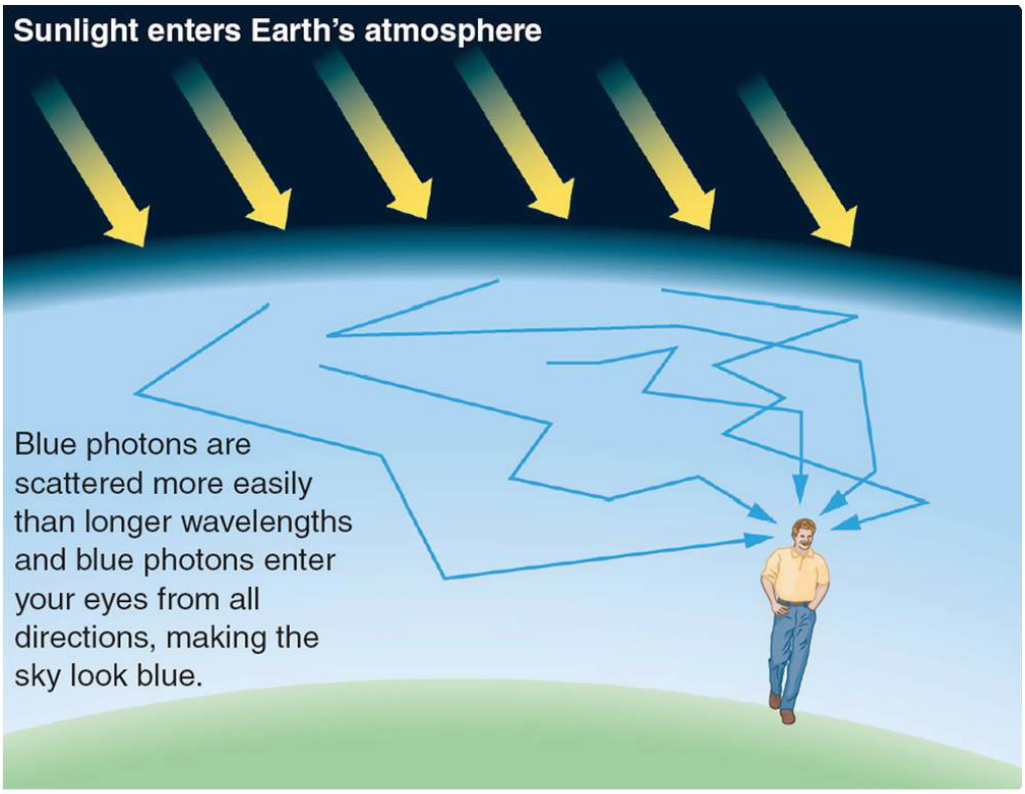
1 The Interstellar Medium

Gas and dust that lies between us and the stars

1.1 Why is the sky blue?

Scattering is a complicated process. The presence of matter changes the direction that light travels. Different colors or wavelengths are scattered differently.



1.2 Nebula

Latin for mist or cloud

1.2.1 Emission Nebula

Mainly ionized hydrogen
- Reddish-pink in color
- Hot, low density gas
- Temperature of about $10,000\,\mathrm{K}$

Density of about 100 to 1000 atoms per cubic centimeter

The gas is excited by the high amounts of ultra violet radiation being emitted

Emission nebula typically lie close to or surround very hot stars $T > 25,000\,\mathrm{K}$ which is spectral class $B1$

Embedded stars must be hotter than $B1$ to ionize hydrogen

Wavelengths shorter than 91.2 nanometers will ionize hydrogen

Emission nebula are also called $H\ II$ regions

$H\ I$ is neutral hydrogen

Protons capture free electrons (from the ionization process) and the electron cascades down through the energy levels emiting photons

The visible photons emitted (Violet, Blue, and Red) produce the pinkish color

Example: M 42 The Great Orion Nebula (next to M43)

