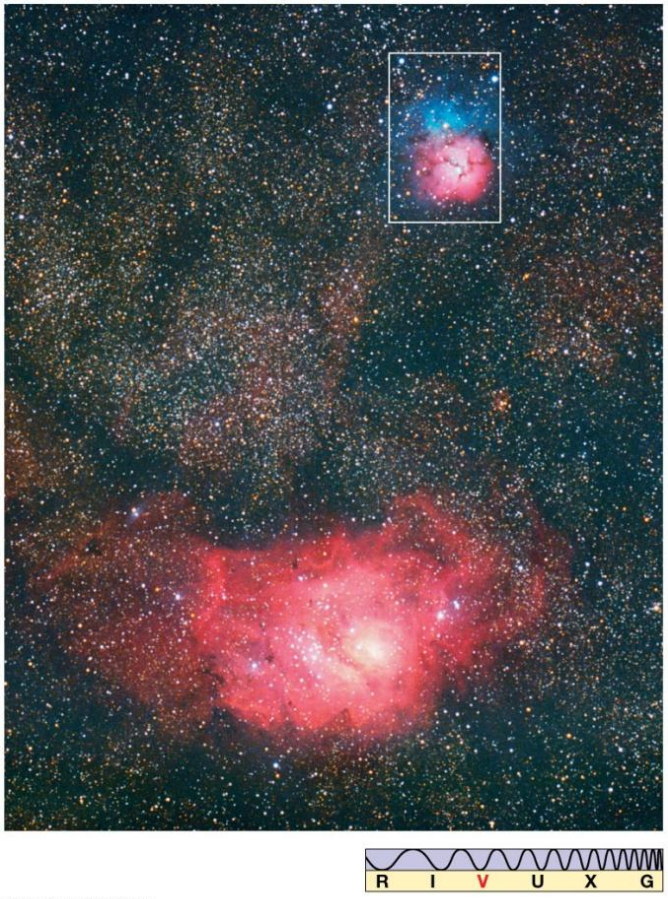
18.2 Emission Nebulae

Here is a view of the central portion of the picture on the first slide, with several nebulae indicated

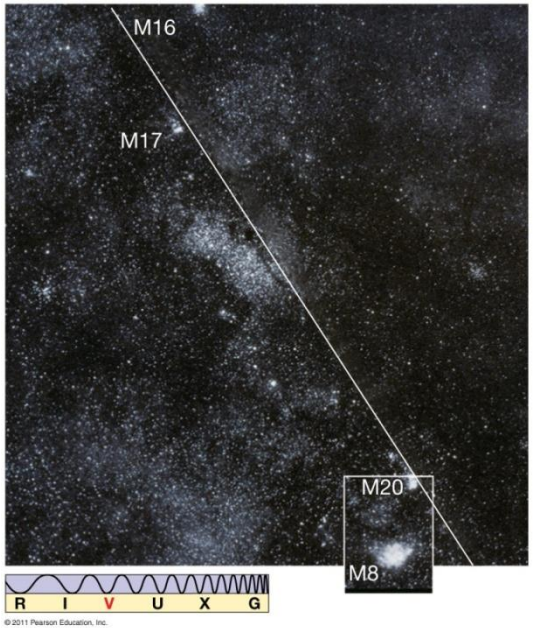


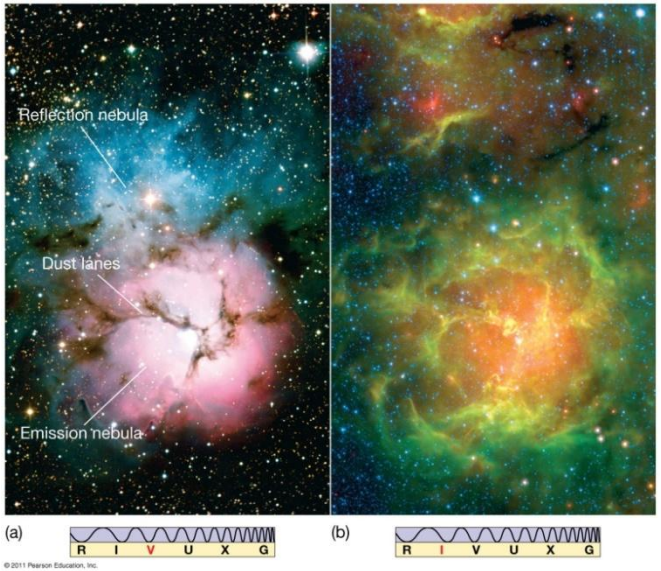
18.2 Emission Nebulae

"Nebula" is a general term used for fuzzy objects in the sky:



