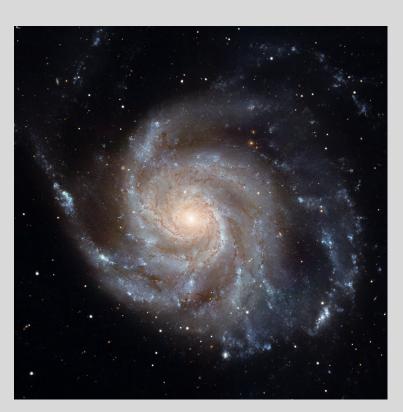
Deriving M101 Properties: Surface Brightness and Color Profile

Remember what you did in HW #2 for M84:

- Image in one filter (V)
- Binned pixels by radius, got median pixel intensity (I_{med}) as a function of radius
- Turned pixel intensity into magnitude using 1-band photometric solution:
 - $m = -2.5 \log(I_{med}) + 28.60$
- Turned magnitude into surface brightness given the area of an individual pixel:

 $\mu = m + 2.5 \log(1.45^2)$





But for the M101 data it's *different*:

- Images in two filters (B and V)
- Bin pixels by radius, get average/median pixel intensity for each image ($I_{med,B}$ and $I_{med,V}$) as a function of binned radius
- Turn pixel intensities into magnitude and color using the 2-band photometric solution function we worked out in class (See the Photometry.ipynb worksheet on the M101 Lab page)
- Turn magnitude into surface brightness given the area of an individual pixel: $\mu = m + 2.5 \log(1.45^2)$

The answer is shown in Mihos et al (2013), so you know what you are aiming for.

Deriving M101 Properties: Scale length and central surface brightness

Remember that M101 is a spiral galaxy, and we characterize its light profile as an exponential: $I(r) = I_0 e^{-r/h}$

Rewritten using surface brightness this becomes $\mu(r) = \mu_0 + \frac{2.5}{h \ln 10} r$

Fit a straight line to your surface brightness profile (decide what range of radii is best to fit and explain/justify your choice!) and use the fit to derive the central surface brightness (μ_0) and scale length (h).

Deriving M101 Properties: Total Apparent Magnitude

With your fitted values of central surface brightness (μ_0) and scale length (h), derive the total apparent magnitude of M101: $m_{tot} = \mu_0 - 2.5 \log(2\pi h^2)$. (We worked this out in one of the ASTR 323 Homeworks!)

Deriving M101 Properties: Physical Parameters

Use the distance to M101 (cite your source!) to convert observed properties (apparent magnitude, scale length in arcminutes, etc) into physical properties (absolute magnitude, luminosity, scale length in kiloparsecs).



Handling Uncertainties

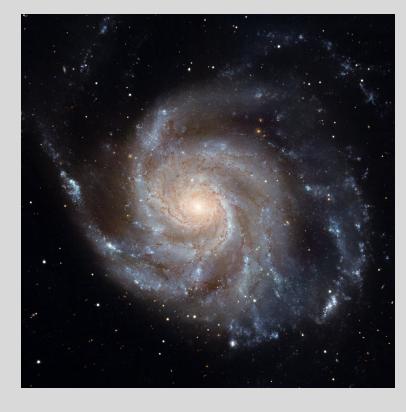
Quantitative: Propagating Random Errors

Use the uncertainties in your fits (slope, intercept) to derive uncertainties in your scale length (h) and central surface brightness (μ_0).

Use the uncertainties in h and μ_0 to derive uncertainty in total apparent magnitude (m_{tot}) .

Qualitative: Discussing Systematic Errors

Systematic errors are much more difficult to quantify. Instead, I want you to think and discuss sources of systematic errors and how they might (qualitatively) change your results.



Thinking, Discussion, and Interpretation

Compare your fitted parameters and colors/profiles to those published in the scientific literature, both for M101 specifically and for spiral galaxies more generally. *I want to see more than just a comparison to Mihos et al 2013!*

Think about what it means that you see a particular color profile. What's happening in the galaxy to give these colors? Why might it change with radius?

Think about / discuss the morphology of M101 as seen in your images: its shape, spiral structure, asymmetry, structure in the inner parts vs the outskirts, presence/absence of a central bulge, etc.

Discuss these issues in the context of galaxy evolution (inside-out galaxy formation, disk galaxy evolution, galaxy interactions, etc).

Research Starting Points (but not ending points!):

- My galaxies classes (<u>ASTR 222</u> and <u>ASTR 323</u>)
- Bill Janesh's galaxies class (<u>ASTR 222</u>)
- van der Kruit and Freeman review paper "Galaxy Disks", in the Annual Review of Astronomy and Astrophysics (ARAA)
- Blanton and Moustakas review paper "<u>Physical Properties and Environments of Nearby Galaxies</u>" in ARAA
- Mihos et al (2013): "<u>The Extended Optical Disk of M101</u>"

