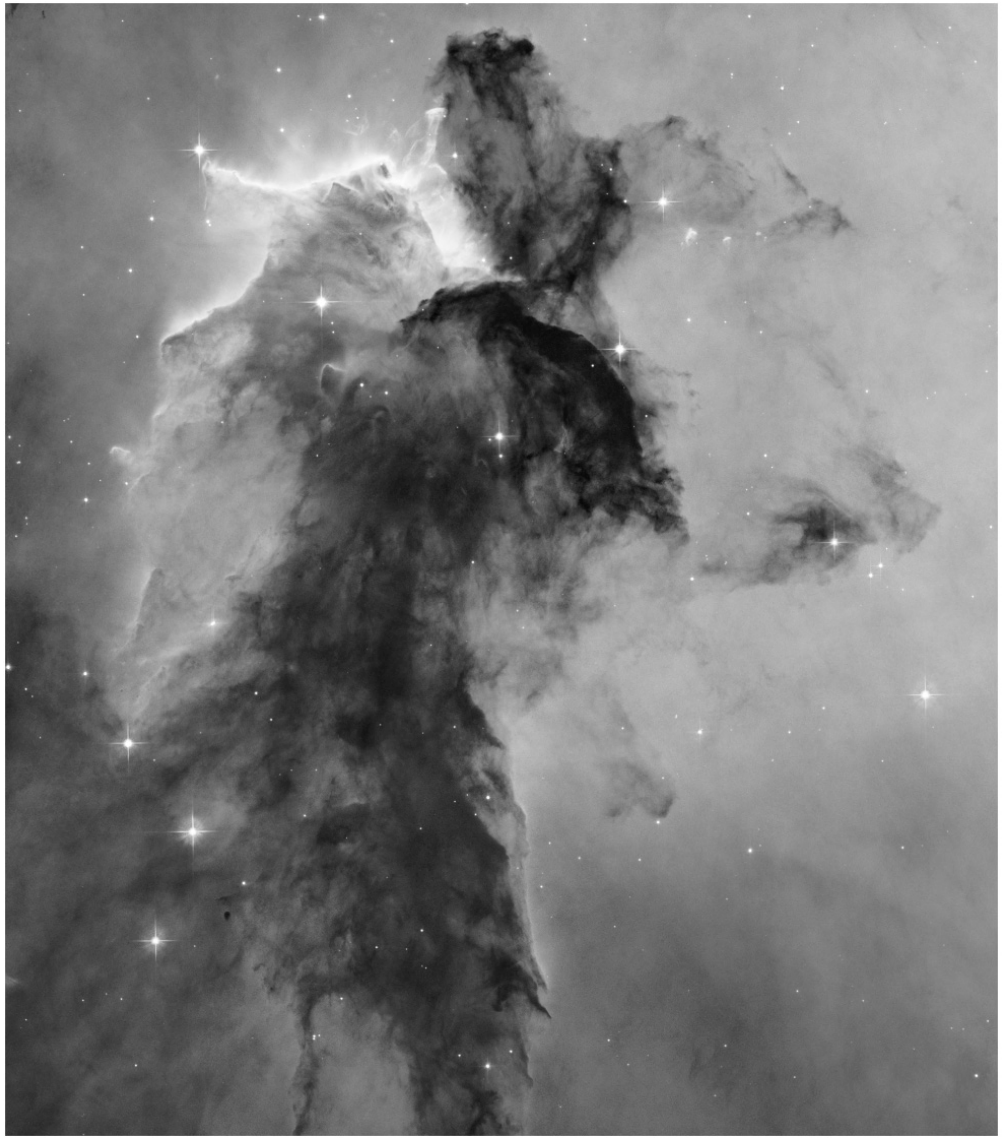
Chapter 11
The Interstellar Medium



Units of Chapter 11

Interstellar Matter

Star-Forming Regions

Dark Dust Clouds

The Formation of Stars Like the Sun

Stars of Other Masses

Star Clusters

11.1 Interstellar Matter

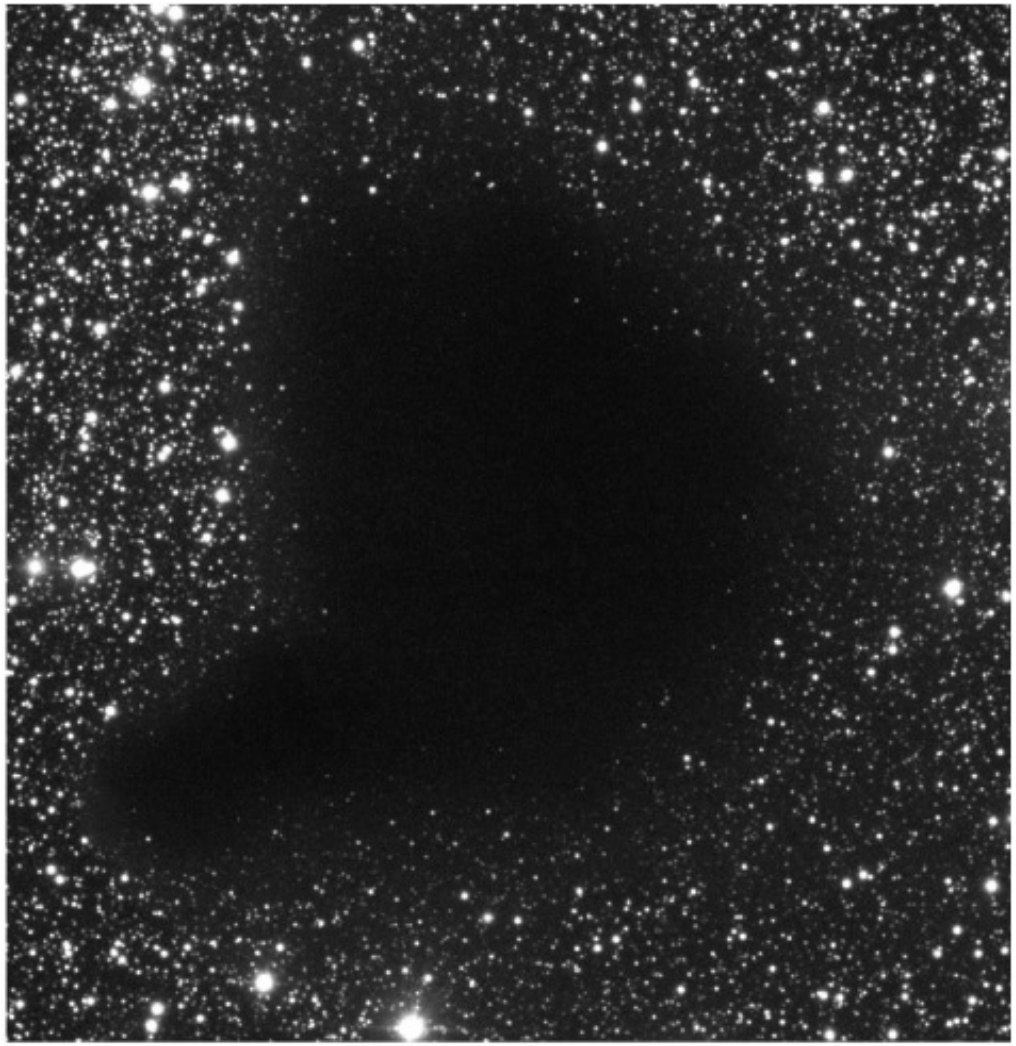
The interstellar medium consists of gas and dust.