Example: M 8 The Lagoon Nebula in Sagittarius

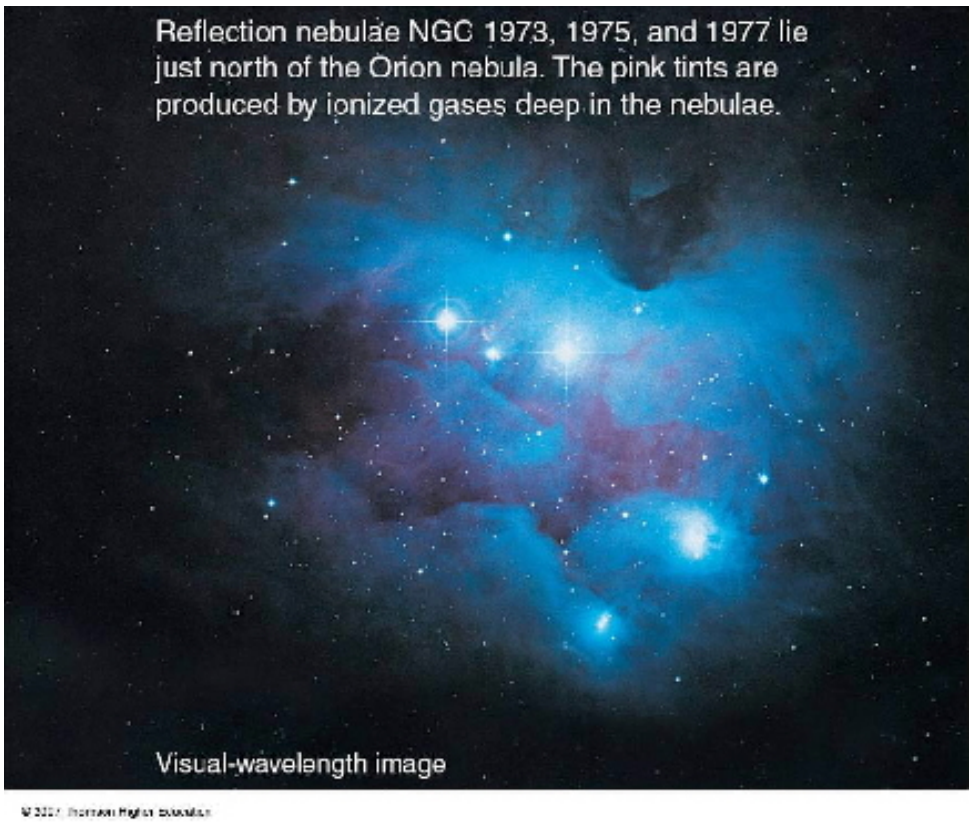
1.2.2 Reflection Nebula

Not made up of excited gas

Reflects the light from nearby stars

Made up mostly of dust

These nebula are blue in color because they reflect the light of hot nearby stars