Dark nebula: dust cloud
Emission nebula: glows, due to hot stars





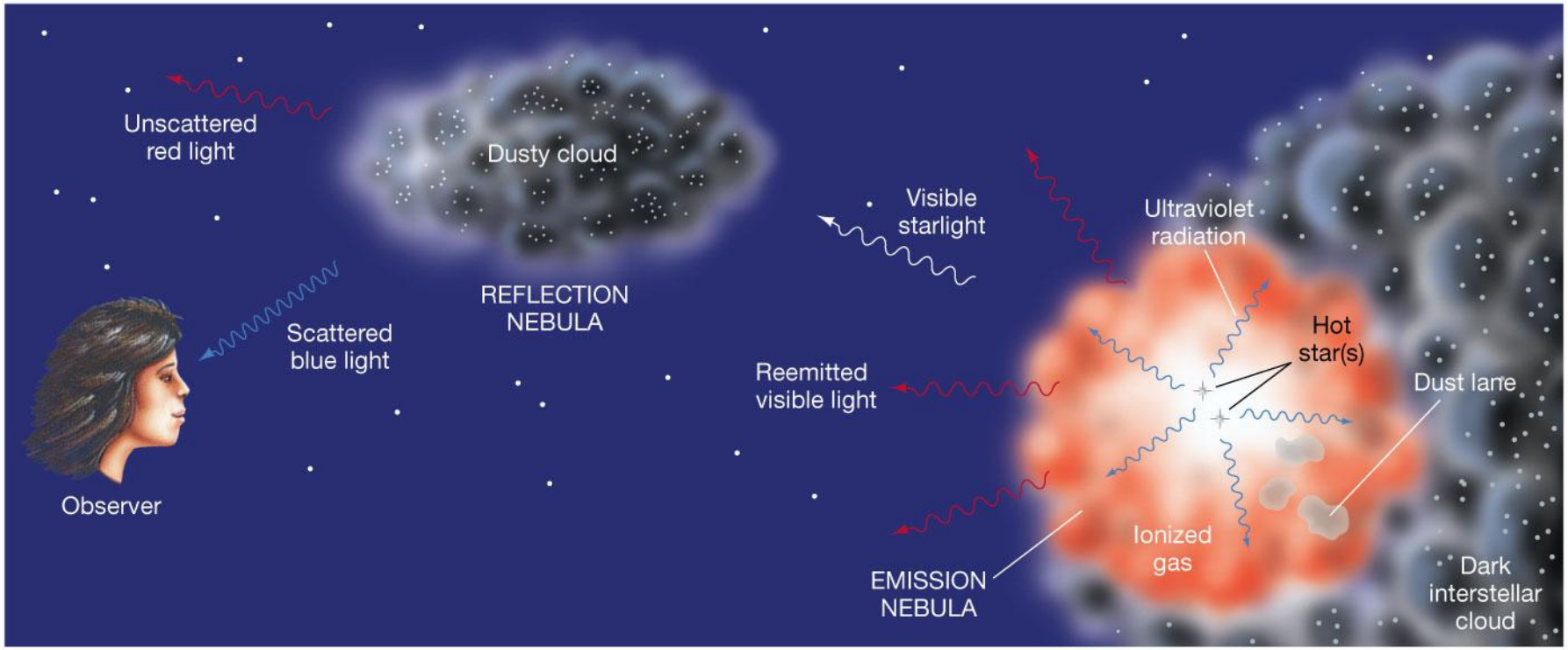
18.2 Emission Nebulae

Emission nebulae generally glow red—this is the H_α line of hydrogen.

The dust lanes visible in the previous image are part of the nebula and are not due to intervening clouds.

