Surface Brightness, How it is measured, How surveys are affected by it

Surface Brightness

- Galaxy luminosities are much harder to measure than stellar luminosities because they are extended objects and have no well defned edges.
- We defne the surface brightness of a galaxy to as the amount of light per square arcsecond on the sky. The table given below contains the lunar age and corresponding night sky brightness in different filters.

Days from new moon	U	B	V	R	I
0	22.5	22.8	21.8	20.9	19.7
3	22.3	22.5	21.6	20.8	19.6
7	21.4	21.4	20.7	20.2	19.1
10	20.4	20.3	19.6	19.2	18.2
14	19.3	19.1	18.5	18.2	17.3

- There is less variation seen in sky brightness measured in I band.
- In addition to air glow, zodiacal light and moon glow, there is a considerable contribution from diffuse star light to surface brightness. Its not as predominant as the other sources.
- Surface brightness due to diffuse star light:

$$\mu \simeq 25 + 250e^{-|b|/20^o} \quad (1)$$

  μ-surface brightness expressed in magnitudes. b-galactic latitude

- Surface brightness is high at the center of the galaxies.

Defining the size of the Galaxy:

- We use surface brightness as a measure of the size of the galaxy.
- Using this concept, isophotes are drawn on the surface. Isophotes are contours of constant brightness.Isophotes of magnitude 25/arcsec^{-2} are termed as D_{25}.
- We use D_{25} to mark the edges of the galaxies. Though its not the actual edge of the galaxy, its used to compare their sizes. Galaxies do not have sharp edges.
- Elliptical galaxies have well defined isophotes than spiral galaxies as seen from fig1, fig2, fig3.

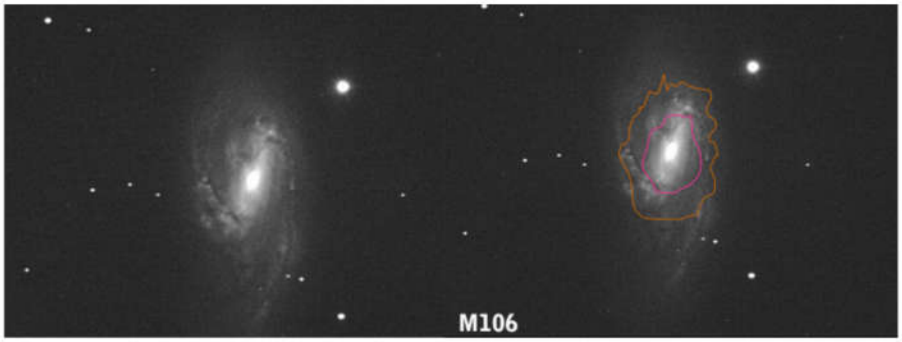

fig1:(a)M106 galaxy (b)Isophotes drawn on M106

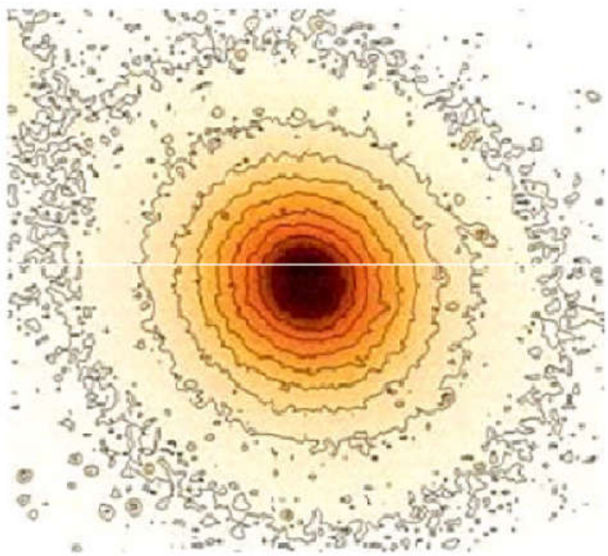

fig2:An elliptical galaxy with several isophotes drawn.

