Hubble's Galactic Morphology

- The radiation coming from galaxies are basically added up different components
  - i Stars
  - ii Dust
  - iii Nebulae
  - iv Galactic Center.
- **Comparison of light curves**
  - a The spectrum produced by stars have different absorption lines.
  - b The spectrum of HII region and SNRs contain different emission lines to ion electron recombination happening in those regions.

  The comparison of both type of spectrum gives us some sense of the type of astrophysical processes involved. Which eventually helps in understanding the characteristics of the Galaxy types we are observing and leads to estimation of age of Galaxies and the type of objects present on basis of their morphology.
- **Note :**
  For all the spectrum of different objects like stars or the SNRs or the HII regions refer to the slides provided for it in the website.

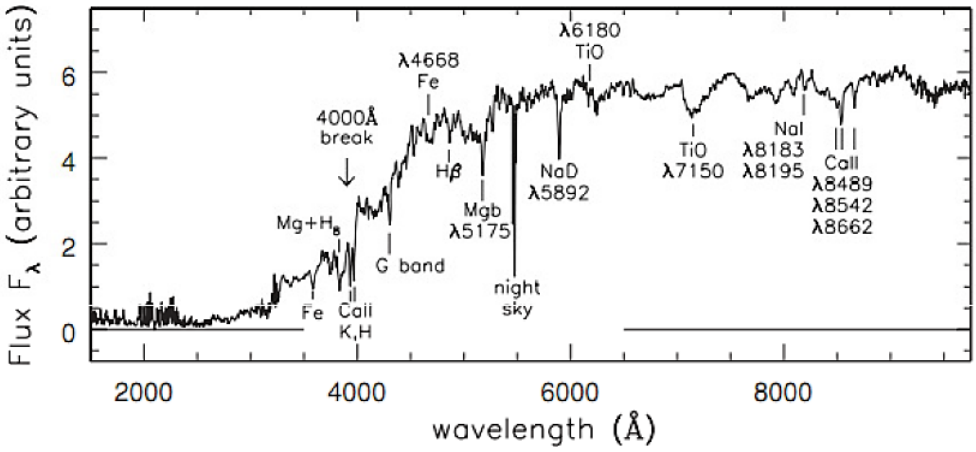

Figure 1: Spectrum of an typical Galaxy

- **Galactic spectrum's for different type based on their morphology**

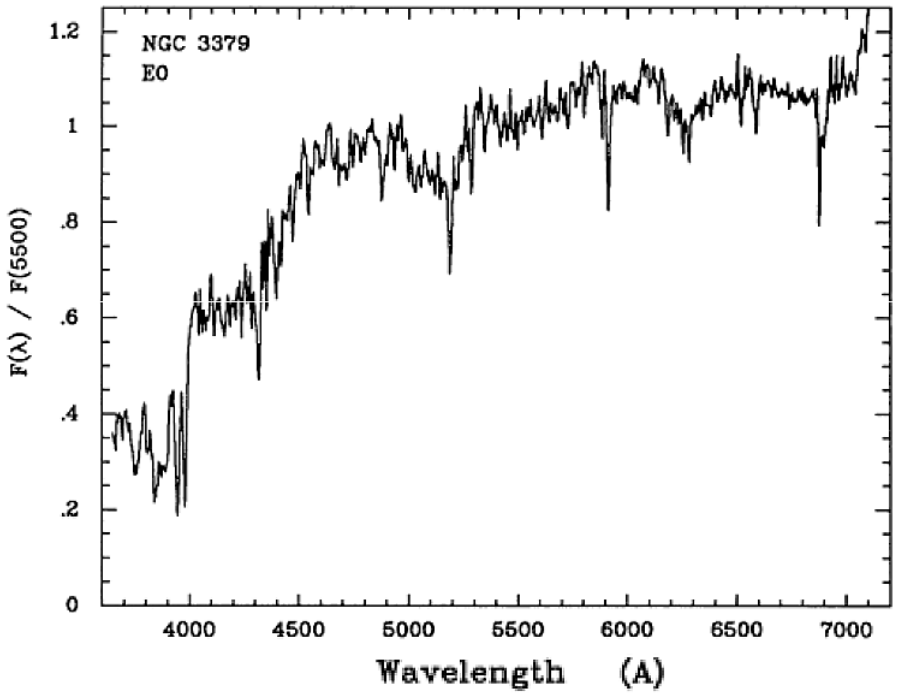

Figure 2: Spectrum of E0 galaxy

- *The spectrum of Elliptical type galaxy shows the absence of Emission lines which can be inferred as the fact that there are no more ongoing star formation going on in these galaxies as no HII region detected in them.*
  The population of stars present are very old and generally are K or M types with a life time as similar as age of Universe.
  While on the other place the spectrum of Spiral type galaxies shows strong emission line(HII regions or SNRs) inferring an underlying young stellar population, and possibly ongoing star formation.

- ***Hubble's Tuning Fork***
  Based on the observed morphologies, Edwin Hubble set out to place the galaxies in some sequential order which resulted in what is now famously known as Hubble's tuning fork. Hubble believed that galaxies started at the left end of the diagram and evolved to the right. This lead to the hypothesis that newly formed