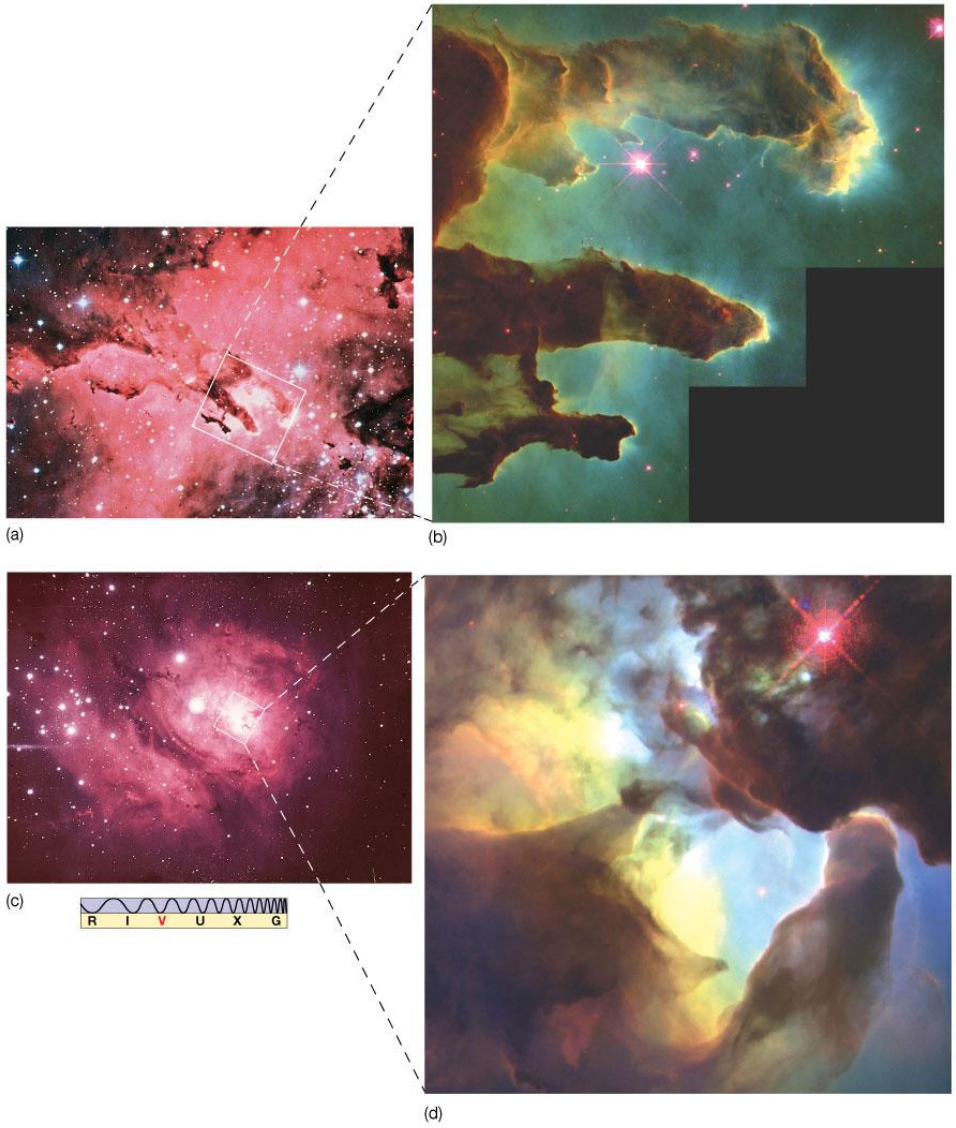
18.2 Emission Nebulae

How nebulae work



18.2 Emission Nebulae

There is a strong interaction between the nebula and the stars within it; the fuzzy areas near the pillars are due to photoevaporation.



18.2 Emission Nebulae

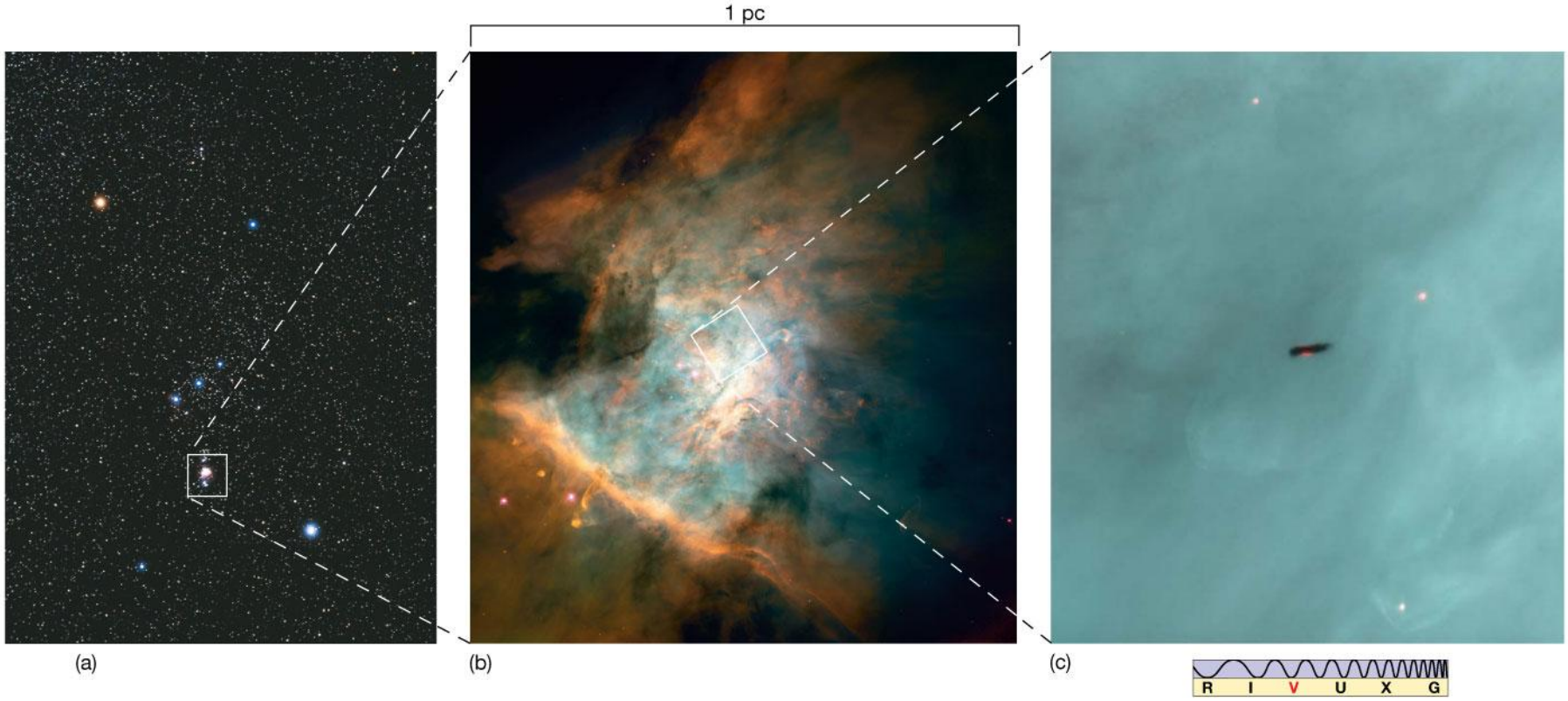
Emission nebulae consist of hydrogen, helium, and trace components.