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

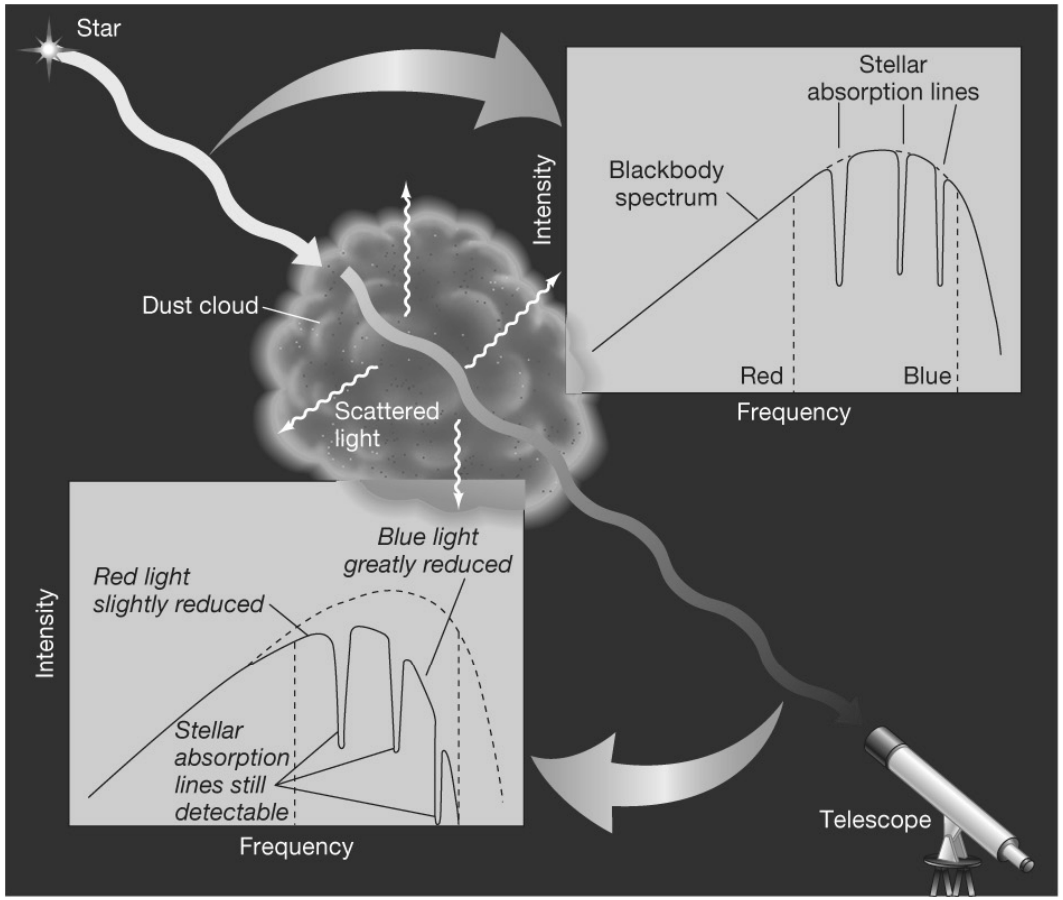
Dust is more like soot or smoke; larger clumps of particles.

Dust absorbs light, and reddens light that gets through.

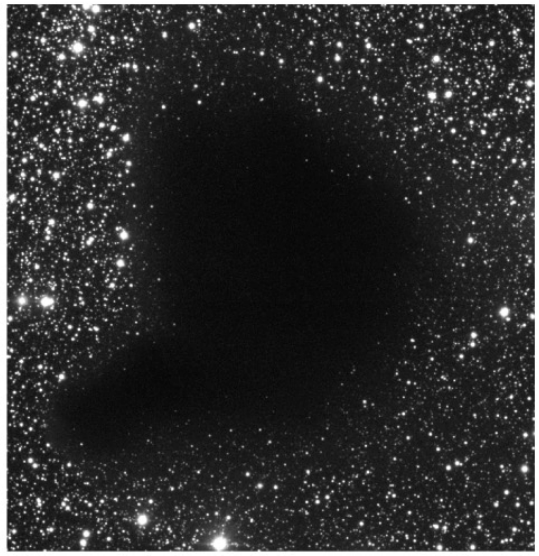
This image shows distinct reddening of stars near the edge of the dust cloud:



11.1 Interstellar Matter



(a)



