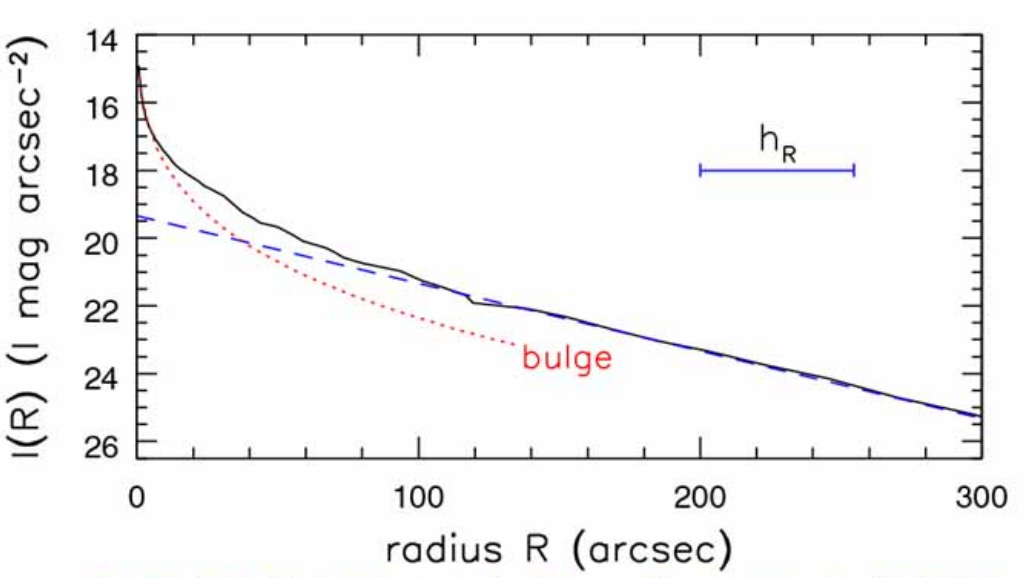
Problem Set #3: Photometry & Morphology

Due: Monday, October 5 by 5pm to Dickinson 104

1. *Extragalactic Astronomy and Cosmology*, Problem 3.1

2. Show that a surface brightness of 15 mag arcsec^{-2} in the *I* band corresponds to 18000 $L_\odot pc^{-2}$; explain why this does not depend on the galaxy's distance.

3. The Spiral Galaxy NGC 7331
   - *a.* The radial velocity of spiral galaxy NGC 7331 is v_r=820 km s^{-1}; if H_0=70 km s^{-1} Mpc^{-1}, find its distance using Hubble's Law.
   - *b.* Given that its total V-band apparent magnitude is 8.75, show that its V-band luminosity is $L_V \approx 3.7 \times 10^{10} L_{V,\odot}$. Is NGC 7331 more or less luminous than the Milky Way and M31?
   - *c.* Below is a plot of the surface brightness of NGC 7331 (*Note: Confusingly, this plot uses "I" for surface brightness, probably because it's I-band surface brightness. I use μ below, but it's the same thing*). From the graph, what is the scale length, h_R in arcsec? What is the disk radius R_{25} (the radius at which the surface brightness falls to 25 mag arcsec^{-1}) in **kpc**? How does that compare to the Milky Way's disk?



