Interstellar Medium (ISM)

ISM consists of dust and gas

Properties of Dust

1) Dust dims starlight; makes an object look fainter.
2) Dust reddens starlight : it scatters blue photons more than red photons [Rayleigh scattering]. Note that there is no shift in the spectral lines due to dust. Reddening is not the same as redshift!
3) Dust polarizes starlight.
4) Dust does not affect the angular size of an object.

Fraction of interstellar matter in the form of dust grains $\approx 10\%$

Composition : graphite (C), silicates (compounds of Si), with a coating of water ice.

Size : 20 to 2000 Å

Shape : The fact that dust polarizes starlight indicates that dust grains are not spherical but elongated in shape.

Evidence for dust in the Milky Way

0) In 1930 Robert Trumpler studied the distribution of galactic clusters.
1) He measured distances to galactic clusters through main-sequence fitting technique.
2) Measured angular diameters for these galactic clusters.
3) Obtained linear diameter from angular diameter and distance.
[Linear diameter $\propto$ Angular diameter x distance]
4) Observed that more distant clusters are bigger than nearby ones.
5) There is a systematic error made in the measurement of distance which could be due only to dust. Hence the presence of dust was verified.

Interstellar Gas : is present in both atomic and molecular form.

Detection of interstellar gas cloud

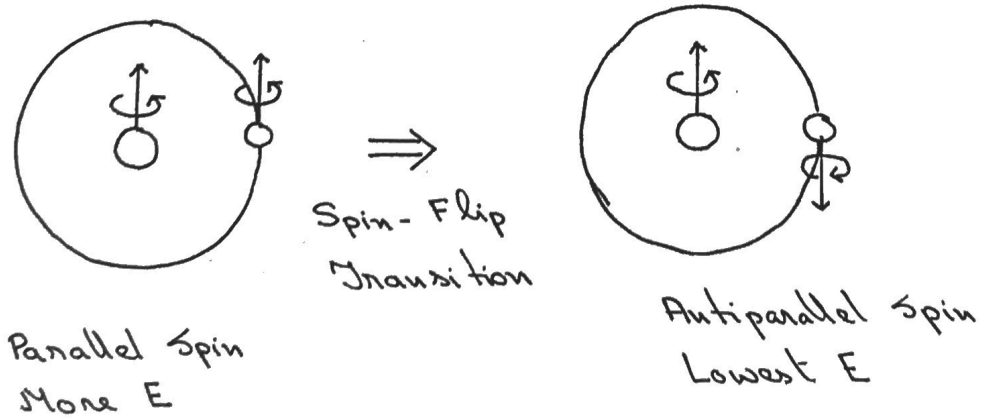
Interstellar absorption lines superimposed on stellar spectra. The interstellar absorption lines are : 1) very narrow (sharp) , 2) have different Doppler shift from stellar lines. There are forbidden lines of ionized Nitrogen [NII] and Oxygen [OII] and [OIII]. The forbidden lines are produced from transitions from metastable states.

Radio radiation from HI : In a neutral hydrogen atom both the proton and the electron have spin. If the sense of the spin is the same for both the proton and the electron then the atom is in a parallel spin state. If the sense of the spin is opposite then the atom is in an anti-parallel spin state. The atom has more energy in the parallel spin state than the anti-parallel spin state. When the atom goes from a parallel state to an anti-parallel state it goes from a higher to a lower energy level. This is called a spin flip transition. A photon is emitted $\lambda = 21$cm and f = 1420 MHz.

Interstellar Molecules : In 1940 two molecules were discovered in the interstellar medium CH and CN. Now we know over 100 molecules in space - the most abundant being H_2 and CO.

There are several energy states in a molecule : rotational, vibrational, and electronic.

Changes in { rotational, vibrational, electronic } energy states produce { radio, infrared, visible } photons



Interstellar Gas Clouds

Molecular Clouds

- Cold, T = 20 to 50 °k
- Dense, 10^4 to 10^5 particles / cm^3
  [⊕'s atmosphere has $2x10^{19}$ particles / cm^3]
- Contains dust

Dust is necessary for the existence of molecules.

- dust shields molecules from disruption by u.v. photons
- dust provides a surface (and an energy sink) for atoms to come together and form molecules.

Neutral HI clouds

- Densities : 1 to 1000 particles / cm^3
- Temp : 50 to 150°k

HII Regions or Emission Nebulae

- Regions of ionized H surrounding hot O and B stars which produce a copious amount of u.v. photons.
- Need u.v. photons with $\lambda < 912$ Å to ionize neutral hydrogen.
- The ultra violet light from star gets degraded to visible light.
- Emission lines are produced, the strongest being Hα at $\lambda = 6563$Å
- The HII region or emission nebula appears red in color even though the ionizing star is quite blue.

Reflection Nebulae

A cloud of gas and dust that reflects starlight. It has no light of its own. The spectrum is that of the illuminating star. But is bluer than the illuminating star because of Rayleigh scattering.

Superbubbles or Coronal gas

Temp ~ 10^6 °k and Density < 0.01 particles / cm^3
Produced by supernova explosions