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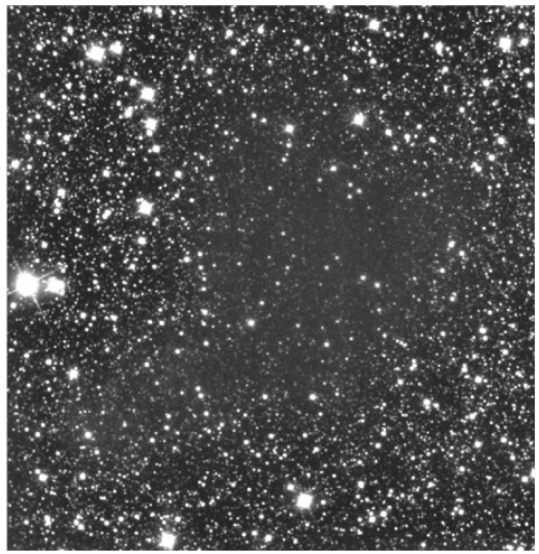
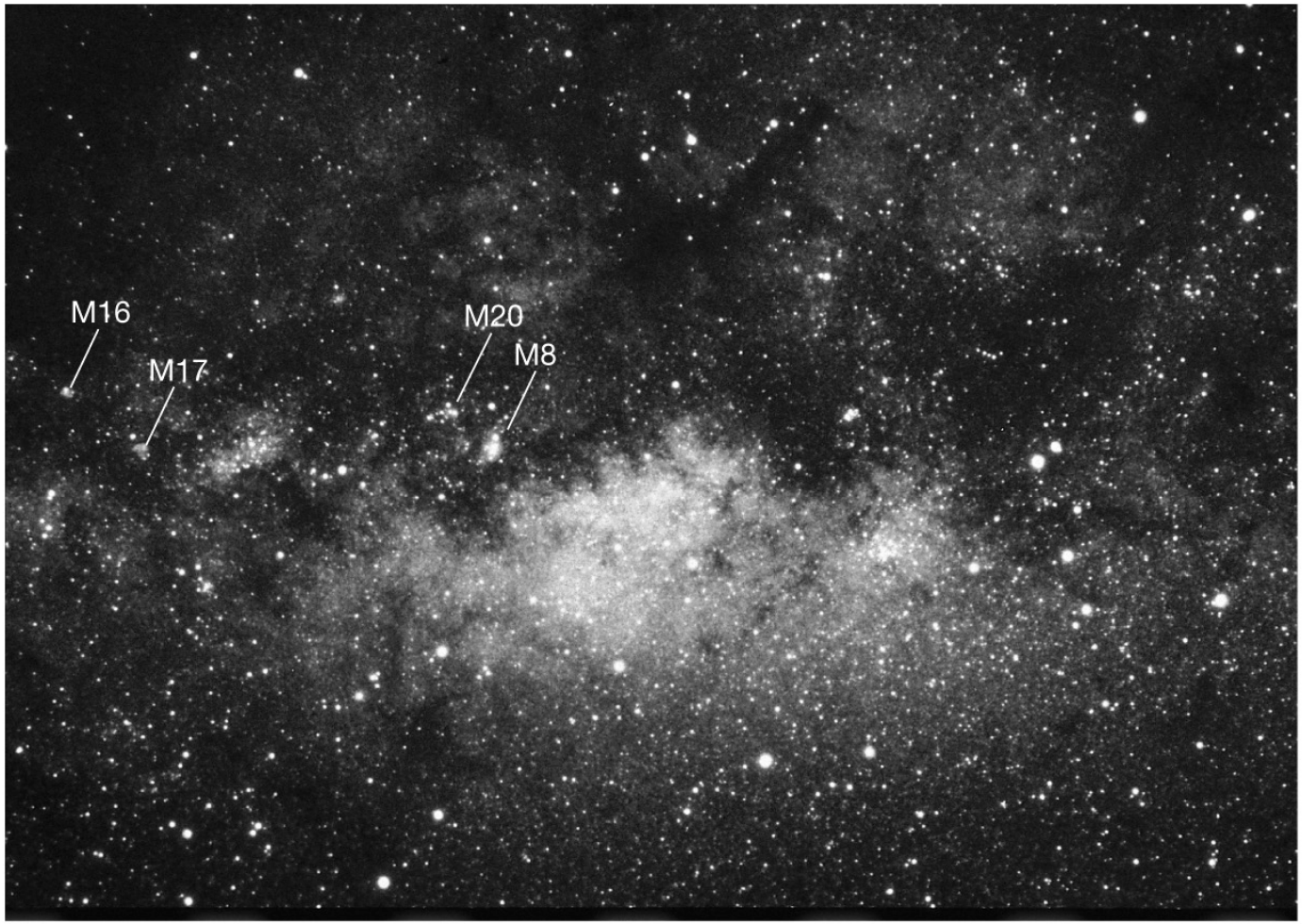


(c)

Dust clouds absorb blue light preferentially; spectral lines do not shift

11.2 Star-Forming Regions

This is the central section of the Milky Way galaxy, showing several nebulae, areas of star formation.



11.2 Star-Forming Regions

These nebulae are very large and have very low density; their size means that their masses are large despite the low density.