galaxies were ellipticals and they flattened and developed into spirals with the passage of time. Based on this, Hubble called the ellipticals early type galaxies and spirals as late type galaxies. The Hubble's Tuning Fork basis of the classification involved the color of the galaxies as well. Ellipticals are predominantly red in color, whereas in spirals, the spiral arms are blue in color. Almost all irregular galaxies are blue. Hubble inferred (correctly) this to be due to a predominantly older stellar population in ellipticals and a younger stellar population in spirals. But from there he came to the (incorrect) conclusion that ellipticals are older galaxies that formed early in the history of the universe and spiral galaxies formed much later and therefore are younger.

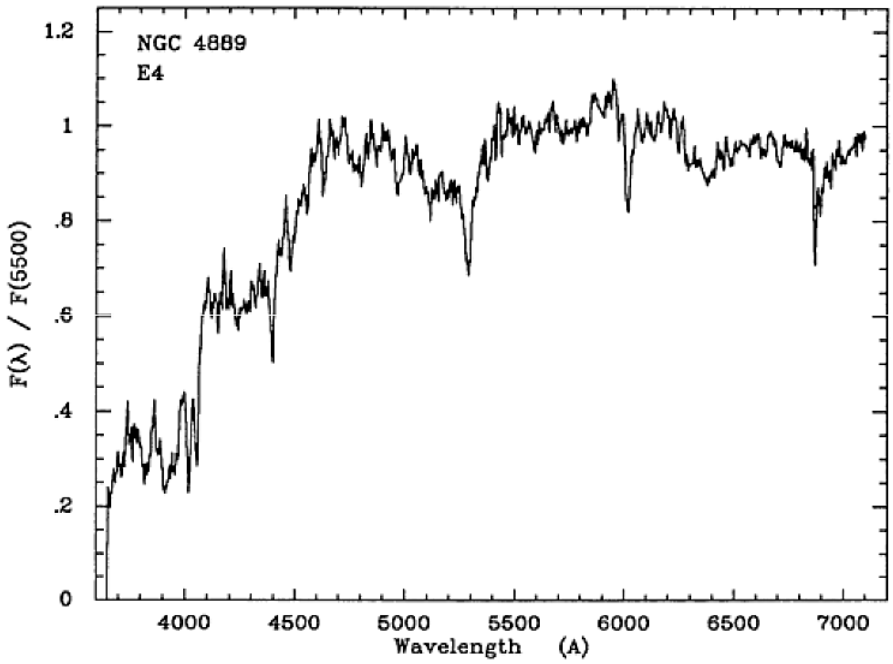

Figure 3: Spectrum of E4 galaxy

Hubble used the tuning fork diagram to put forth the idea that galaxies start at the left end of the diagram and over time evolve to the right end. This notion that the Hubble sequence is an evolutionary sequence is now completely rejected. We know this because spiral galaxies have systematic rotation, while elliptical galaxies have only random motion (not known to Hubble). It would be very rare for an elliptical galaxy to spontaneously begin rotating. The current understanding is that the morphologies of galaxies are primarily dictated by the environment in which they form. Galaxies do evolve after they form, but that evolution is not along the Hubble sequence.
Although Hubble was wrong about his theory on galaxy evolution, his diagram provides a convenient way of classifying galaxies based on their observed morphology. Astronomers still classify galaxies based on his terminology: elliptical galaxies are still referred to as "early galaxies" and spirals as "late galaxies." Despite the lack of an evolutionary trend, Hubble classification of galaxies do show some trends in certain important galaxy properties (see Figure 11).