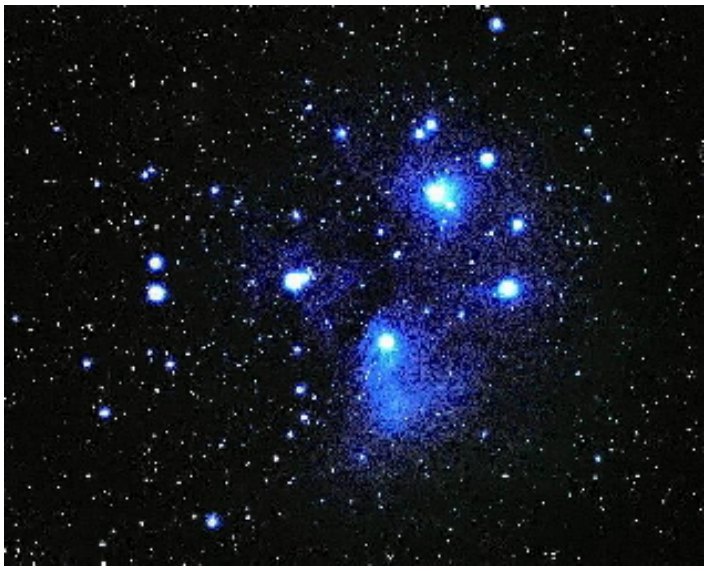


Example: M 45 Pleiades in Taurus

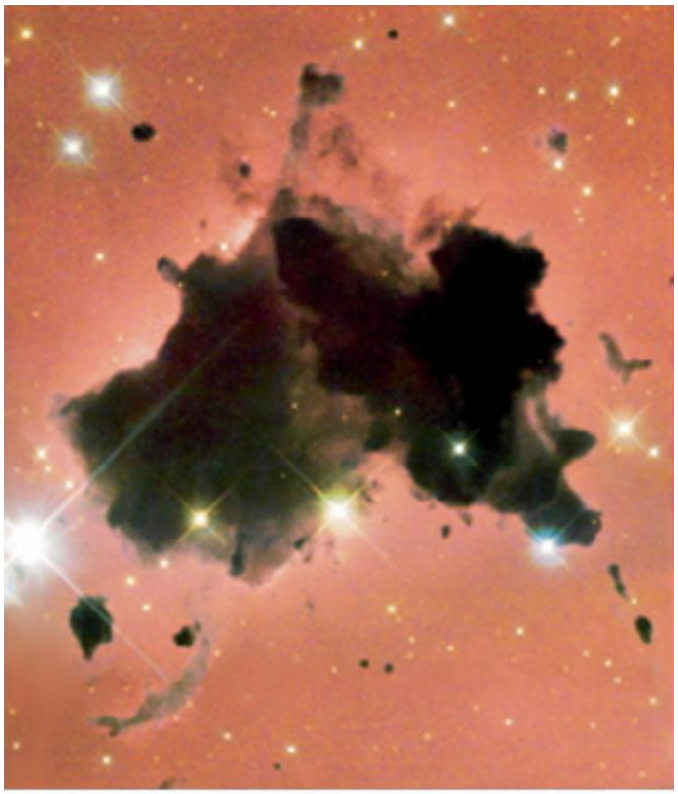
1.2.3 Dark Nebula

Dark clouds

Dense clouds that block the light from background stars

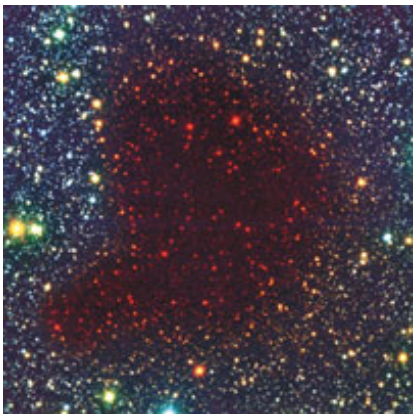


The smallest of these dark nebula are called Bok Globules



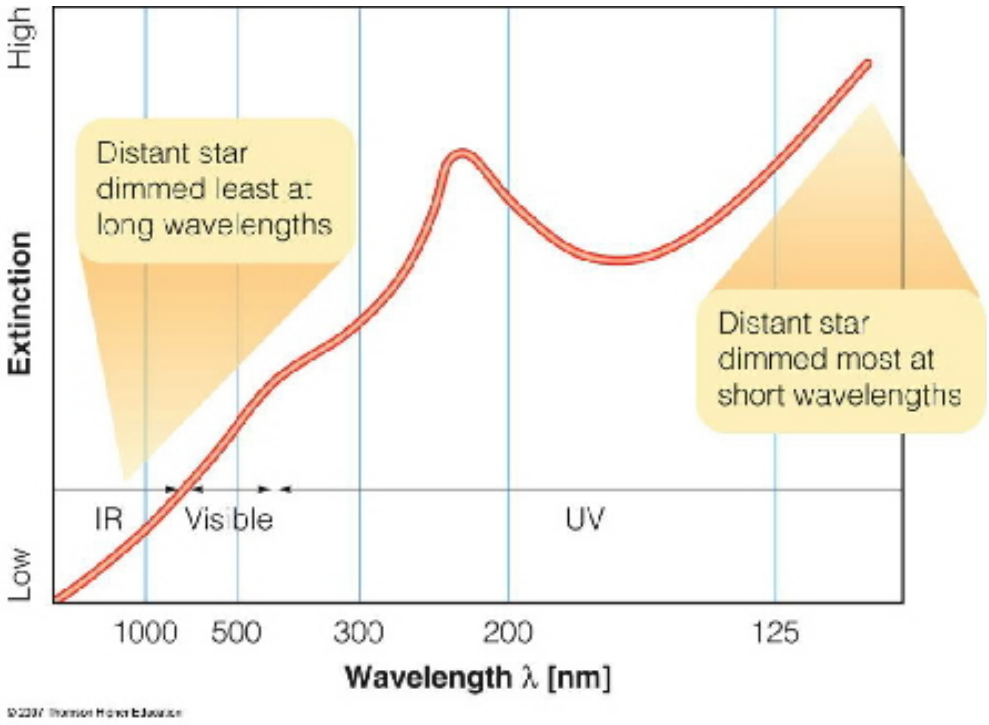
In the visible part of the spectrum, light is blocked

In the infrared part of the spectrum we see the heat given off by the background stars



1.2.4 Extinction

The absorption and scattering of light by matter (dust and gas) as it moves through space. In general, interstellar dust blocks blue light, allowing red light waves through, making stars appear redder than they are. Broadly speaking, interstellar extinction is strongest at short wavelengths.