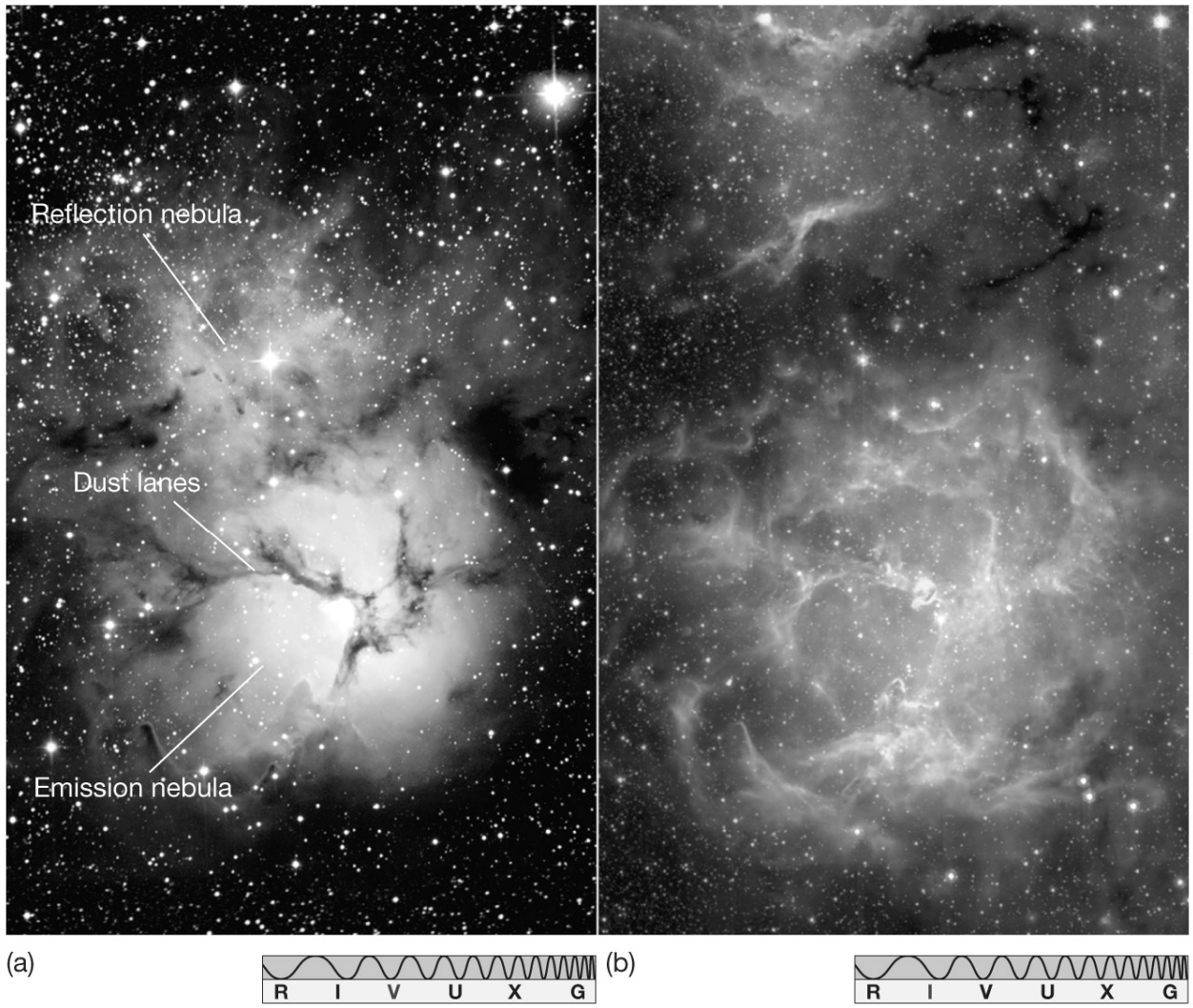
TABLE 11.1 Nebular Properties

OBJECT	APPROX DISTANCE (pc)	AVERAGE DIAMETER (pc)	DENSITY (10^6 particles/m^3)	MASS (SOLAR MASSES)	TEMPERATURE (K)
M8	1200	14	80	2600	7500
M16	1800	8	90	600	8000
M17	1500	7	120	500	8700
M20	1600	6	100	250	8200

11.2 Star-Forming Regions

“Nebula” is a general term used for fuzzy objects in the sky.

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



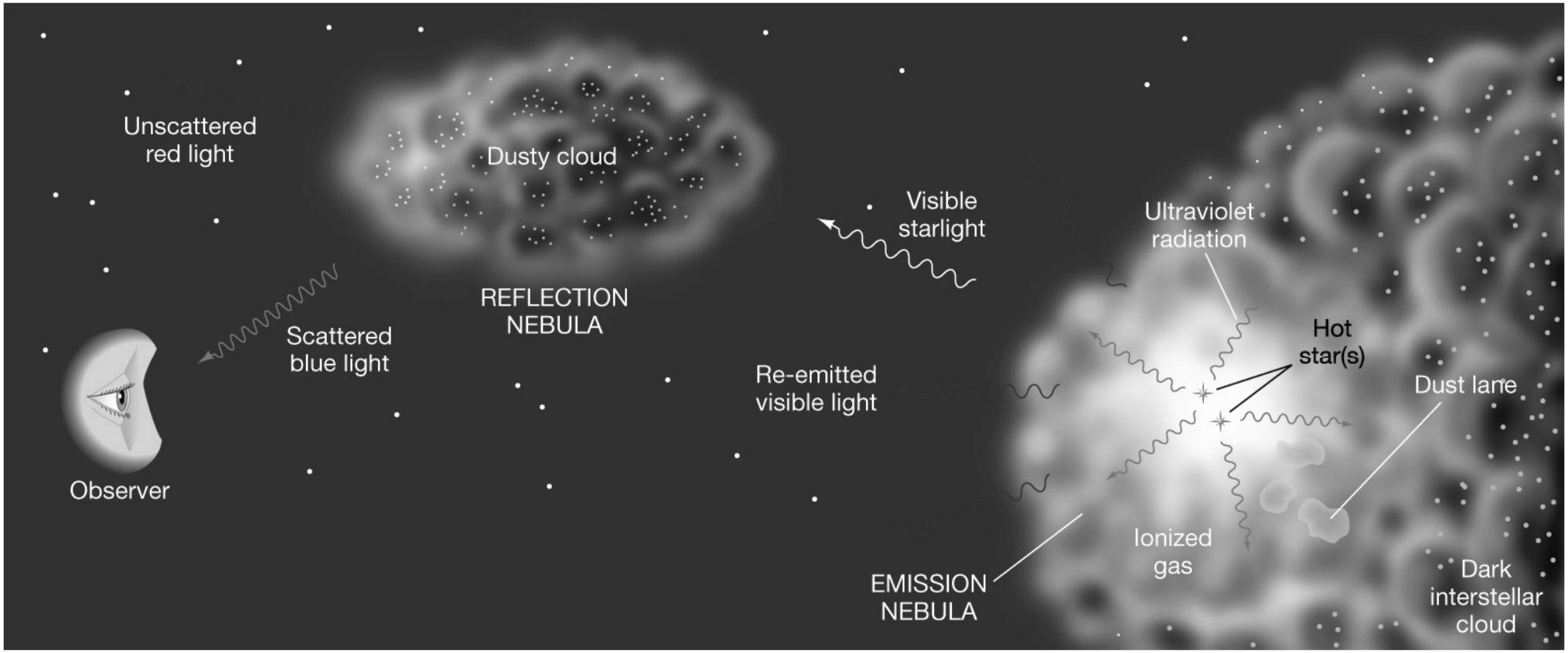
11.2 Star-Forming Regions

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.

