30 Astro notes 2018/11/5 - Mon - Galaxies

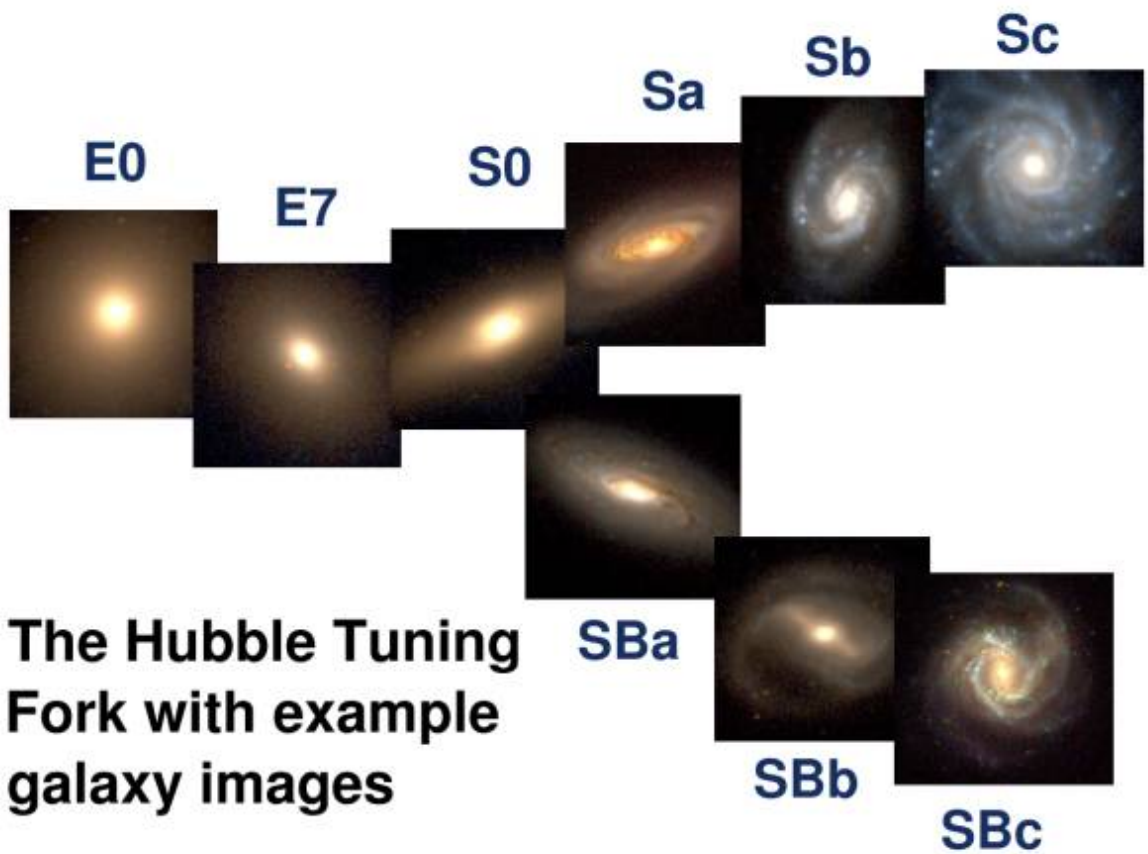
30.1 Galaxy fundamental parameters

The two major physical parameters determining the properties of galaxies are their **total mass** and their **specific star formation rate** (or more generally star formation history.

Note that SSR is related / corellated with many other properties: luminosity-weighted stellar age, color, presence of disk and spiral structure (called morphology, often quantified as bulge/disk ratio), presence of cold gas. Exactly which of these is the cause - and which others are the result - is not entirely clear. Also it is apparent that galaxies can change state and morphology in response to their evolution and environment. e.g. mergers, gas accretion, stripping, depletion of cold gas. Note that with mergers the identity of "a galaxy" is no longer well defined, and mergers are ubiquitous.