1.2.5 Interstellar Absorption Lines

Gives us a way to study the gas between the stars

Astronomers differentiate the absorption lines of stellar atmospheres from the absorption lines of the interstellar medium by identifying absorption lines that should not be in the star's spectra and by measuring the widths of the spectral lines

Example: If we see lines of ionized calcium in the spectra of an 0 type star then we know that those lines are not from the star but from the interstellar medium

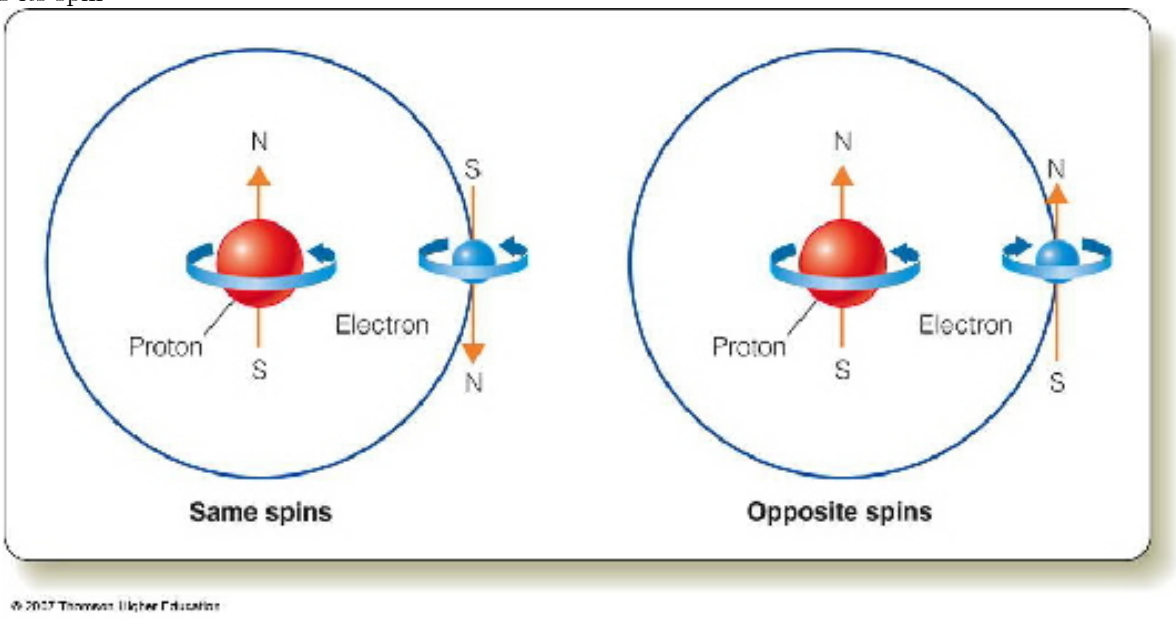
O type stars do not have lines of ionized calcium