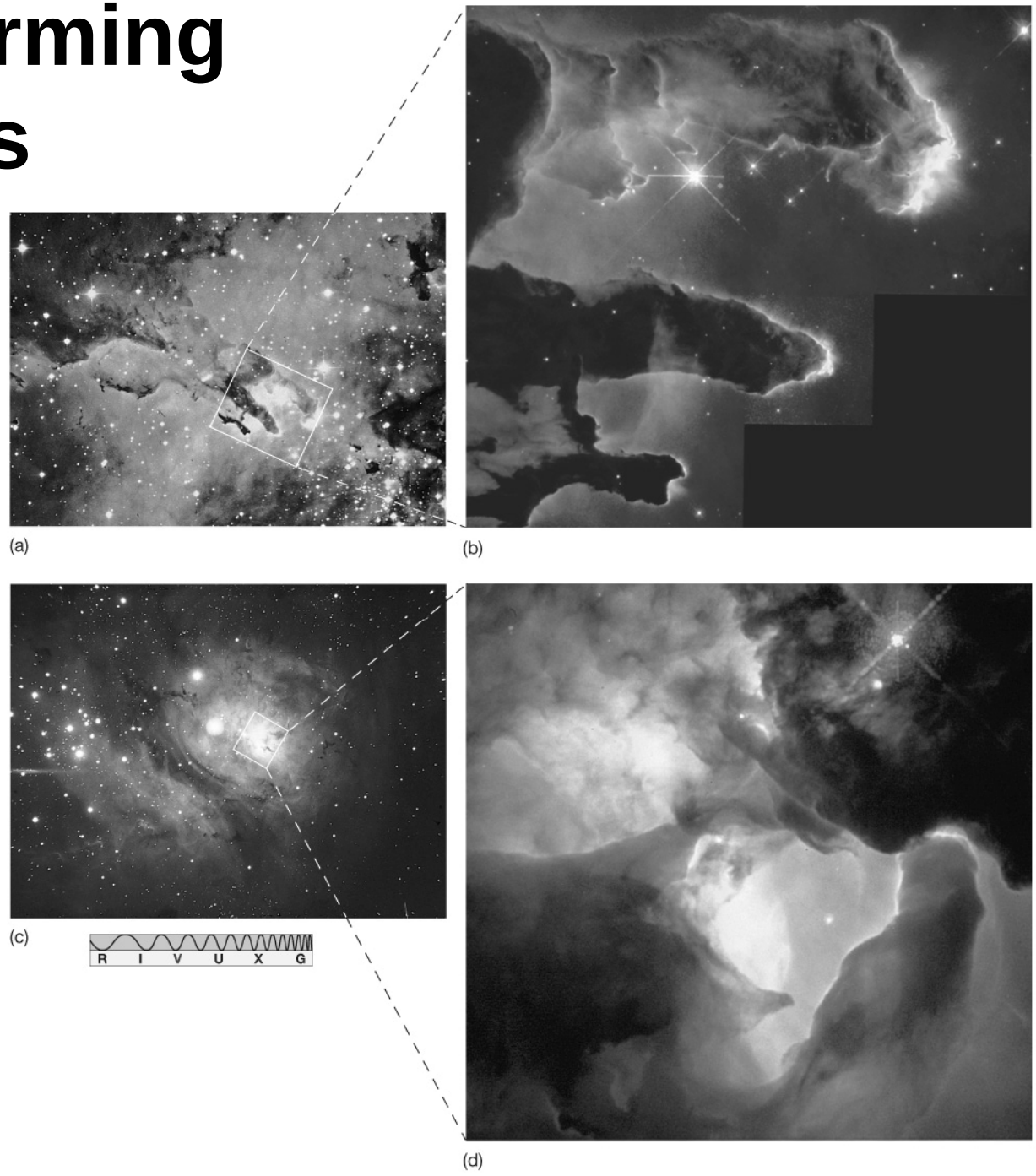
11.2 Star-Forming Regions

How nebulae work:



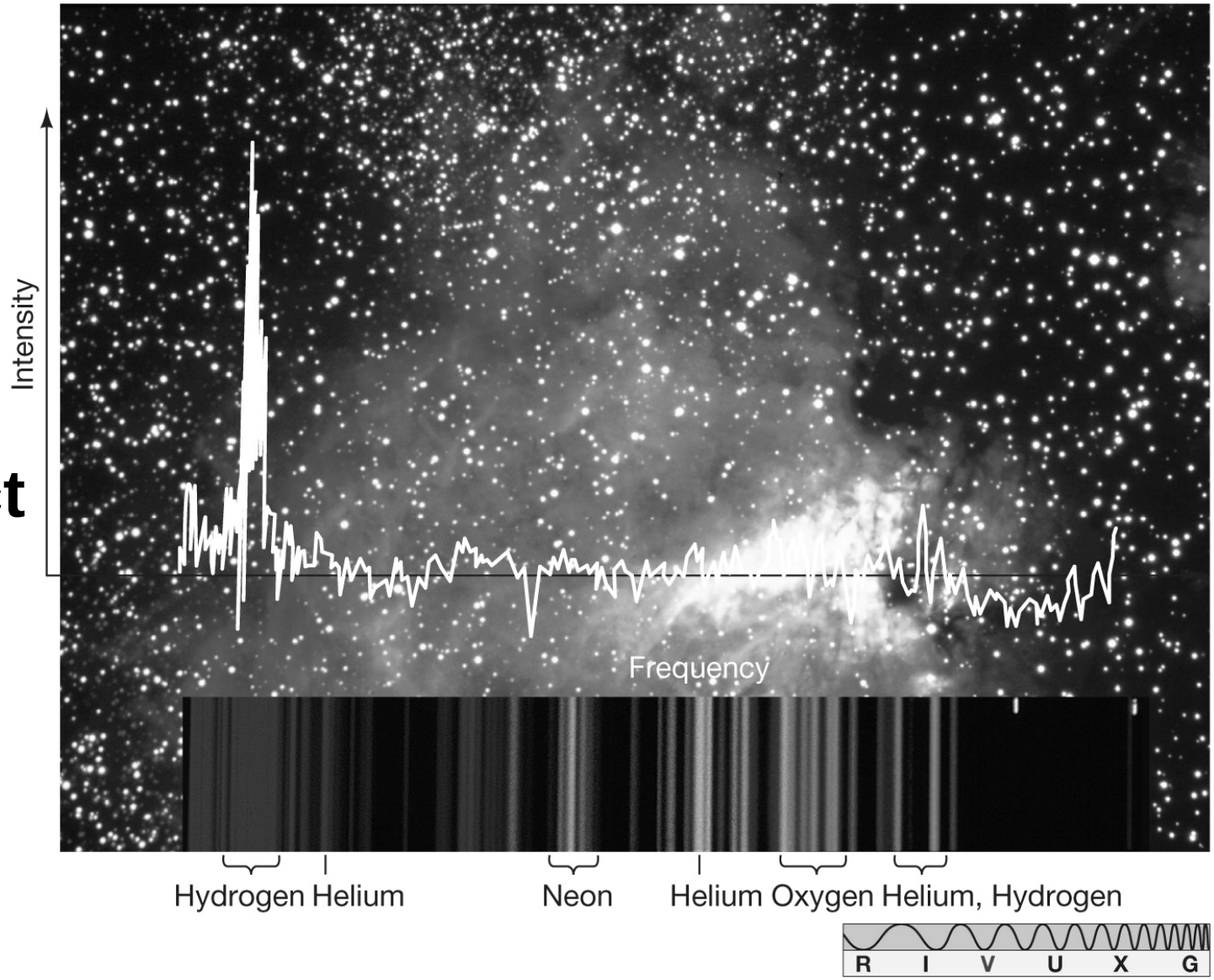
11.2 Star-Forming Regions

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



11.2 Star-Forming Regions

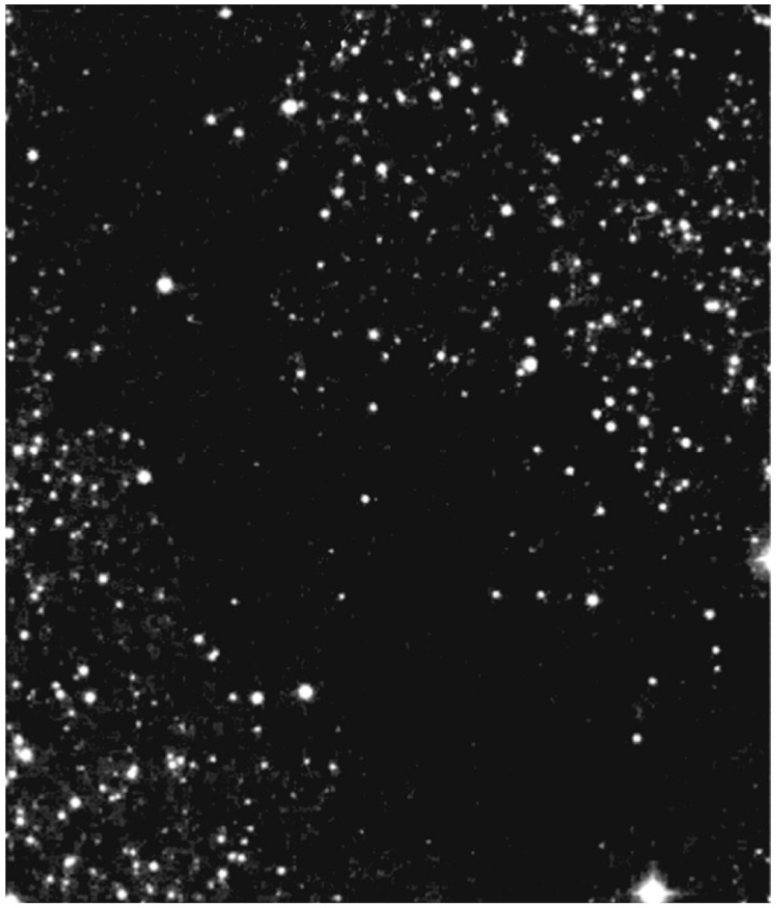
Emission nebulae are made of hot, thin gas, which exhibits distinct emission lines:



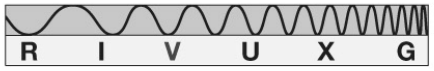
11.3 Dark Dust Clouds

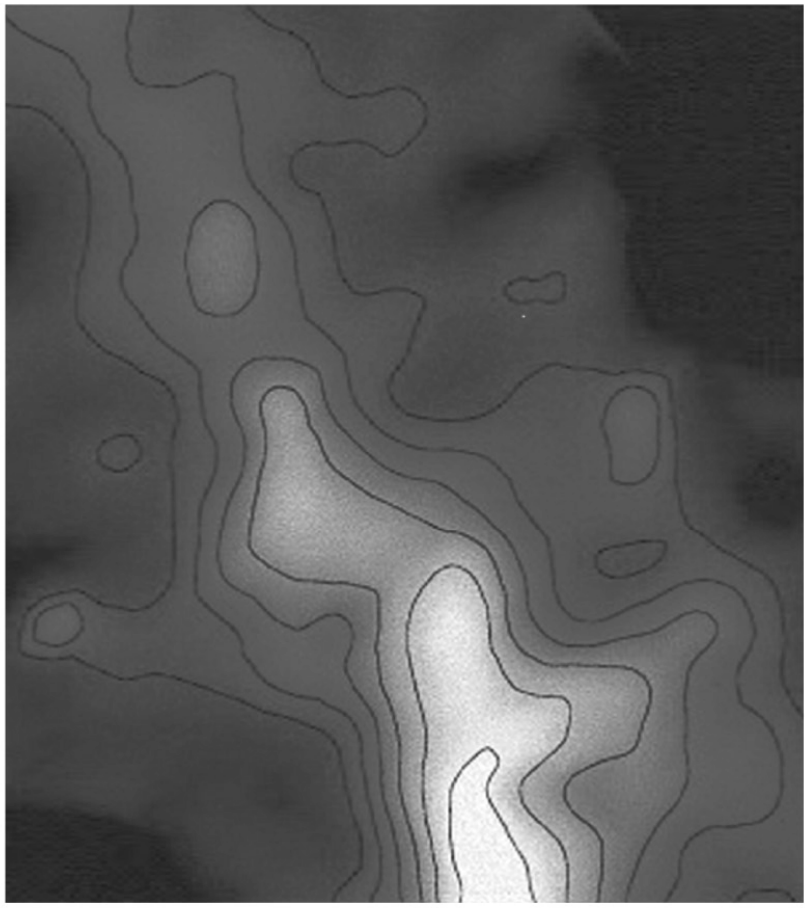
Average temperature of dark dust clouds is a few tens of kelvins

These clouds absorb visible light (left), and emit radio wavelengths (right)

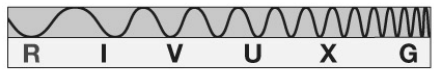


(a)