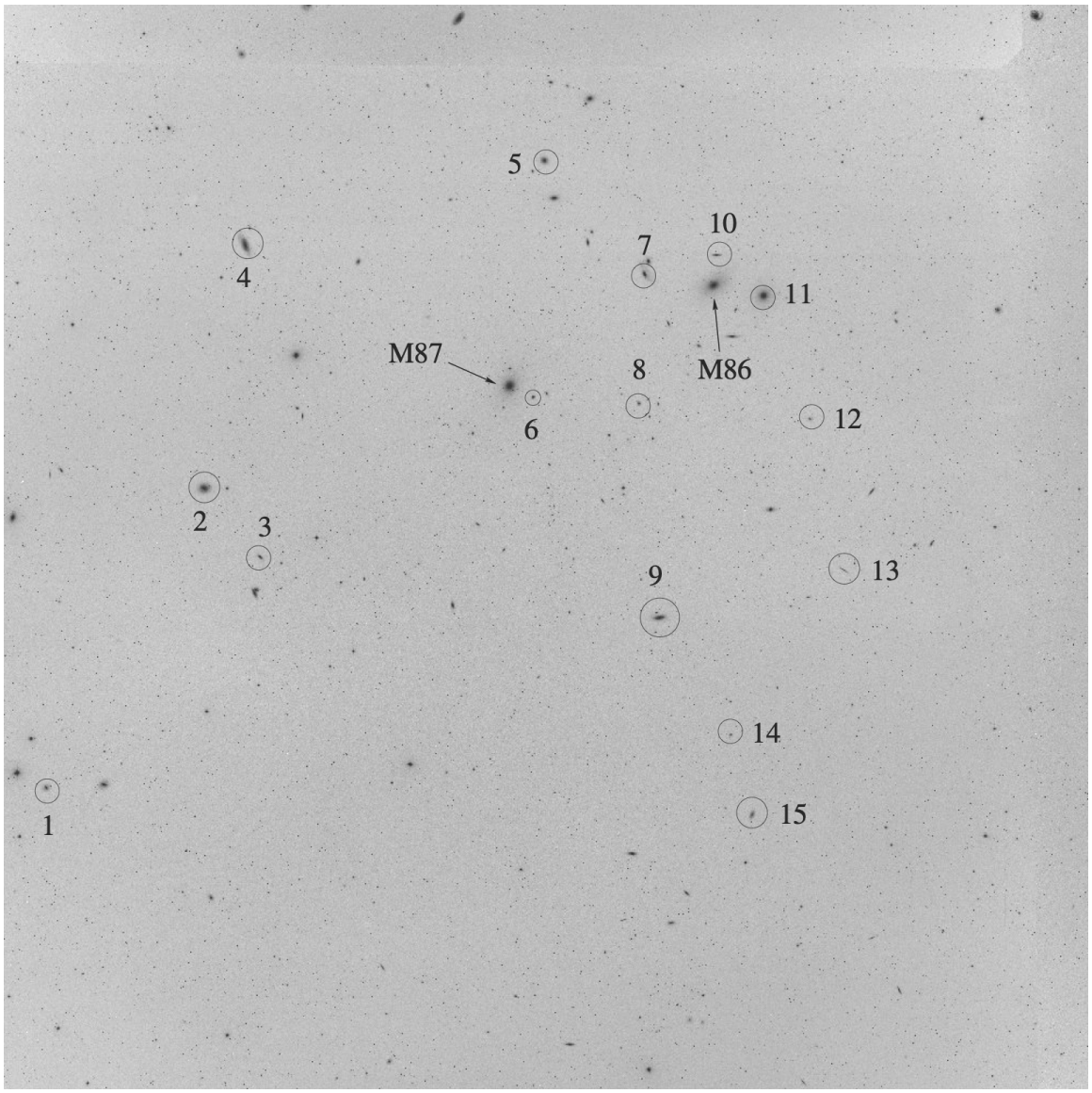
   - d. Using the techniques from Problem 2 and the above graph, show that the disk's extrapolated central surface brightness in the I band is $\mu(0) \approx 345\ L_\odot\ pc^{-2}$. Using the definition of the exponential disk (i.e. $\mu(R) = \mu(0) \exp(-R/h_R)$) and calculus, show that the total disk luminosity $L_D = 2\pi\mu(0)h_R^2 \approx 2.1 \times 10^{10} L_{I,\odot}$ (i.e. approximately 60% of the light is in the disk). What is the surface density of starlight at R = 8 kpc?

4. Locate the following galaxies in the SDSS online catalog. Look up the coordinates (using NED or Simbad) and then find them using the SDSS Finder Chart tool: https://skyserver.sdss.org/dr20/VisualTools/explore/chartinfo To show that you've successfully located each galaxy, print out an image of the target object and include it with your problem set.
   Notes for printing out images:
   a. *If you click the print button, it will auto-invert the images (i.e. stars are dark, sky is light). Please do use these settings; you'll save a lot of ink/toner.*
   b. *For larger galaxies (most of the galaxies below), please zoom out a little bit to show the field that surrounds the target galaxies.*

NGC 772
NGC 3034
NGC 4565
NGC 5457
NGC 7331

Note: Please settle on your answers for the final question below individually. It is fine to discuss general strategies, help each other through technical issues, but please make sure that your classifications and one-line descriptions are your own.

5. Below is a (much reduced) copy of a portion of a POSS print for the Virgo Cluster (RA: ~12h 30m, Dec: +12 deg). Using the SDSS navigation tool (https://skyserver.sdss.org/dr18/VisualTools/navi), assign morphological types (e.g. "E4", "S0", "SBa", etc.) to the 15 circled galaxies. The types should be on the Hubble system, as discussed in class. *Please take care to ensure that you are looking at the correct galaxies* – it can be a little tricky at first, but all of the galaxies are able to be unambiguously identified by looking carefully at the POSS plate and comparing their locations to other galaxies in the field. For this exercise, **please do not use other sky viewing tools** as they may report Hubble types for many of the galaxies (which, by the way, are incorrect in a surprising number of cases for this field). Simply turn in a list which includes the number given on the image, your assigned type, and a ***brief*** (**~1 line**) explanation for your choice. Under no circumstances should you refer to catalogs or atlases to check your answers; do your best based on what you have learned from class and the reading.


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M87
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M86
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