Surface Photometry
Surface Photometry

Galaxy apertures and Sky apertures – accurate sky estimate is critical!
Surface Photometry

\[ m = \text{-}2.5\log(I) + \text{calibration terms} \]

\[ \mu = m + 2.5\log(\text{area}) \]

Spiral galaxies: exponential disks

so \( \mu \) vs \( r \) should be straight line.
Surface Photometry
Surface Photometry
Surface Photometry

Elliptical galaxies: not exponential, classically $r^{1/4}$ or, now, Sersic profiles:

$$I(r) \sim e^{-kr^{1/n}}$$

$n=1 \Rightarrow$ exponential, $n=4 \Rightarrow$ classic elliptical.

Plot $\mu$ as a function of $r^{1/4}$ or log($r$):

![Graph 1: $\mu$ vs. $r^{1/4}$](image1)

![Graph 2: $B-V$ vs. log($r$)](image2)
**Binning** (how to get going on HW#3, problem #3)

Say you have a dataset of noisy \((x,y)\) values. You want to make a binned plot of the median value of \(y\), in bins of \(x\). You also want to estimate the sum of all the \(y\) values if they had followed the median values (instead of their actual noisy values) as a function of \(x\).

Lets do 20 bins of \(x\), where each bin has a width \(dx=5\).

```python
nbin, dx = 20, 5
inbin = np.trunc(x/dx)
bin_x = np.zeros(nbin)
bin_med = np.zeros(nbin)
bin_medsum = np.zeros(nbin)
for i in range(0,nbin):
    want = (inbin==i)
    bin_med[i] = np.median(y[want])
    bin_medsum[i] = bin_med[i]*len(y[want])
    bin_x[i] = np.average(x[want])

plt.scatter(x,y)
plt.plot(bin_x,bin_med)
print('Sum of median*npix = {}'.format(np.sum(bin_medsum)))
```
Example binning

grey dots: raw unbinned noisy data
red line: median of y values in 20 bins of x with bin size dx=5.
Surface Brightness Profile of M84 (for use with HW#3, problem #3)

Your plot for M84’s surface brightness profile should look a lot like this.
Combining Images

We can digitally combine N individual images into one master image of much better quality.

**Advantage #1:** Increase exposure time and signal-to-noise.

**Advantage #2:** Correct for image contaminants (cosmic rays, satellite trails, scattered light)

**Advantage #3:** Correct for detector problems (bad columns, flat fielding variations, etc)

**Advantage #4:** Reduce observing risk.
Combining Images

Problem #1: Different Photometric Zeropoints

Images were taken at different airmasses (and sometimes on different nights) so they have different photometric zeropoints. The same star will produce fewer counts when observed at greater airmass. We can’t just average all the images together, we have to scale them to correct for the different zeropoints.

Method #1: Observe standard stars, work out photometric solution, apply to individual images.

\[ m_V = m_{\text{inst}} + K_V \cdot \sec(z) + C_V \cdot (B-V) + ZP_V \]

Method #2: Measure stars of known brightness on the image, calibrate zeropoints directly.

\[ m_V = m_{\text{inst}} + C_V \cdot (B-V) + \text{ZP}_{\text{FRAME}} \] (where \( \text{ZP}_{\text{FRAME}} = K_V \cdot \sec(z) + ZP_V \))

Each star on the image gives a value for \( m_V - m_{\text{inst}} \) and \( (B-V) \), plot those values and work out \( C_V \) and \( \text{ZP}_{\text{FRAME}} \).
Combining Images

Problem #2: Different Sky values

Sky brightness can change over the course of a night, and also depends on airmass and direction you are observing. So the images all have different sky levels and we have to subtract off this sky level before combining.

Method #1: Measure sky at many spots across the image, work out an average value, subtract it off.

\[ \text{SKY} = \text{average sky} \]
Combining Images

Problem #2: Different Sky values

Sky brightness can change over the course of a night, and also depends on airmass and direction you are observing. So the images all have different sky levels and we have to subtract off this sky level before combining.

Method #1: Measure sky at many spots across the image, work out an average value, subtract it off.

\[ \text{SKY} = \text{average sky} \]

Method #2: Measure sky at many spots across the image, fit a plane to the sky level as a function of X,Y position on the image.

\[ \text{SKY} = X \times dx + Y \times dy + \text{const} \]