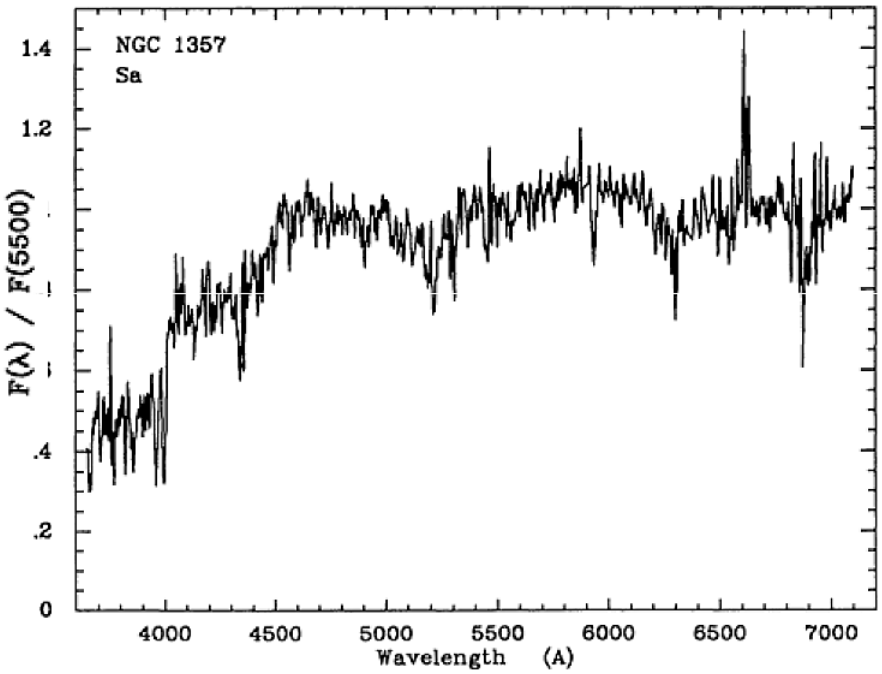

Figure 4: Spectrum of Sa galaxy

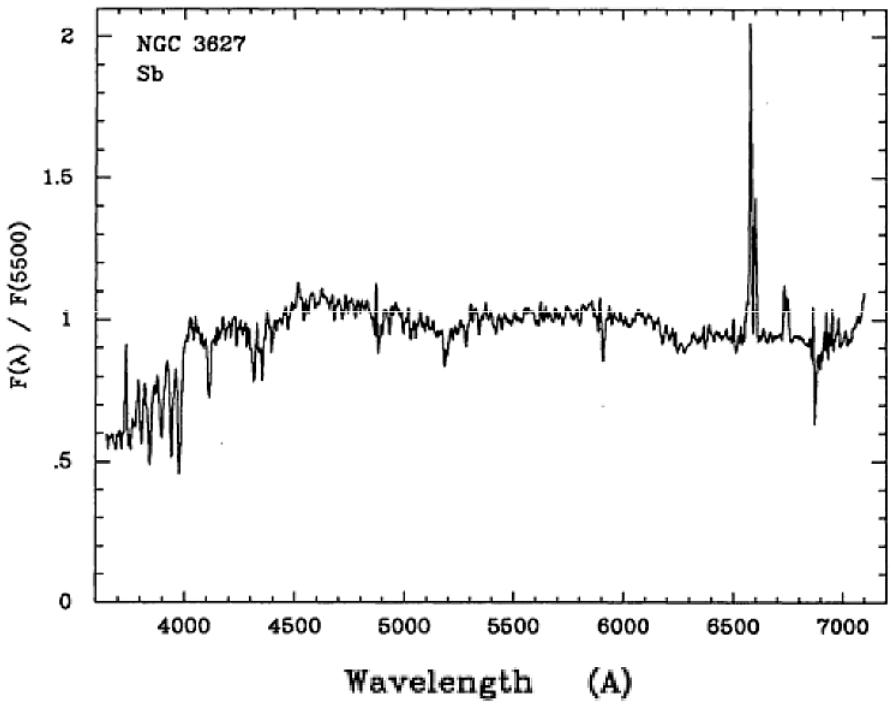

Figure 5: Spectrum of Sb galaxy