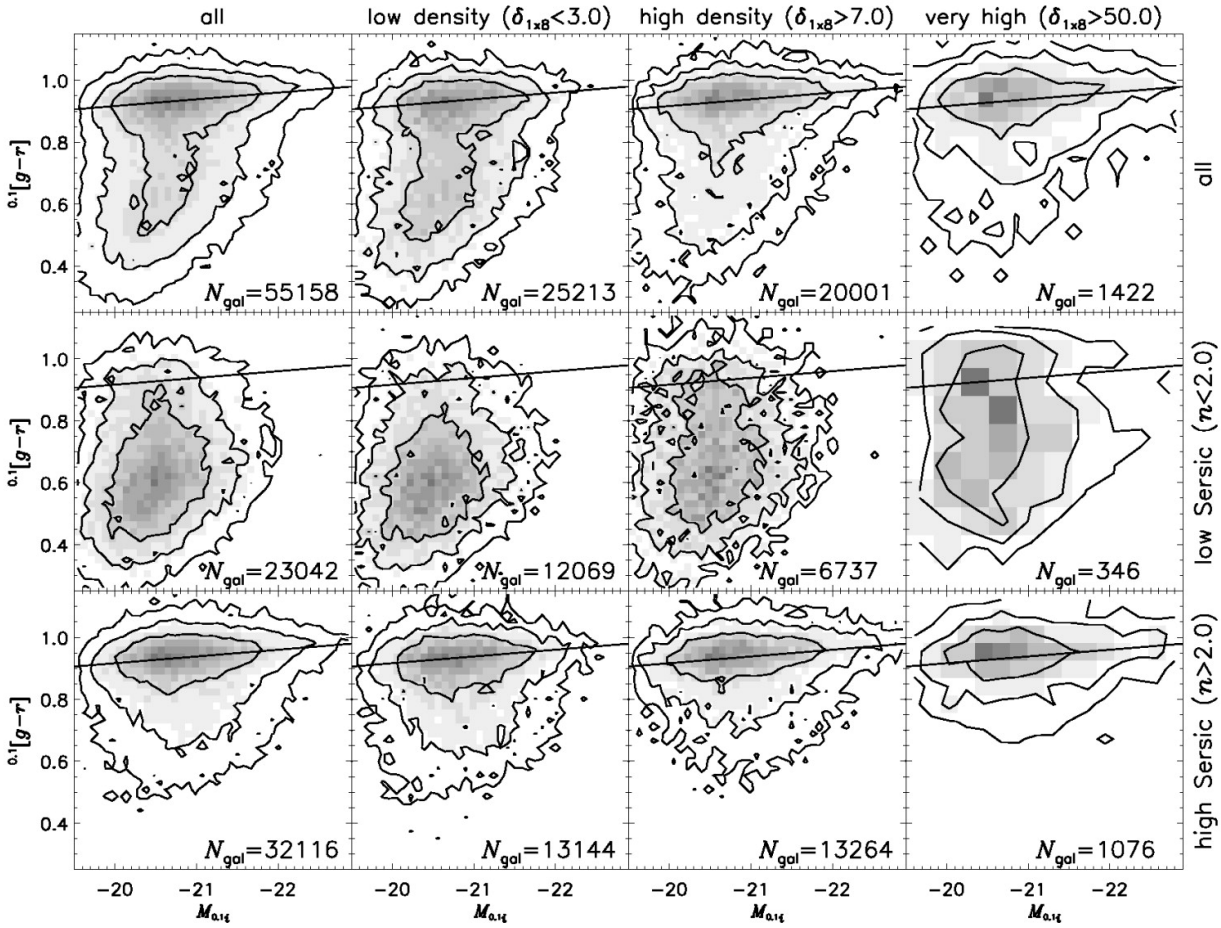
Two views of galaxies:

1. galaxy shape / morphology typically discussed via the hubble type



From left to right this sequence correlates with SSR and all the other properties mentioned above.

2. Color-magnitude, from Hogg et al. (2004, (http://adsabs.harvard.edu/abs/2004ApJ...601L..29H)

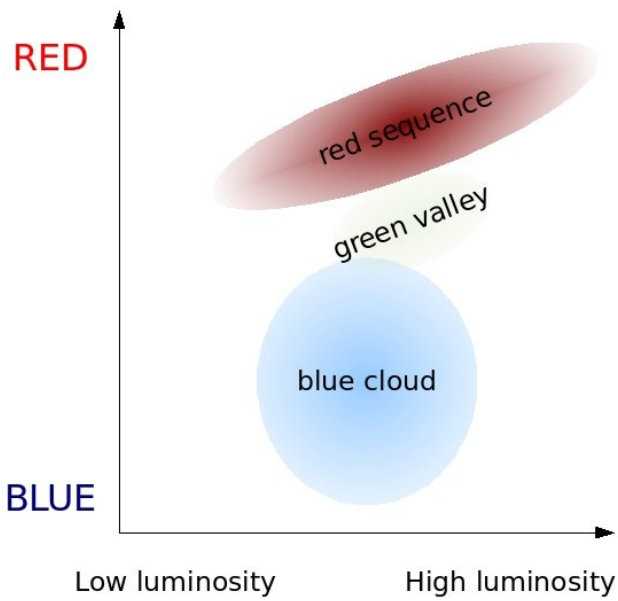


A measure of morphology can be obtained by fitting a Sersic profile of surface brightness:

$$\mu(r) = \mu_e + 8.3268 \left[\left(\frac{r}{r_e} \right)^{1/n} - 1 \right]$$

where n, r_e and μ_e are fitting parameters. r_e is called the "effective radius" and is the half-light radius. n, when fit, is **about 4 for an elliptical galaxy** (which is an exponentially falling spheriodal distribution), and **about 1 for an exponential disk**. The plots below are split by Sersic index to identify disk or spheroid-dominated galaxies.

Blue colors (toward the bottom on the vertical scale) indicate younger stellar populations (more high-mass, high T_{surf} stars). This shows that the population is split into two groups by their profiles, quantified here by Sersic index.



(from `http://en.wikipedia.org/wiki/Galaxy_color%E2%80%93magnitude_diagram`)

From this we find that galaxies with a significant disk fraction are blue but have a wide variety of colors. On the other hand spheroid-dominated galaxies for a fairly tight sequence in color vs. luminosity.

The third fundamental parameter for galaxies is their dynamical state. For example their specific angular momentum, which can determine more about details of their morphological type. e.g. the presence of a bar.

30.2 Spiral galaxies - Mass-Luminosity

One of the major features of spiral galaxies is their rotation curve. (draw example) This increases to some V_{max} toward the edge of the star/gas component, as a result of the surrounding dark matter halo in which all galaxies are imbedded. This is one of the major evidences for dark matter, as the rotation curve should fall off as $1/r$ away from the visible component without dark matter.

A relation between the galaxy's absolute brightness (luminosity) and its V_{max} is observed. Called the Tully-Fisher relation.

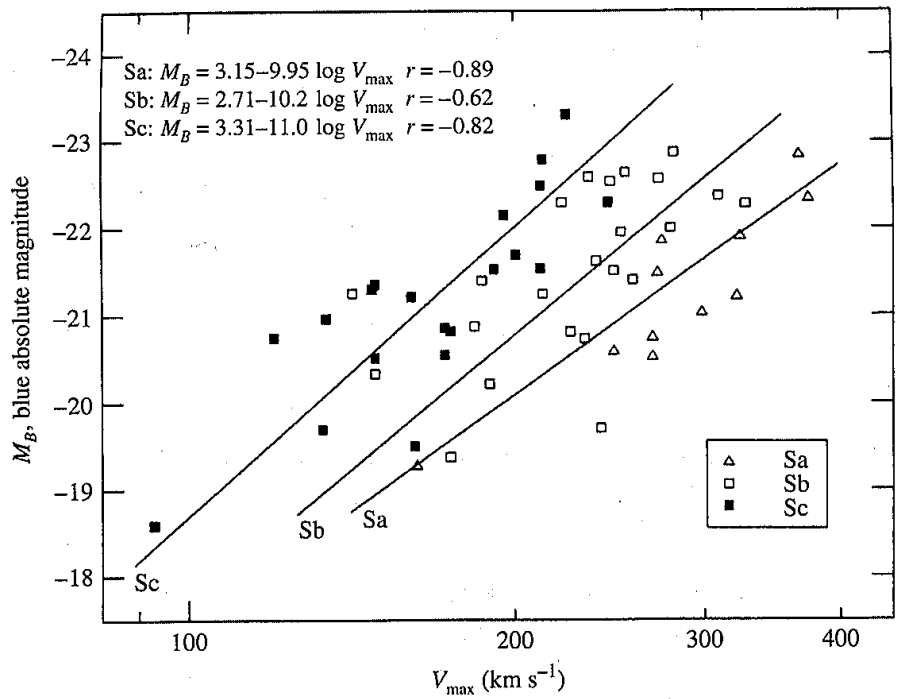


FIGURE 25.10 The Tully–Fisher relation for early spiral galaxies. (Figure adapted from Rubin et al., *Ap. J.*, *289*, 81, 1985.)

from Carroll & Ostlie