Interstellar Warm Ionized Medium (Cont.)

- The Glow of HII Regions

  Mean free path of photons in HII regions is given by,

$$l = 1/n_e\sigma_T \tag{1}$$

  *On considering typical values for n and sigma, the value of l comes out to be around 500pc. Since this is greater than Stömgen radius by a factor of 100, photons would not be able to interact enough with matter in order to attain thermodynamic equillibrium and we would observe negligible part of black body continuum.
  *Optical light is due to recombination of free electrons with ions folllowed by de-excitation

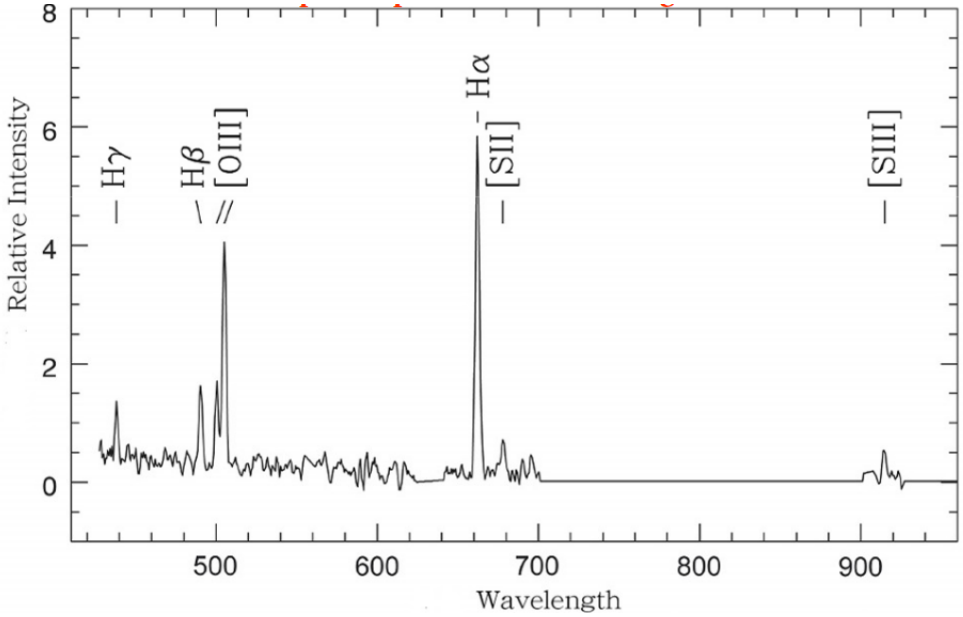

Figure 1. Optical spectrum of a HII region

- Planetary nebulae are similar to HII regions. They emit very little continuum.

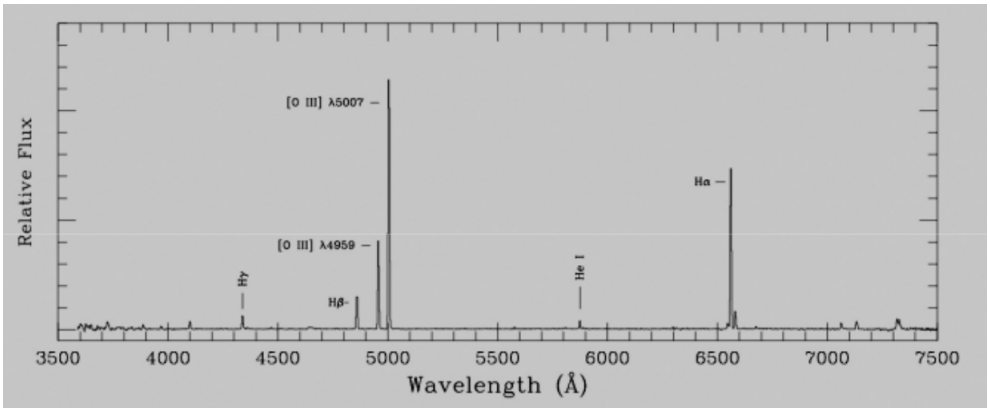

Figure 2. Optical spectrum of a planetary nebula

- HII Regions + Planetary Nebulae = Emission Nebula

Interstellar Warm Neutral Medium

- Fine Structure Energy Levels of H

  They are generated due to magnetic interaction between spin and orbital angular momentum of the electron.

$$\vec{j} = \vec{l} + \vec{s} \tag{2}$$

- Hyperfine Structure of H

  It is present due to interaction between the total angular momentum of the electron and the spin angular momentum of the proton.