Some emission lines come from so-called "forbidden" transitions; they are not actually forbidden but are so rare that under standard laboratory conditions they are never seen.

In a nebula, however, the gas is so thin that an atom, once excited, has only a small probability of interacting before it decays spontaneously.

18.2 Emission Nebulae

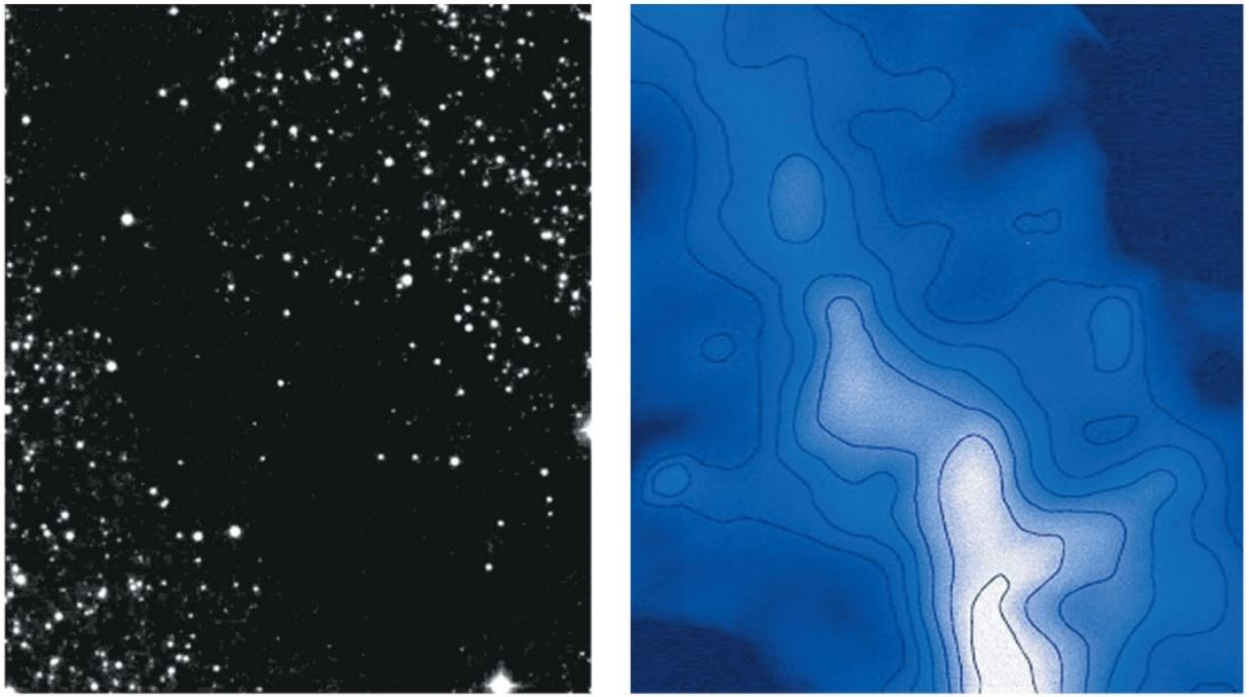
A forbidden transition in oxygen is responsible for the greenish color in the Orion nebula



18.3 Dark Dust Clouds

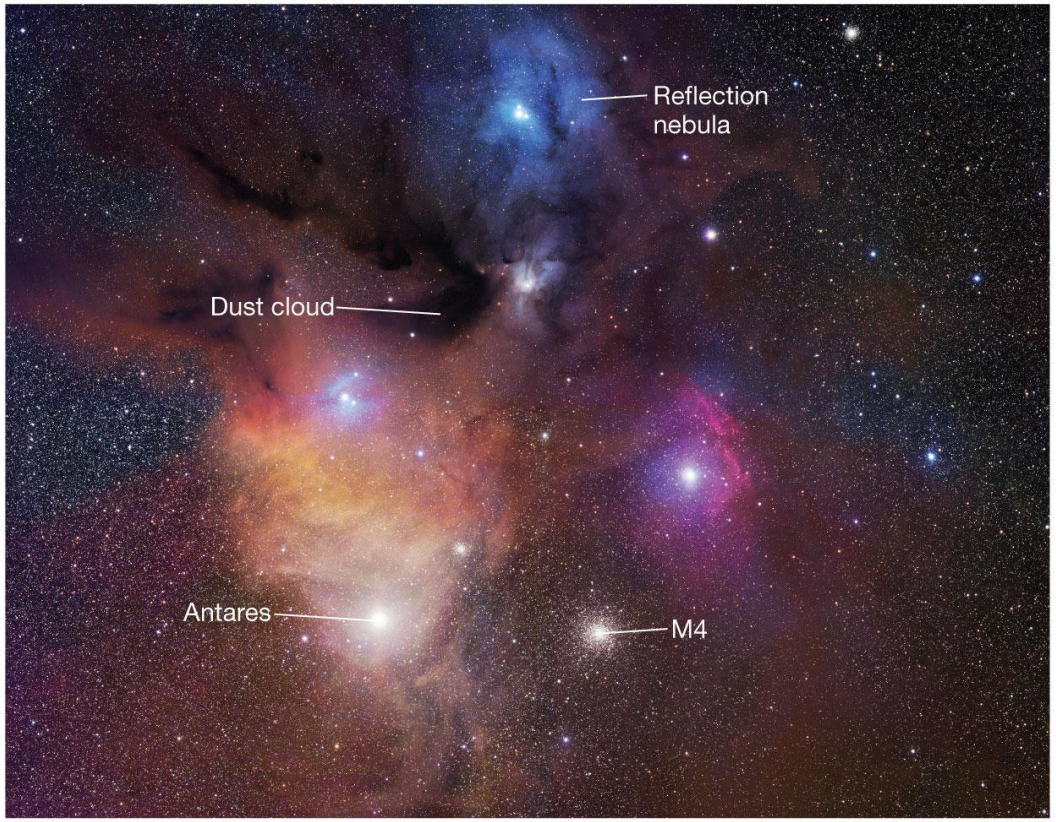
Average temperature of dark dust clouds is a few tens of kelvins