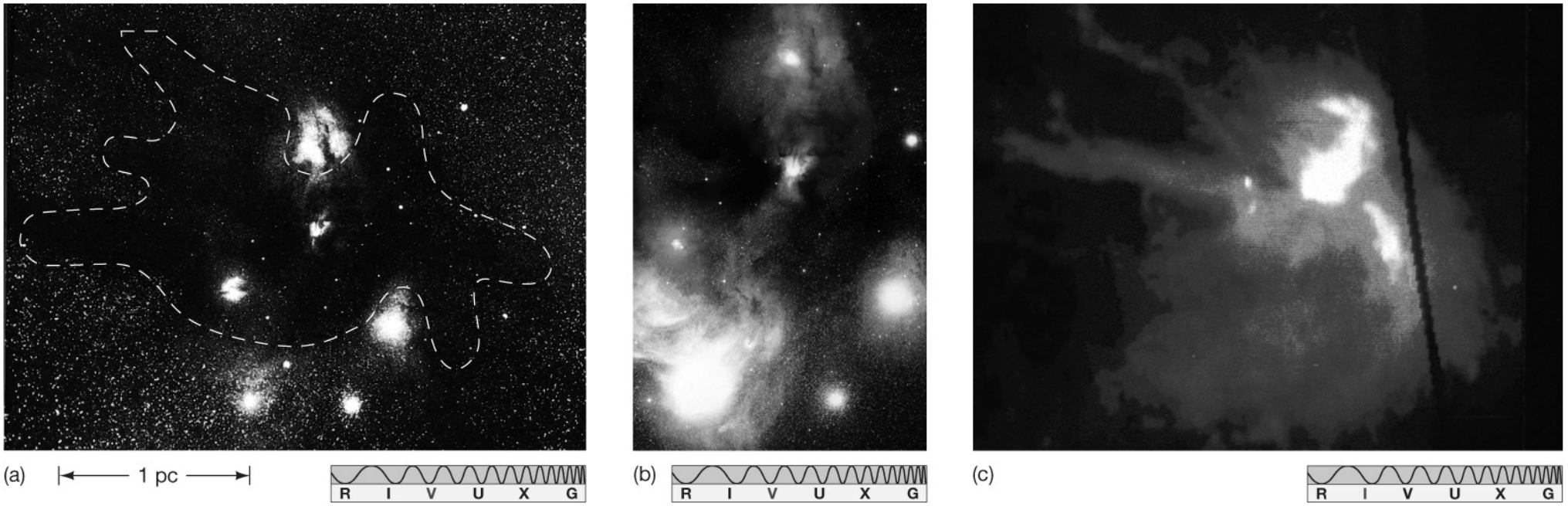


(b)



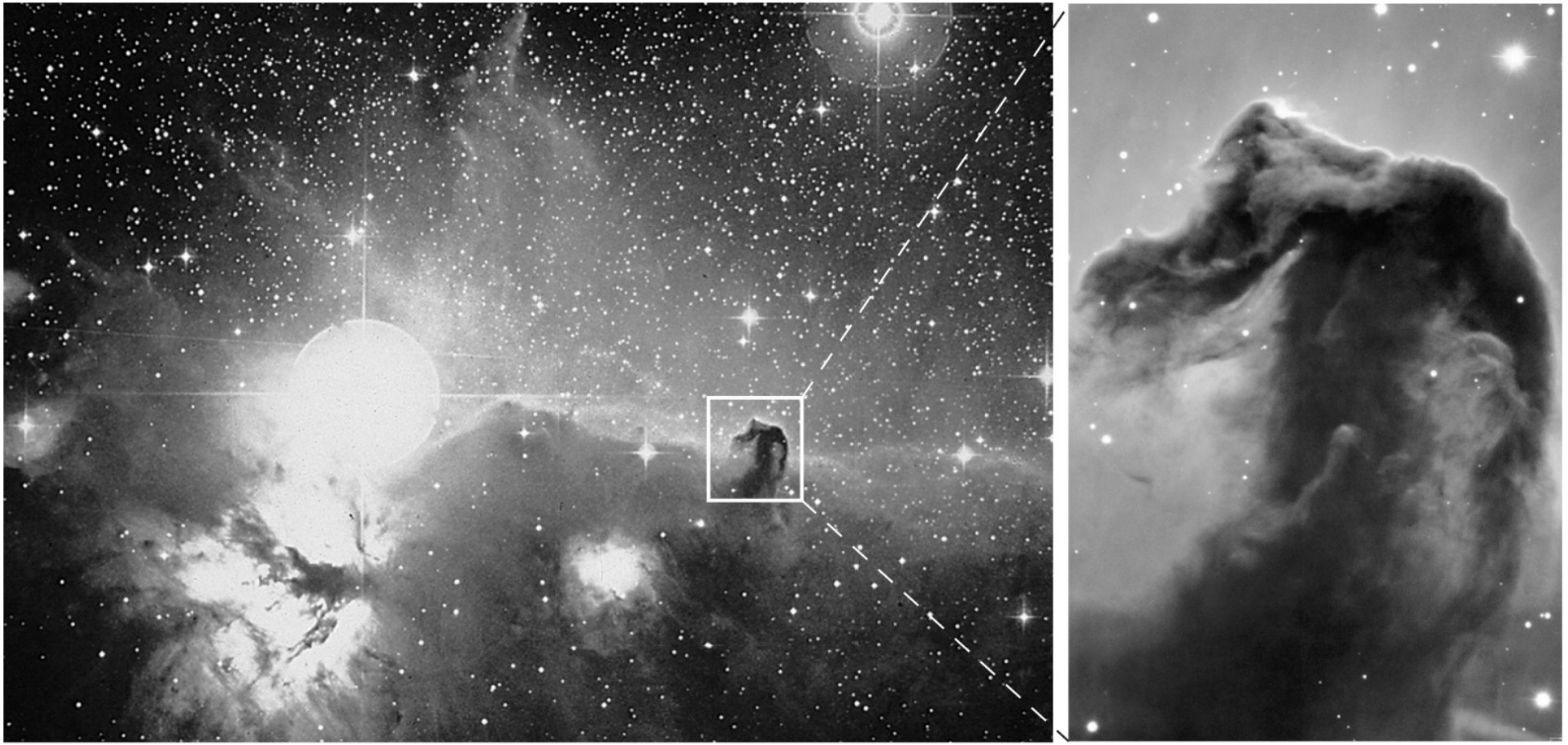
11.3 Dark Dust Clouds

This cloud is very dark, and can be seen only by its obscuration of the background stars. The image at right is the same cloud, but in the infrared.