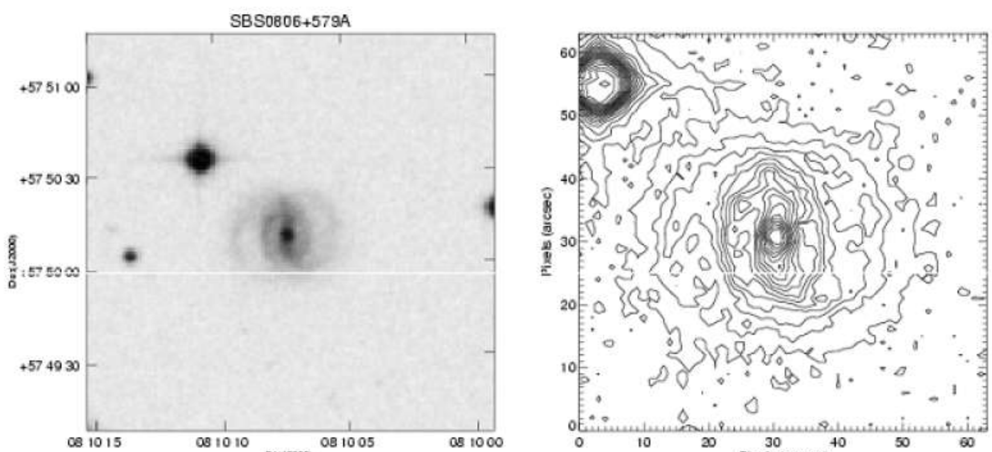

fig3:A Spiral galaxy with the isophotes drawn.

Sersic Profile

- Empirically devised by Sersic (1963) as a good fitting function
- By measuring the apparent surface brightness of a galaxy over its brighter parts, it is possible to calculate its total flux by assuming that the surface brightness over its unmeasured regions follows a standard surface brightness profile.

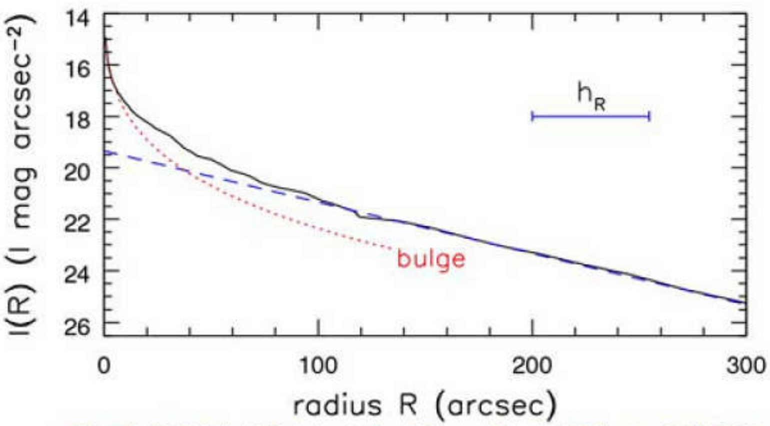

Fig 4 (R. Peletier) 'Galaxies in the Universe' Sparke/Gallagher CUP 2007

- The intensity is given by,

$$I(R) = I_e exp\left\{-b_x\left[\left(\frac{R}{R_e}\right)^{\frac{1}{n}} - 1\right]\right\} \tag{2}$$

n: sersic index 0.5$\leq$ n$\leq$ 10

I:surface brightness in flux/arcsec^2

R_e:half light radius(half of the luminosity is emitted within this radius)

I_e:surface brightness of half light radius

$$\int_0^{R_e} I(R)RdR = \frac{1}{2}\int_0^{\infty} I(R)RdR \tag{3}$$

where R=R_e and I(R)=I_e

b_n:define the shape of the sersic profile. It defines the slope of the curve in fig4.

$$b_n = 1.9992n - 0.3271....[capaccioli(1989)] \tag{4}$$

b_1=1.678 and b_4=7.669

n=4⇒de Vaucouler's Profile. This fits curves of most of the galaxies. Its given by

$$I(R) = I_e exp\left\{-7.669\left[\left(\frac{R}{R_e}\right)^{\frac{1}{n}} - 1\right]\right\} \tag{5}$$

- Surface brightness of Spiral galaxies have an exponential fall off for the disk and a $r^{\frac{1}{4}}$ fall for the bulge.
- Surface brightness of Elliptical galaxies have a $r^{\frac{1}{4}}$ fall.

Total Luminosity of a Galaxy

The luminosity, L is given by

$$L = \int_0^\infty I(R) 2\pi R dR = 7.215\pi I_e R_e^2 \tag{6}$$

R_e:half light radius; For Milky Way, $R_e \sim 0.7$kpc, which corresponds to the spheroidal component.

I_e:surface brightness of half light radius