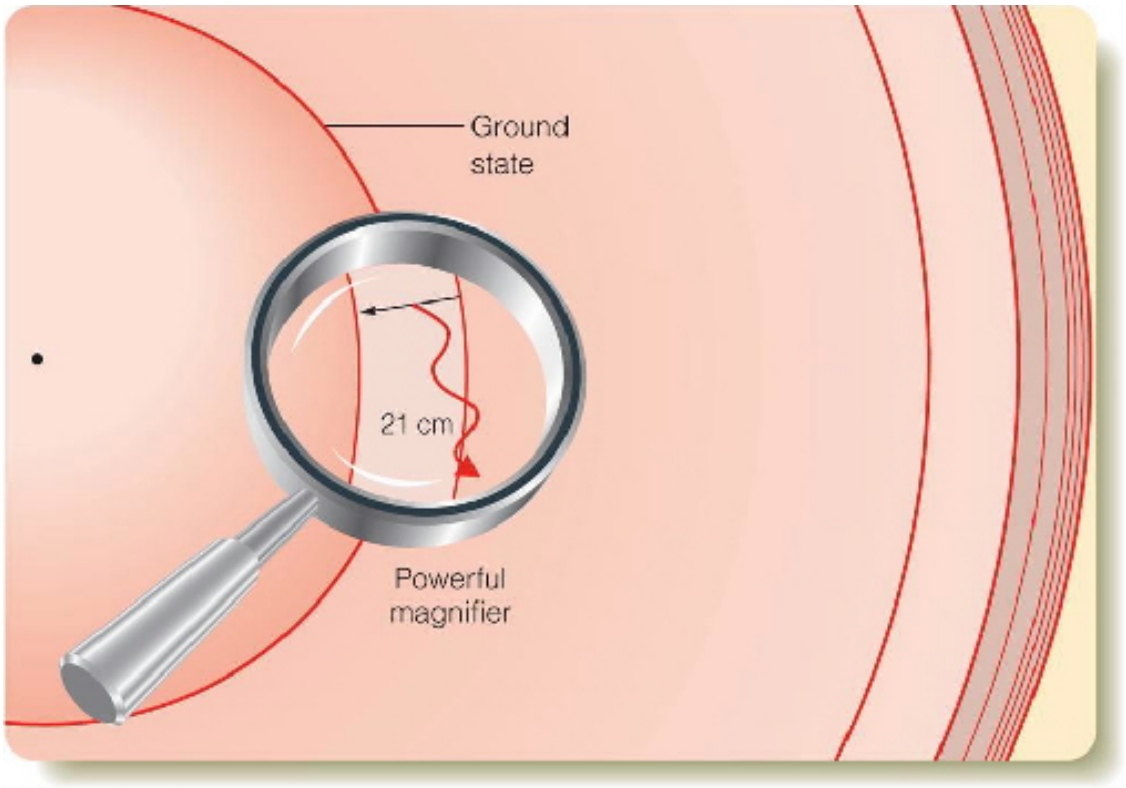
Hot stars have lines that are broadened by collisions and the Doppler effect