These clouds absorb visible light (top) and emit radio wavelengths (bottom)



18.3 Dark Dust Clouds

The Ophiuchus dust cloud can be seen in this image. Its shape is irregular, with streamers to the upper left.

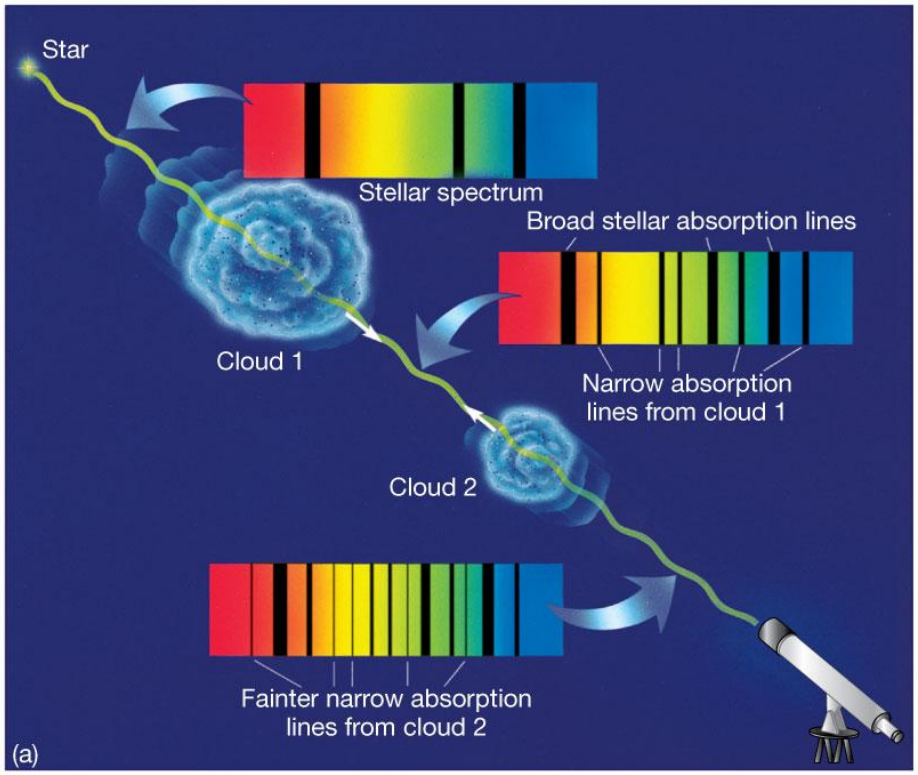


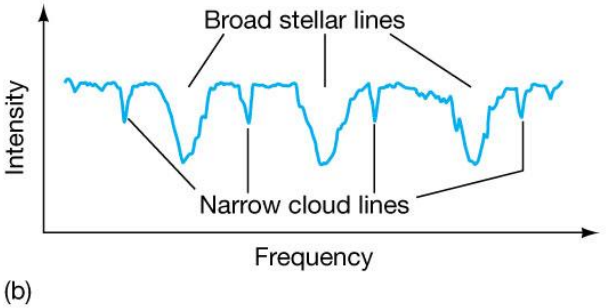
18.3 Dark Dust Clouds

This is the Horsehead Nebula, one of the most famous of dark dust clouds

18.3 Dark Dust Clouds

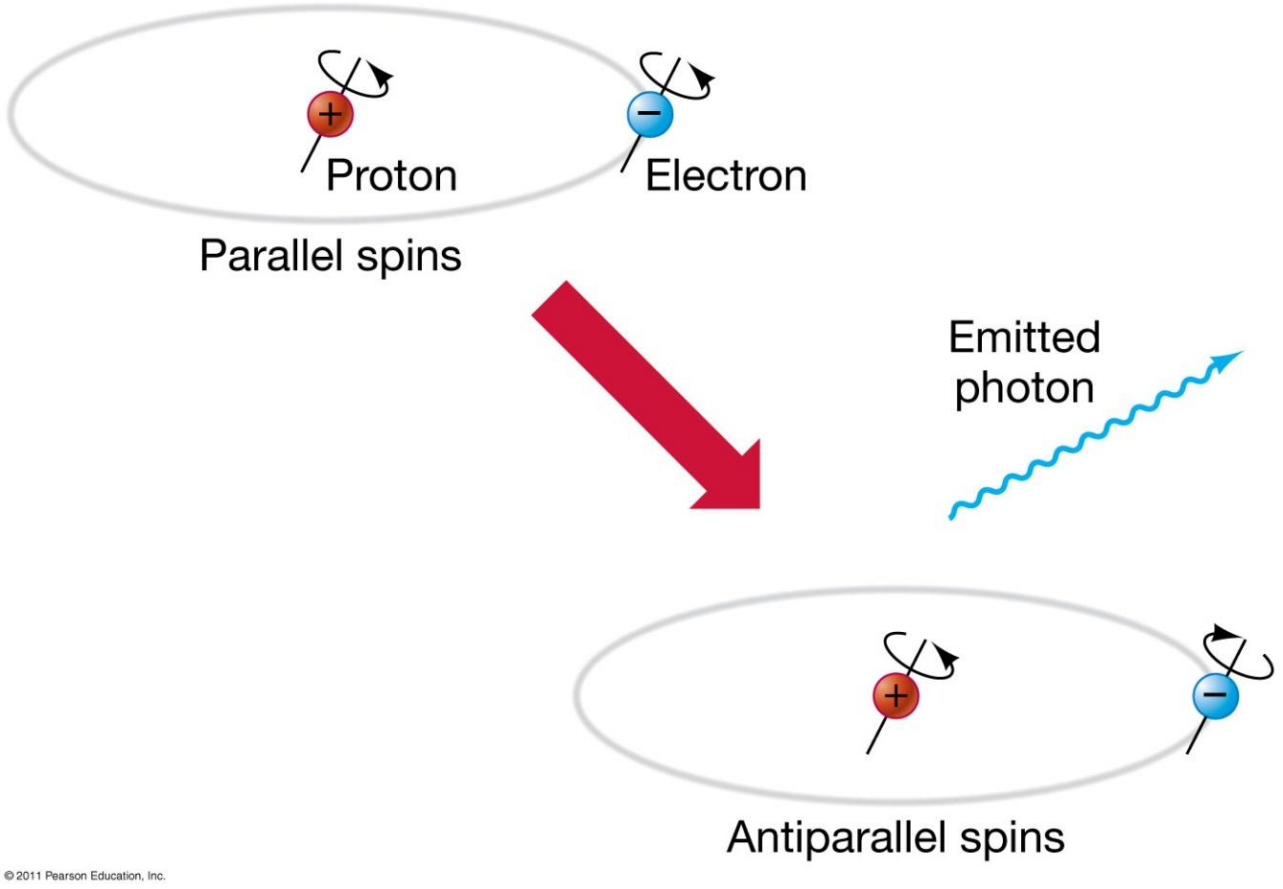
