## Measuring galaxy luminosities

Galaxies, unlike stars, are not point sources. The *Hubble Space Telescope* can resolve (i.e. detect the extended nature of) essentially all galaxies. Even from the ground, most galaxies can easily be distinguished from stars morphologically.

Define the **surface brightness** of a galaxy I as the amount of light from the galaxy per square arcsecond on the sky.

Consider a small square patch, of side D, in a galaxy at distance d:


Angle patch subtends on sky $\theta = D/d$

If the luminosity of all the stars within the patch is L, total flux is:

$$F = \frac{L}{4\pi d^2}$$

Define surface brightness as:

$$I \equiv \frac{F}{\theta^2} = \frac{L/4\pi d^2}{D^2/d^2} = \frac{L}{4\pi D^2}$$

Units of I are mag arcsec$^{-2}$ - i.e. if a galaxy has a surface brightness of 20 mag arcsec$^{-2}$ then we receive as many photons from one square arcsecond of the galaxy's image as from a star of 20th magnitude.

Centers of galaxies have $I_B \sim 18$ mag arcsec$^{-2}$.

To measure the total amount of light coming from a galaxy, need to integrate the surface brightness across the galaxy image. This leads to a related problem - galaxies do not often have sharp edges.

Typically integrate out to some limiting **isophote** - eg sum up all the light coming from regions with surface brightness $I_B < 25$ mag arcsec$^{-2}$.

This measure of the total galaxy brightness is called an isophotal magnitude - numerous variations are possible.