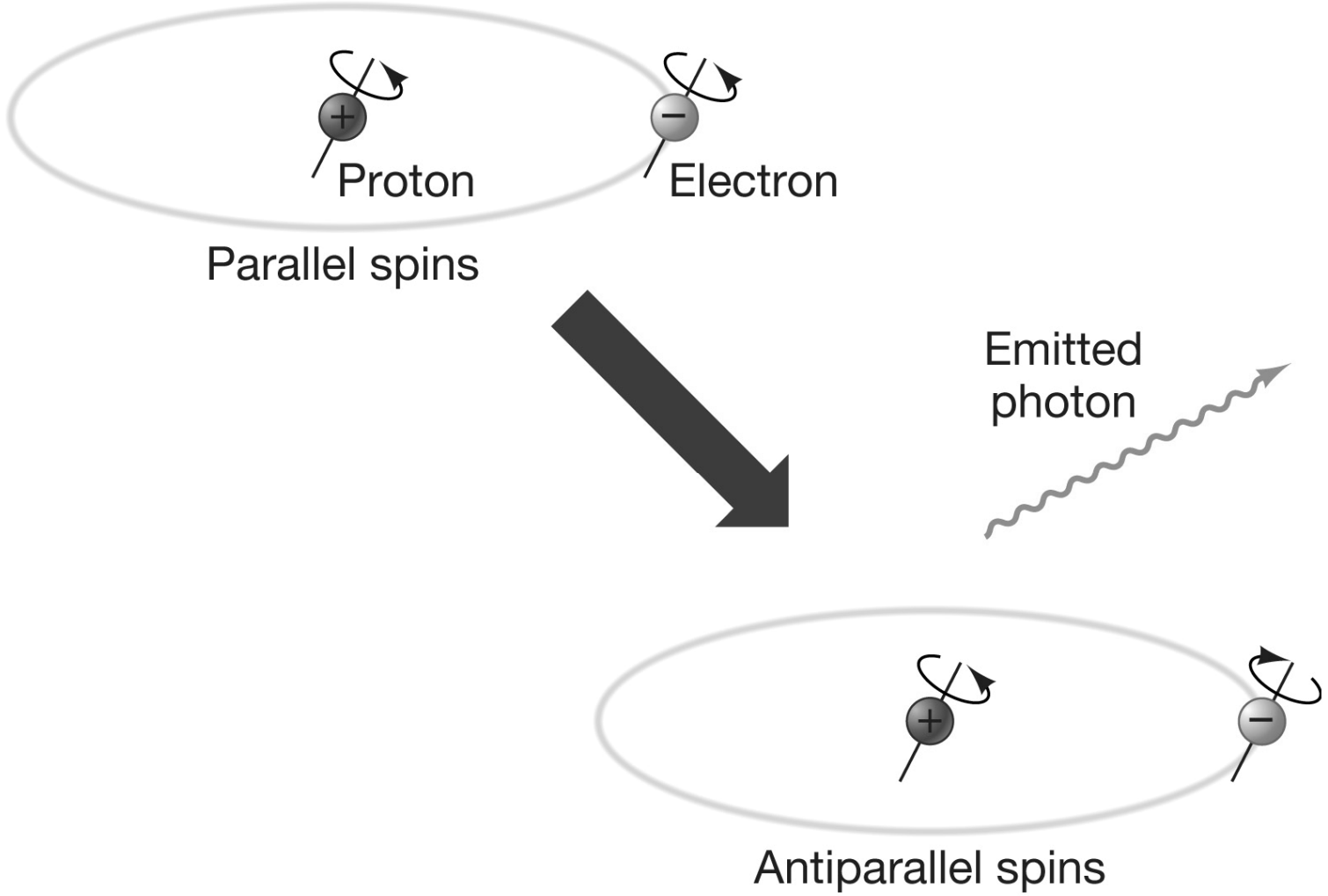
11.3 Dark Dust Clouds

The Horsehead Nebula is a particularly distinctive dust cloud.



11.3 Dark Dust Clouds

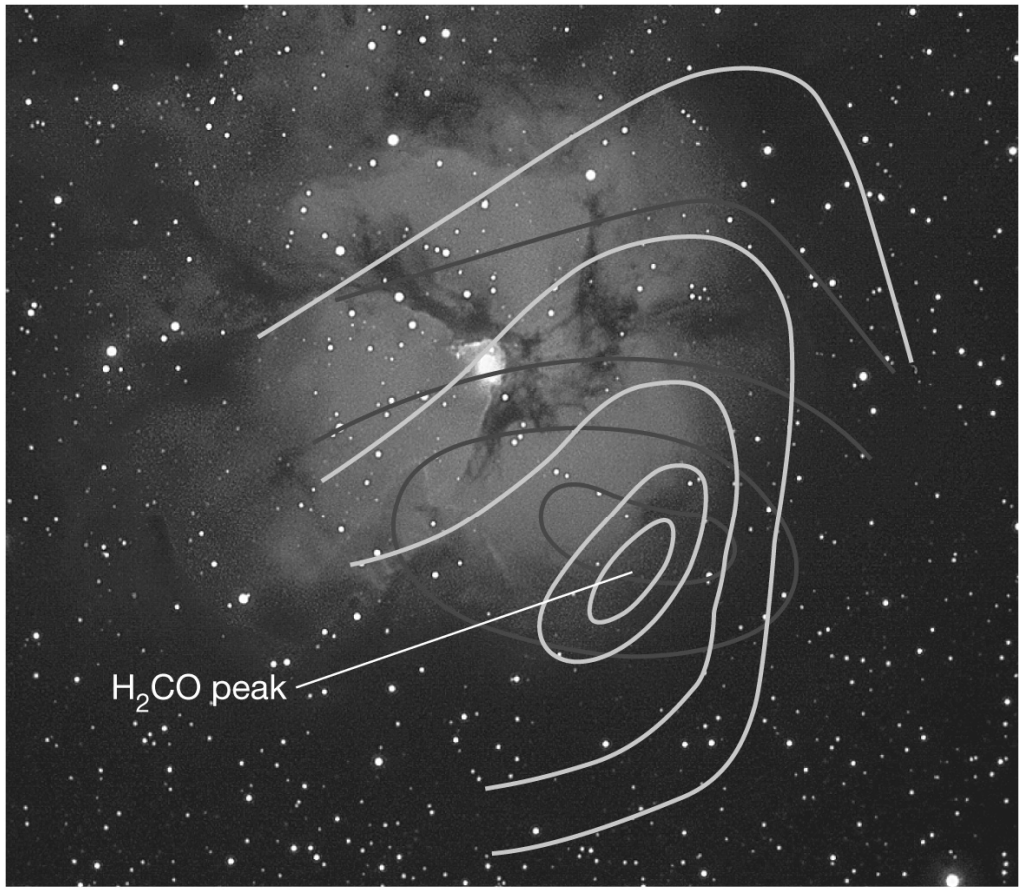
Interstellar gas emits low-energy radiation, due to a transition in the hydrogen atom:

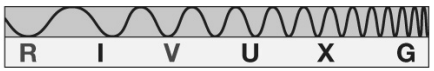


11.3 Dark Dust Clouds

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 red and green lines correspond to different rotational transitions.





11.3 Dark Dust Clouds

These are carbon monoxide-emitting clouds in the outer Milky Way, probably corresponding to regions of star formation.