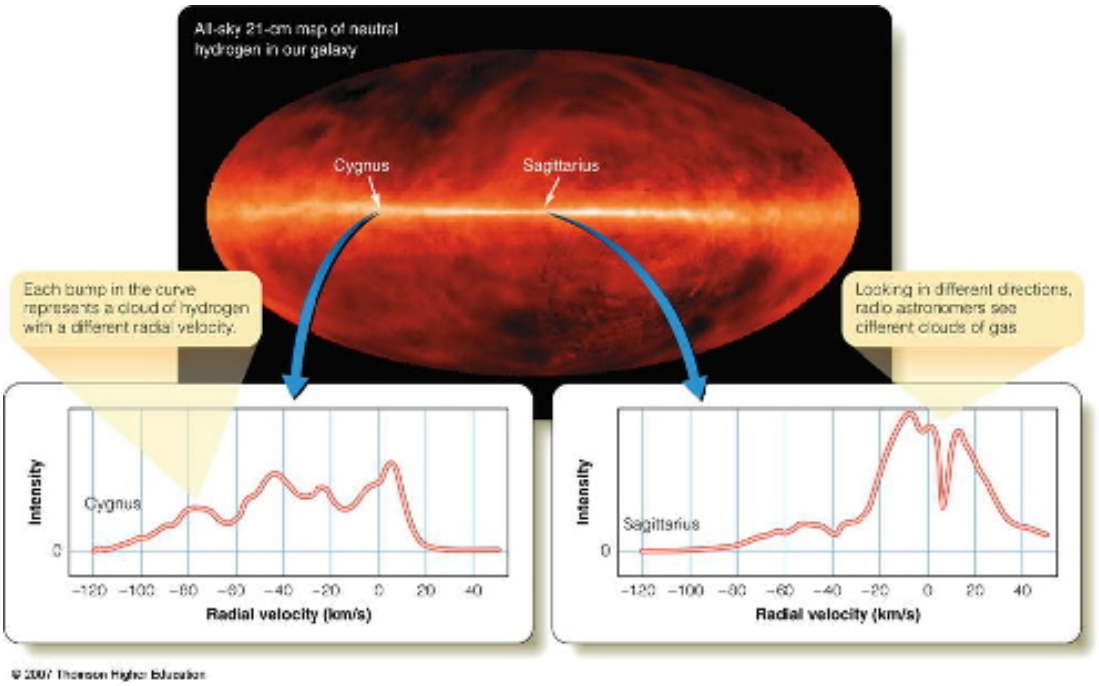
Interstellar lines are sharp

1.2.6 Other Observations

21 cm radiation (radio) - neutral hydrogen atoms (HI), electron in ground state flips its spin







Molecules in nebula Giant molecular clouds - 15 to 60 pc across
High density
Temperature around 10K
Places where stars are likely to form

Table 10-1 Selected Molecules Detected in the Interstellar Medium

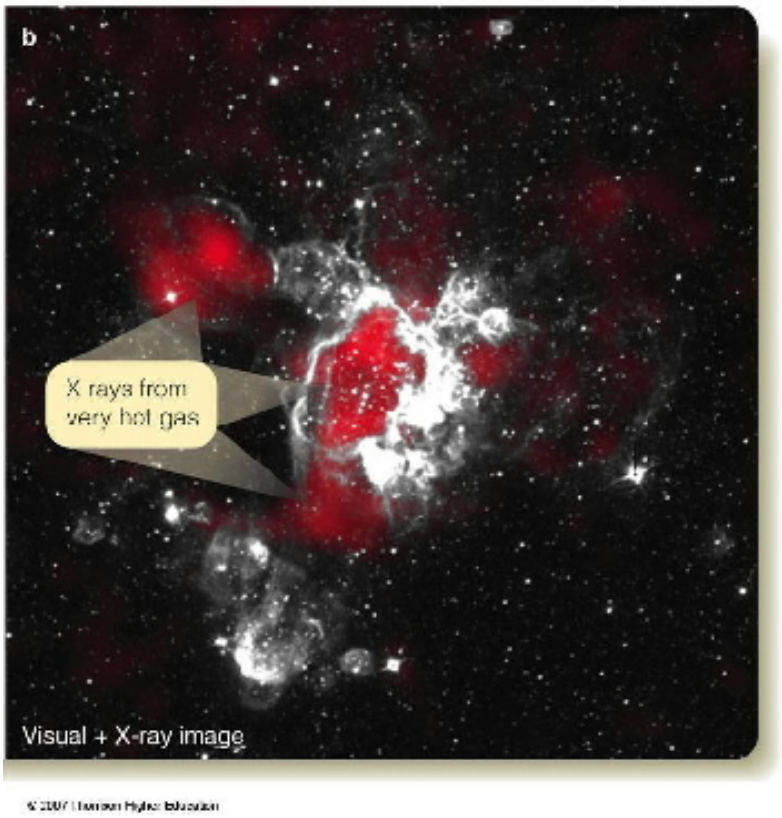
H_2	molecular hydrogen	H_2S	hydrogen sulfide
C_2	diatomic carbon	N_2O	nitrous oxide
CN	cyanogen	H_2CO	formaldehyde
CO	carbon monoxide	C_2H_2	acetylene
NO	nitric oxide	NH_3	ammonia
OH	hydroxyl	HCO_2H	formic acid
NaCl	common table salt	CH_4	methane
HCN	hydrogen cyanide	CH_3OH	methyl alcohol
H_2O	water	CH_3CH_2OH	ethyl alcohol

1.2.7 Infrared Cirrus

Wispy clouds of dust that lie mainly in the plane of the Milky Way
Temperature around 30K

1.2.8 X -rays

Coronal gas



Temperatures above 1 million kelvin
Low density

1.2.9 4 Components of the Intercloud Medium

Table 10-2 | Four Components of the Interstellar Medium

Component	Temperature (K)	Density (atoms/cm^3)	Gas
HI clouds	50–150	1–1000	Neutral hydrogen; other atoms ionized
Intercloud medium	10^3–10^4	0.01	Partially ionized
Coronal gas	10^5–10^6	10^{-4}–10^{-3}	Highly ionized
Molecular clouds	20–50	10^3–10^5	Molecules