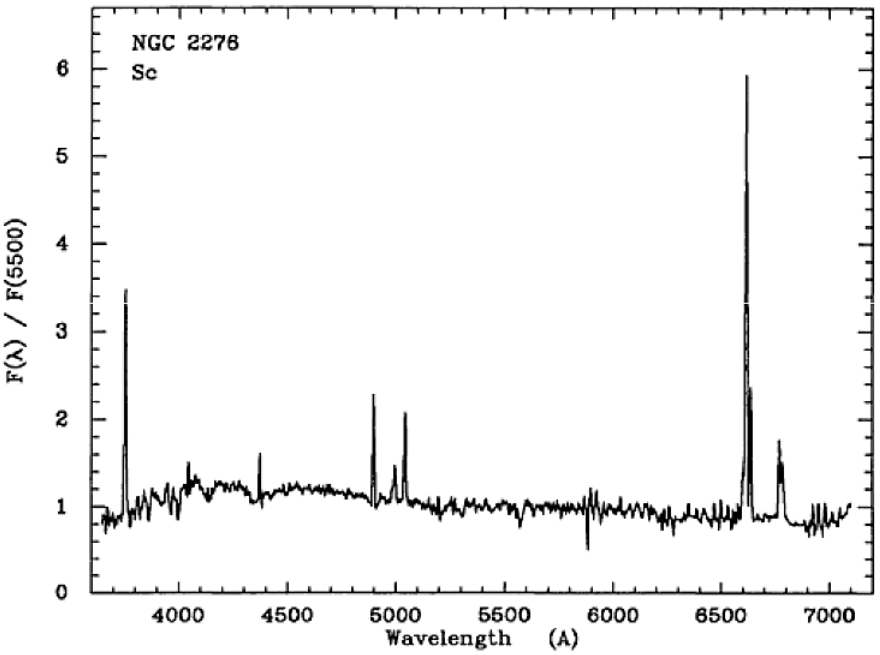

Figure 6: Spectrum of Sc galaxy

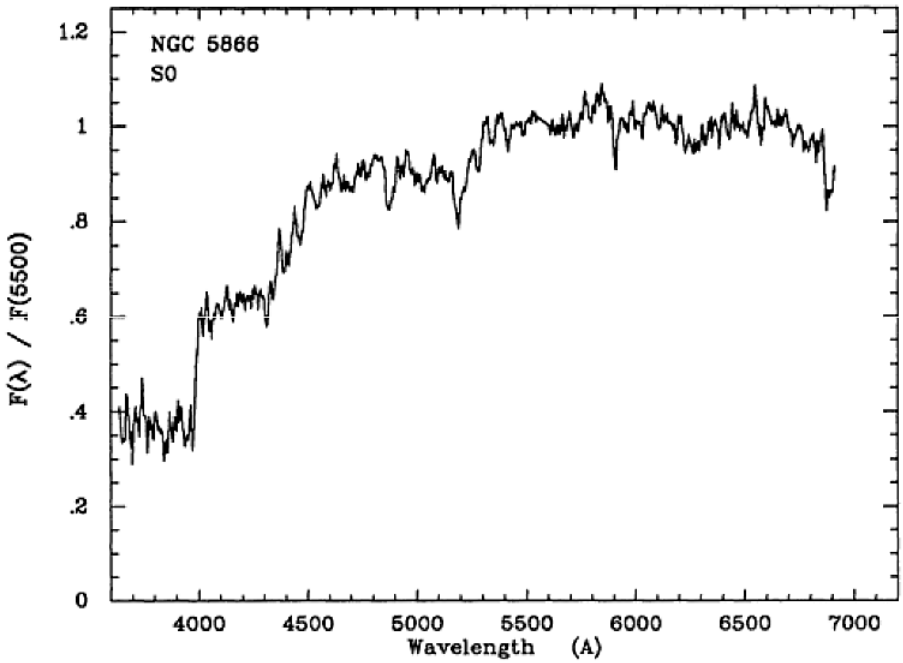

Figure 7: Spectrum of S0 galaxy