Light from distant stars may pass through more than one nebula; it is often possible to sort out the spectra of the star and the nebulae.





18.4 21-Centimeter Radiation

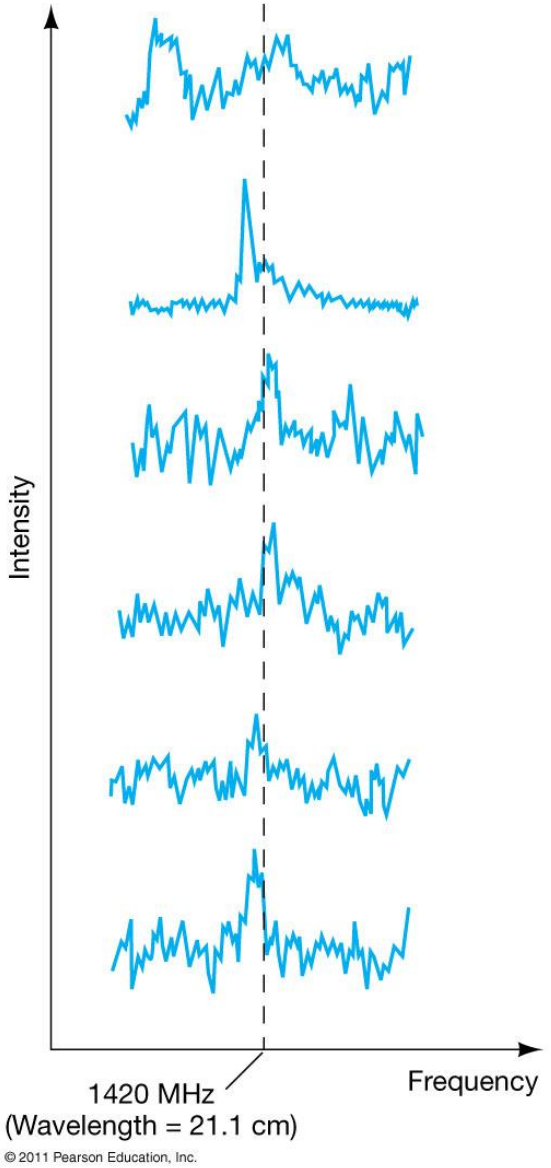
Interstellar gas emits low-energy radiation, due to a transition in the hydrogen atom



18.4 21-Centimeter Radiation

The emitted photon has a wavelength of 21 centimeters, which is in the radio portion of the electromagnetic spectrum.