- Glossary of Energy Scales

Energy Scale	Energy(eV)	Contributing Effect
Gross	1-10	Electrostatic force b/w nucleus and electron.
Fine structure	0.001-0.01	Spin-orbit interaction b/w electrons
Hyperfine structure	0.000001-0.00001	Nucleus and electron interaction.

- The 21cm Line

  *It is generated by transition between hyperfine levels of HI
  *Transition has very low probability
  *Most commonly used tracer of HI regions because atmosphere is transparent to it and HI atoms are fairly ubiquitous in the universe.

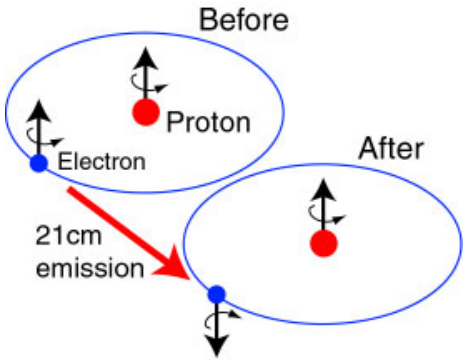

Figure 3. Spin-flip transtion of a H atom

- Spectrum Recording on a CCD
  *Vertical axis is the spatial direction
  *Horizontal axis is the wavelength direction

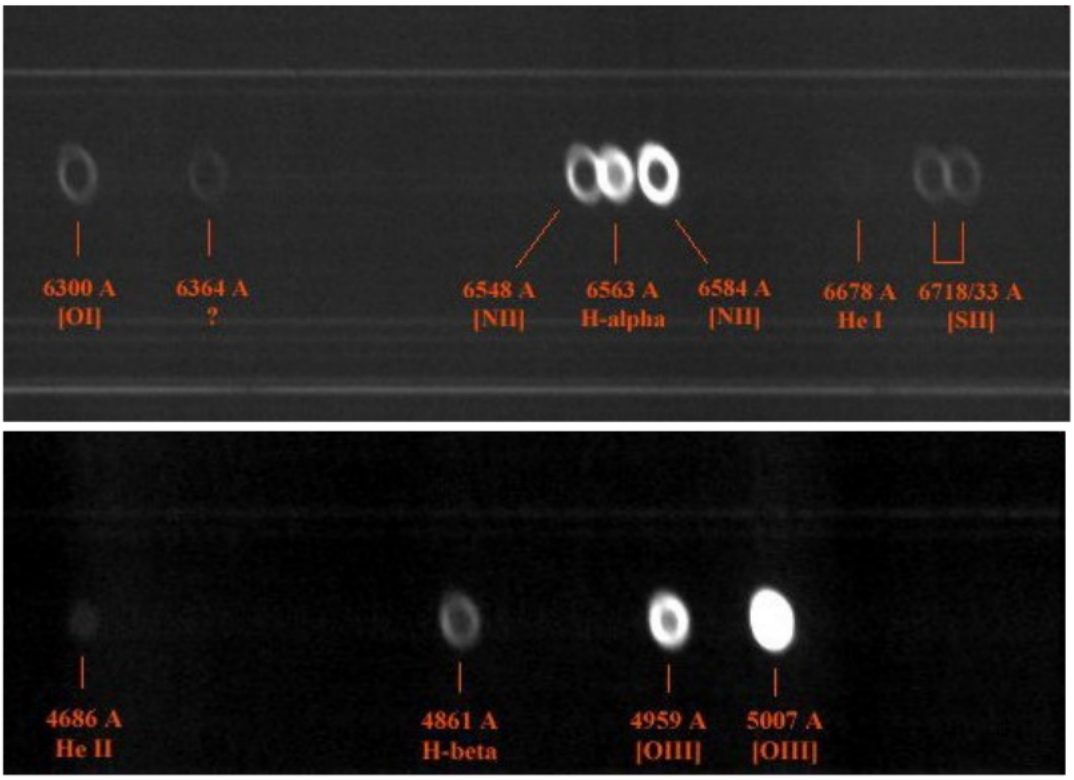

Figure 4. Spectrum of a ring galaxy recorded on a CCD