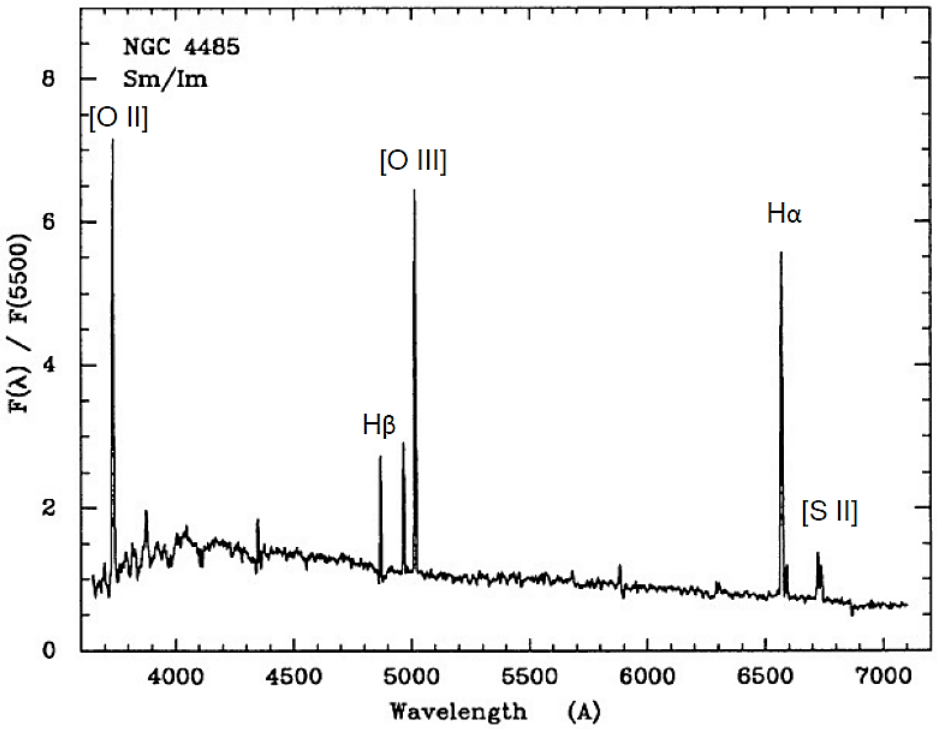

Figure 8: Spectrum of Sm galaxy

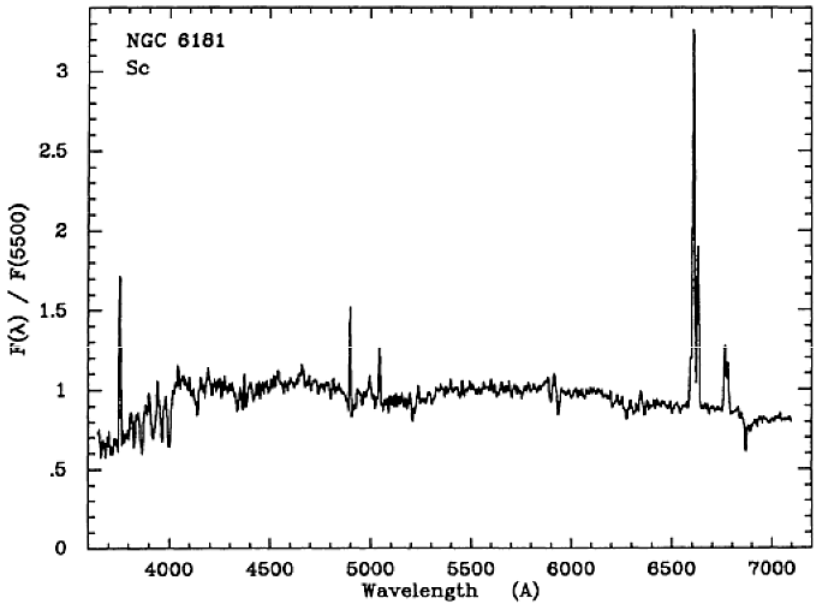

Figure 9: Spectrum of Sc galaxy