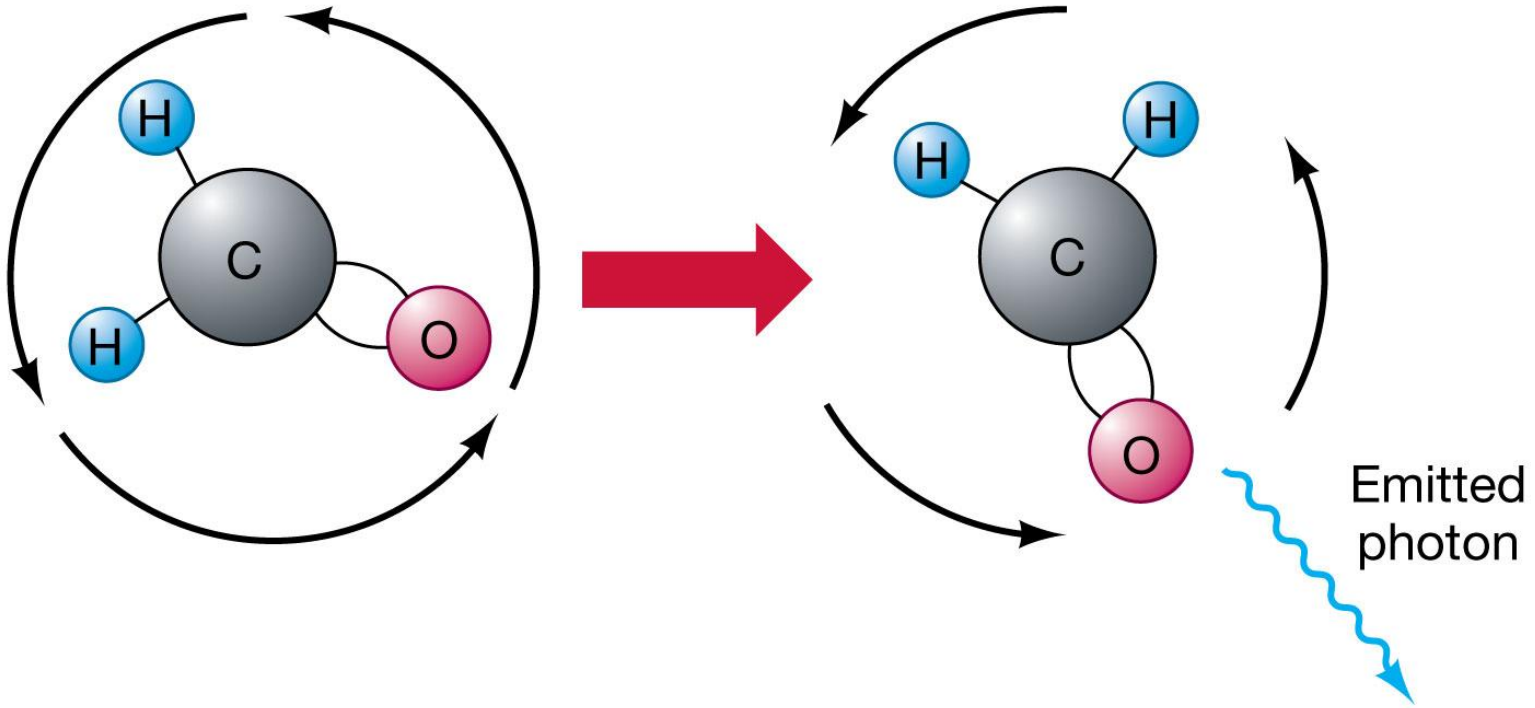
Actual 21-cm spectra are complex, as the lines are Doppler shifted and broadened:



18.5 Interstellar Molecules

The densest gas clouds are also very cold, around 20 K. These clouds tend to contain molecules, rather than atoms.

Transitions between rotation states of a molecule emit radio-frequency photons.



18.5 Interstellar Molecules

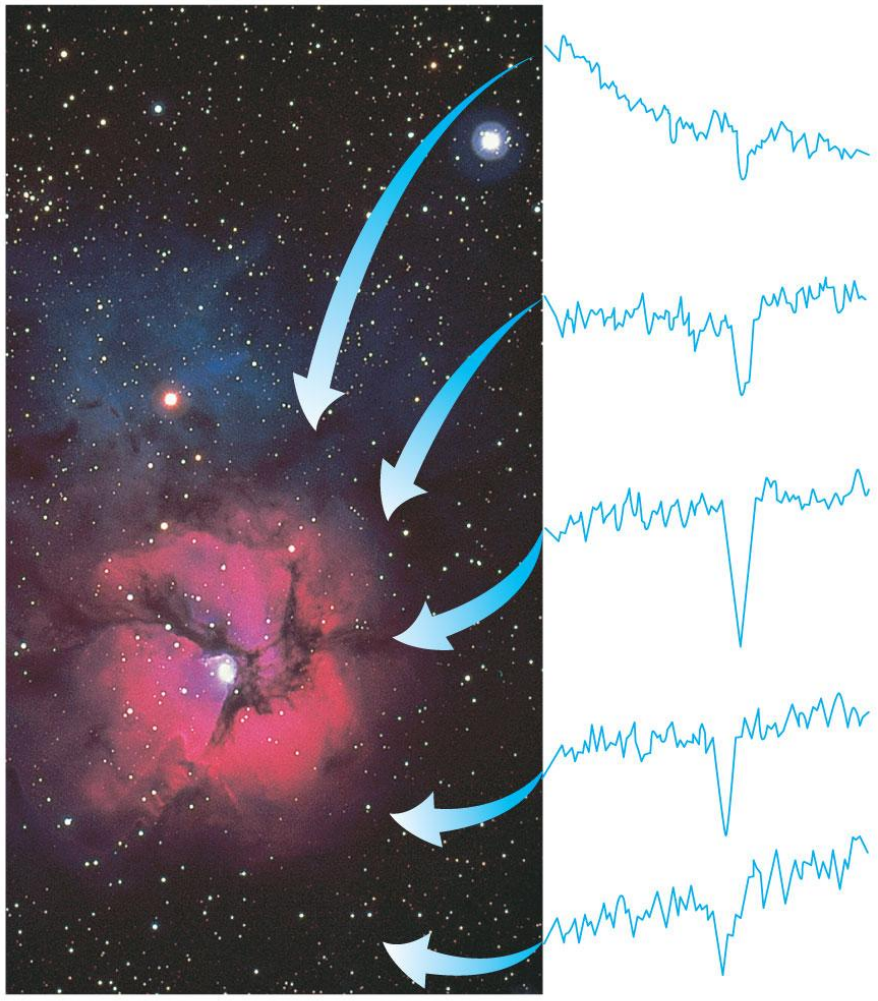
Fortunately, radio waves are not absorbed much, so molecular gas clouds can be detected even though there may be other gas and dust clouds in the way.

