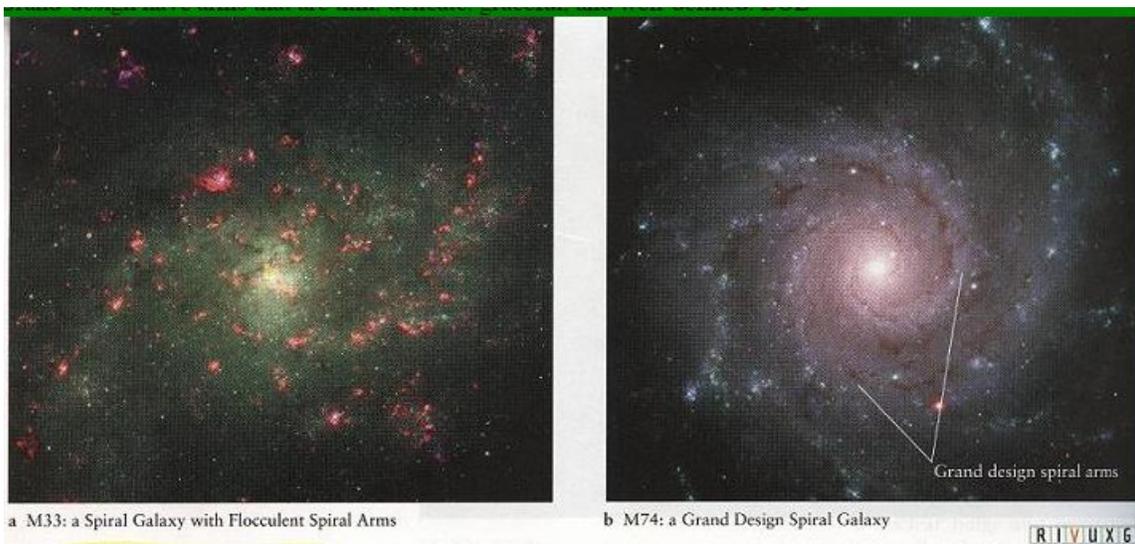


Extragalactic Astronomy

- Extragalactic astronomy was introduced only in the beginning of 20th century. Before that it was not known to people that universe extends beyond Milky Way. The galaxies that we see in the sky, were thought to be spiral nebulae. Soon after Hubble measured the distance to Andromeda Galaxy with the help of Cepheid variables, it became known that we have other galaxies than Milky Way.
- Morphological classification of Galaxies:
 - Spiral Galaxies : Spiral galaxies have three main components: Bulge, disc and halo. The bulge is a spherical structure found in the center of the galaxy. This feature mostly contains older stars. The disk is made up of dust, gas, and younger stars. The disk forms arm structures. Our Sun is located in an arm of our galaxy, the Milky Way. The halo of a galaxy is a loose, spherical structure located around the bulge and some of the disk. The halo contains old clusters of stars, known as globular clusters. Spiral arms are the region of rigorous star formation. Spiral galaxies are further classified into Normal Spiral (S) and Barred Spiral (SB). They are also classified based on tightness of spiral arms and brightness ratio of bulge/disc: a, ab, b, bc, c, cd, d.
 - * Pitch angle: Pitch angle quantifies the tightness of the galaxy. This is one of the defining attribute of Hubble Morphological type.
 - * Spiral galaxies are also classified based on the tightness of spiral arms: Grand design spiral galaxies and flocculent spiral galaxies.
 - * A grand design spiral galaxy is the one that has clearly defined and well organized spiral structures. It is thought that the arms in these spirals are actually overdense regions of the disk which trigger star formation as incoming material is compressed in that region. Flocculent galaxies are patchy with discontinuous spiral arms.



- Elliptical Galaxies:have smooth, featureless light distributions and appear as ellipses in images. They are denoted by the letter "E", followed by an integer n representing their degree of ellipticity on the sky.

Elliptical galaxies have very low HI gas content and even lower H_2 content. This points to the fact that elliptical galaxy is no home to star formation,as evident from the sepctrum of many elliptical galaxies which is dominated by old stellar population.

Elliptical galaxies are classified on the basis of perceived ellipticity:

$$e = b/a \tag{1}$$

- where a is semimajor axis and b is semiminor axis. e ranges from 0 to 7.

- A round elliptical galaxy is E0 while the most elongated are E7.
- Elliptical galaxies come in huge range of mass and luminosity. The smallest galaxies are elliptical and so are the most luminous and massive ones.
- Lenticular galaxies:Transition class between ellipticals and spiral are called lenticular galaxies or S0.S0 galaxies have a rotating disk in addition to a central elliptical bulge,but the disk lacks spiral arms or prominrnt dust lanes.Lenticulars can also have a central bar, in which case they are termed as SB0.

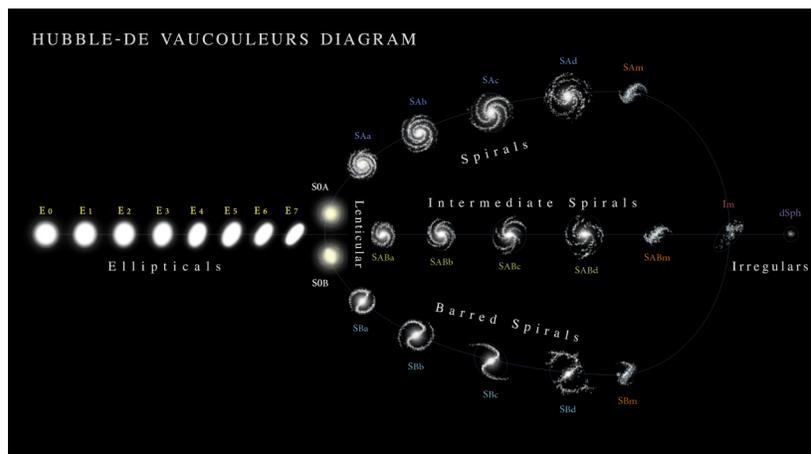


Figure 1: Hubble's classification of galaxies