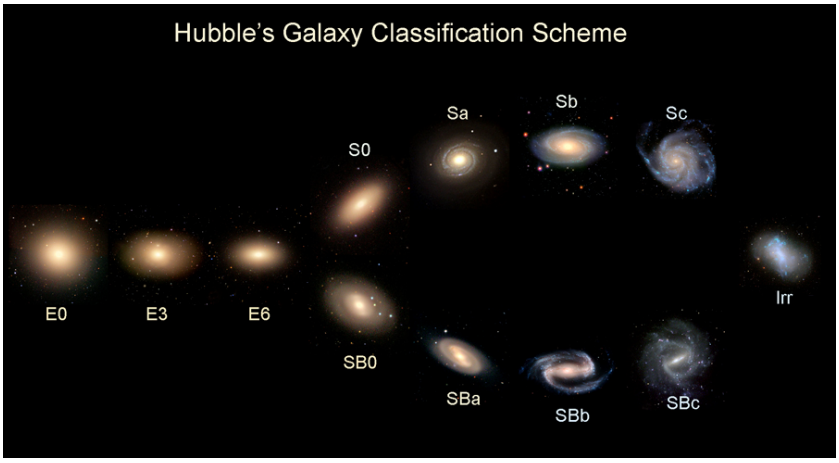

Figure 10: Hubble's Tuning Fork model

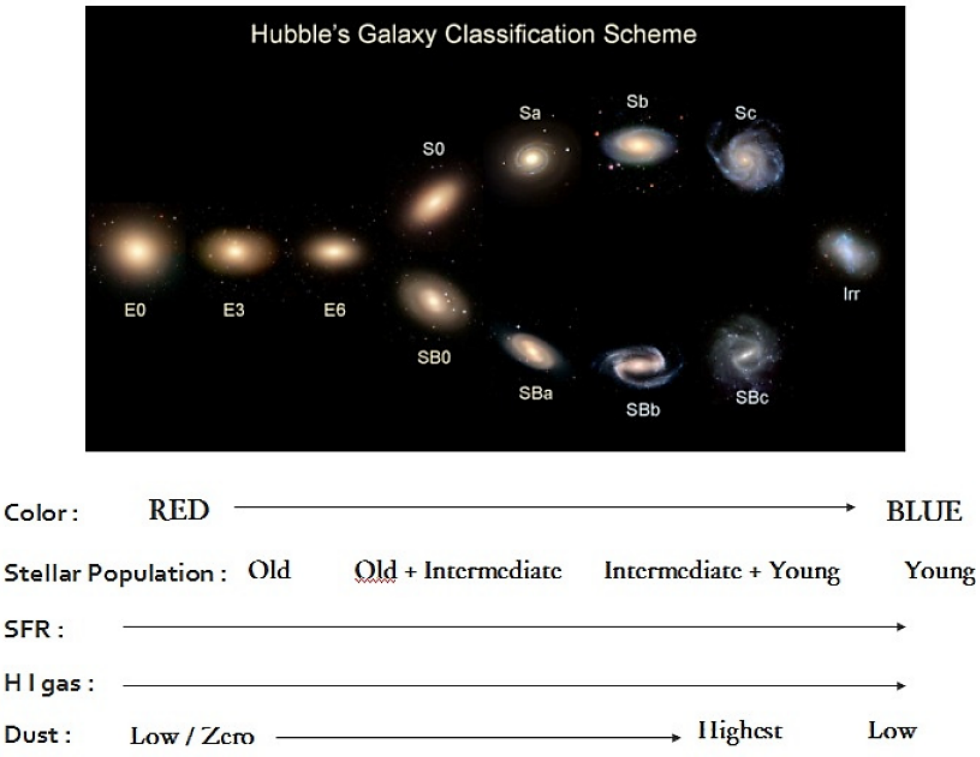

Figure 11: Trends in Hubble's Tuning Fork model