These clouds are mostly molecular hydrogen, which unfortunately does not emit in the radio portion of the spectrum.

Other molecules present include CO, HCN, NH_3, H_2O, CH_3OH, H_2CO, and more than a hundred others.

18.5 Interstellar Molecules

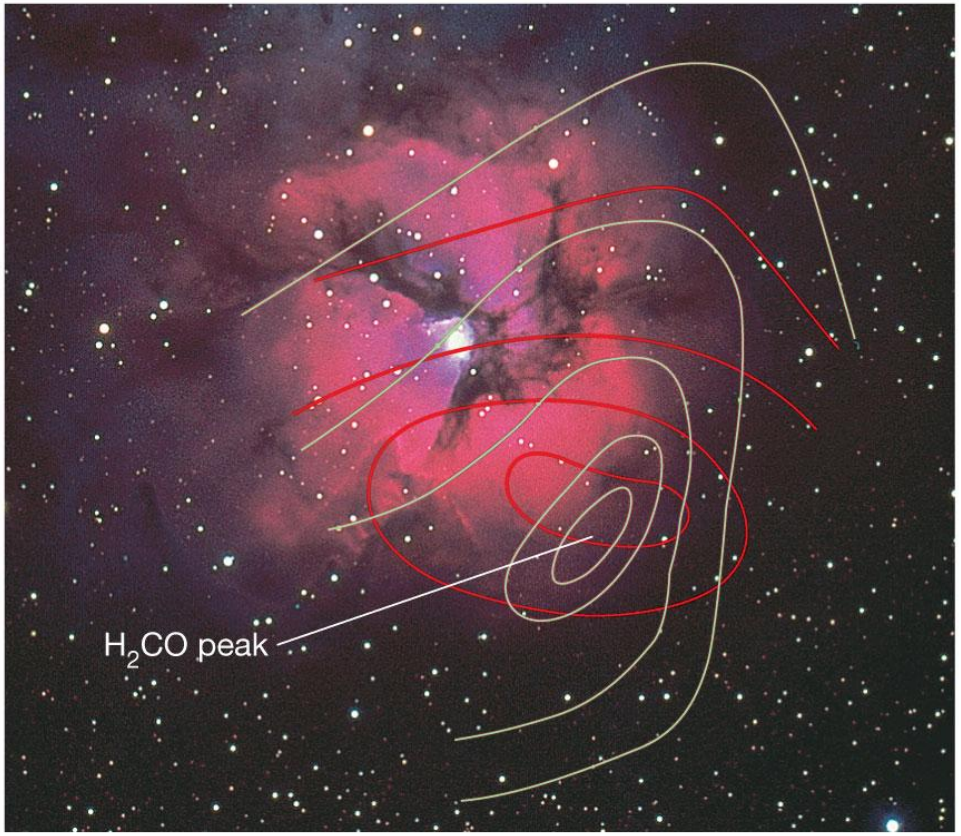
Here are some formaldehyde (H_2CO) emission spectra from different parts of M20.

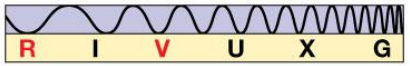


18.5 Interstellar Molecules

This is a contour map of H_2CO near the M20 nebula. Other molecules that can be useful for mapping out these clouds are carbon dioxide and water.

Here, the differently colored lines correspond to different rotational transitions.





Summary of Chapter 18

- The interstellar medium is made up of cold gas and small dust grains
- Dust preferentially absorbs shorter wavelengths, causing reddening
- Dust can also completely block light
- Dust grains must be elongated, as they polarize light
- Emission nebula: Gas that glows on its own, surrounding hot star

Summary of Chapter 18 (cont.)

- Dark dust clouds can be studied by the absorption lines they produce
- Cold gas clouds can be observed using the hydrogen 21-centimeter line
- Molecular clouds can be observed by the radiation from molecular rotational transitions