Draft version February 14, 2019
Typeset using LaTeX **twocolumn** style in AASTeX62

Astro257: Assignment 3

Kevin McKinnon[1]

[1] *Department of Astronomy & Astrophysics, University of California, Santa Cruz, 1156 High Street, Santa Cruz, CA 95064, USA*

1. PURPOSE

Photometry for extended sources like galaxies requires more work than when dealing with point sources. To properly determine the amount of light emitted by such a source, astronomers usually rely on finding isophotes: levels of constant brightness in an image. While levels of constant light can take on any number of shapes, we generally use ellipses to characterize the isophotes for galaxies.

The purpose of this assignment is to practice reducing images to extracting information about extended sources. In this paper, §2 will show the data reduction of NGC3379 while §3 will do the same for Hickson Compact Group #22 (H22).

2. NGC3379

First, I combine the short and long exposure frames of NGC3379 using simple addition. The reason that this works is because the frames are both centered on the galaxy (i.e. don't need to deal with aligning the frames) and the galaxy is not saturated in either exposure. This is proven in Figure 1 where slices through the galaxy's center don't reach saturation.

Next, I use the `photutils` package in `Python` to fit isophotal ellipses to the combined, higher dynamic range NGC3379 image. The fourth-order harmonic coefficient, B4, values from the ellipse fitting process are shown in 2; this shows that the B4 term is insignificant outside of the innermost region of the galaxy. These isophotes can then be used to generate a model galaxy, as shown in Figure 3. Focussing on the residuals, we see that the model does a really good job of characterising the galaxy's light.

Happy with the result of our isophotal ellipse fitting, we can create a surface brightness profile ($\mu = -2.5 \log_{10} I$) for NGC3379. When plotted against the semi-major axis to the quarter power, as in Figure 4, we see that this galaxy follows a De Vaucouleurs' profile until it reaches the sky-limit (around $a = 150$ pixels).

Corresponding author: Kevin McKinnon
kevin.mckinnon@ucsc.edu

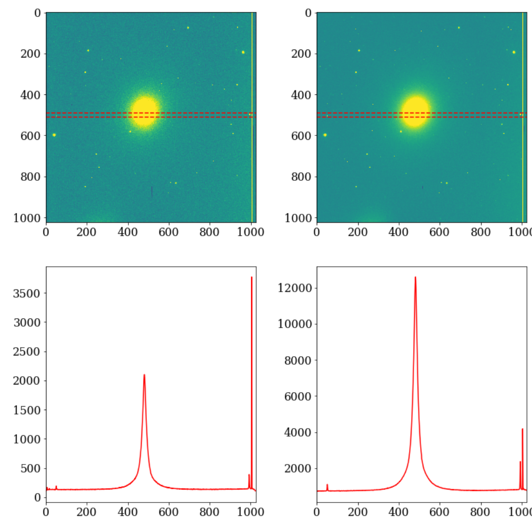

Figure 1. NGC3379 frames with row-averaged slices through each frame. The left and right panels correspond to the short (10s) and long (60s) exposures respectively.

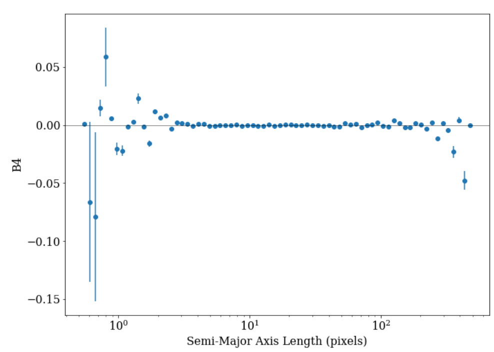

Figure 2. B4 harmonic coefficients for the isophotal ellipses fit to NGC3379.

3. HICKSON COMPACT GROUP #22

Turning our attention to the H22, we can follow a similar procedure as in §2. First, we identify the positions of the 5 largest galaxies in this image and regions devoid of bright objects for an estimate of the sky brightness. This is shown in Figure 5. Calculating the median

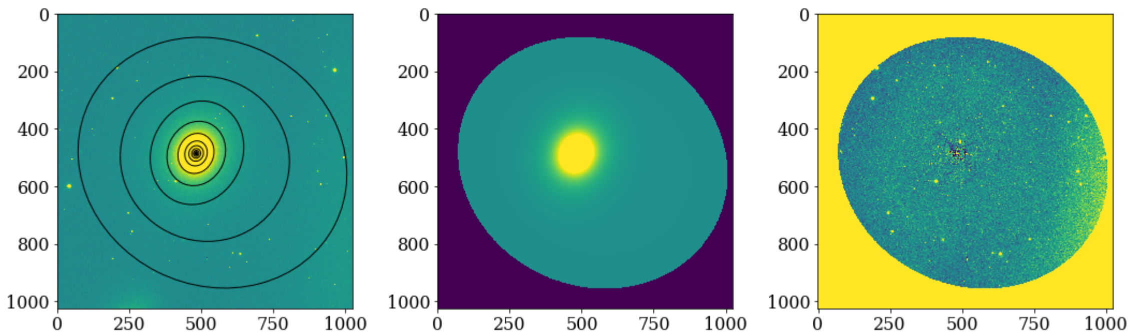

Figure 3. Left: combined NGC3379 image with best-fitting isophotal ellipsed superimposed. Middle: Model galaxy generated from isophotal ellipses. Right: residual plot generated by subtracting the middle image from the left image.

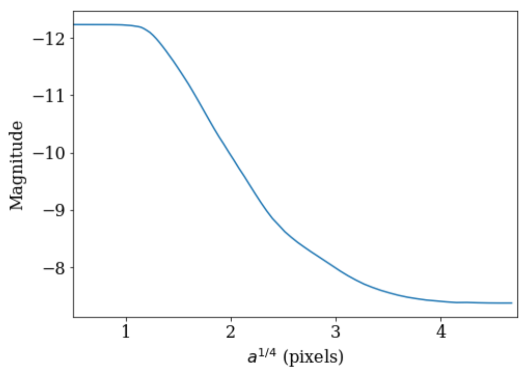

Figure 4. Calculated surface brightness profile of NGC3379.

pixel value in each of the 4 boxes returns a sky level of 761.6 ± 1.7, and this is the value that we subtract from every pixel before fitting isophotes. I then fit the 5 galaxies in the sky-subtracted image sequentially which produces Figure 7.

In this case, we see that fitting each galaxy seperately led to an overestimate of the light contained in the yellow and black contoured galaxies. In general, considering each galaxy seperately is a bad idea because it means mis-attributing light from one object to another. This problem has highlighted how difficult it is to deal with multiple extended sources at once.

The resulting radial surface brightness profiles are shown in Figure 6. These profiles indicate that the galaxy with the red isophotes is the brightest and best described by a De Vaucouleur profile while the black and yellow galaxies seem to have extremely similar surface brightness profiles.

To address the issues of considering each galaxy seperately, I rerun my procedure but fit the galaxies in the order red, blue, purple, yellow, then black. At each step, I generate the model for that galaxy and subtract that from the data before moving on to the next. The results of this are shown in Figure 8 and seem to improve upon the results in Figure 7. Specifically, the light from the yellow and black galaxies seem to be much better described by the new models when comparing the residual plots.

Future work could entail fitting the isophotes for all the galaxies simultaneously as this would be the most accurate way to properly characterize all the sources. This would most likely be quite computationally expensive and difficult to implement, but is ultimately necessary for getting accurate measurements.

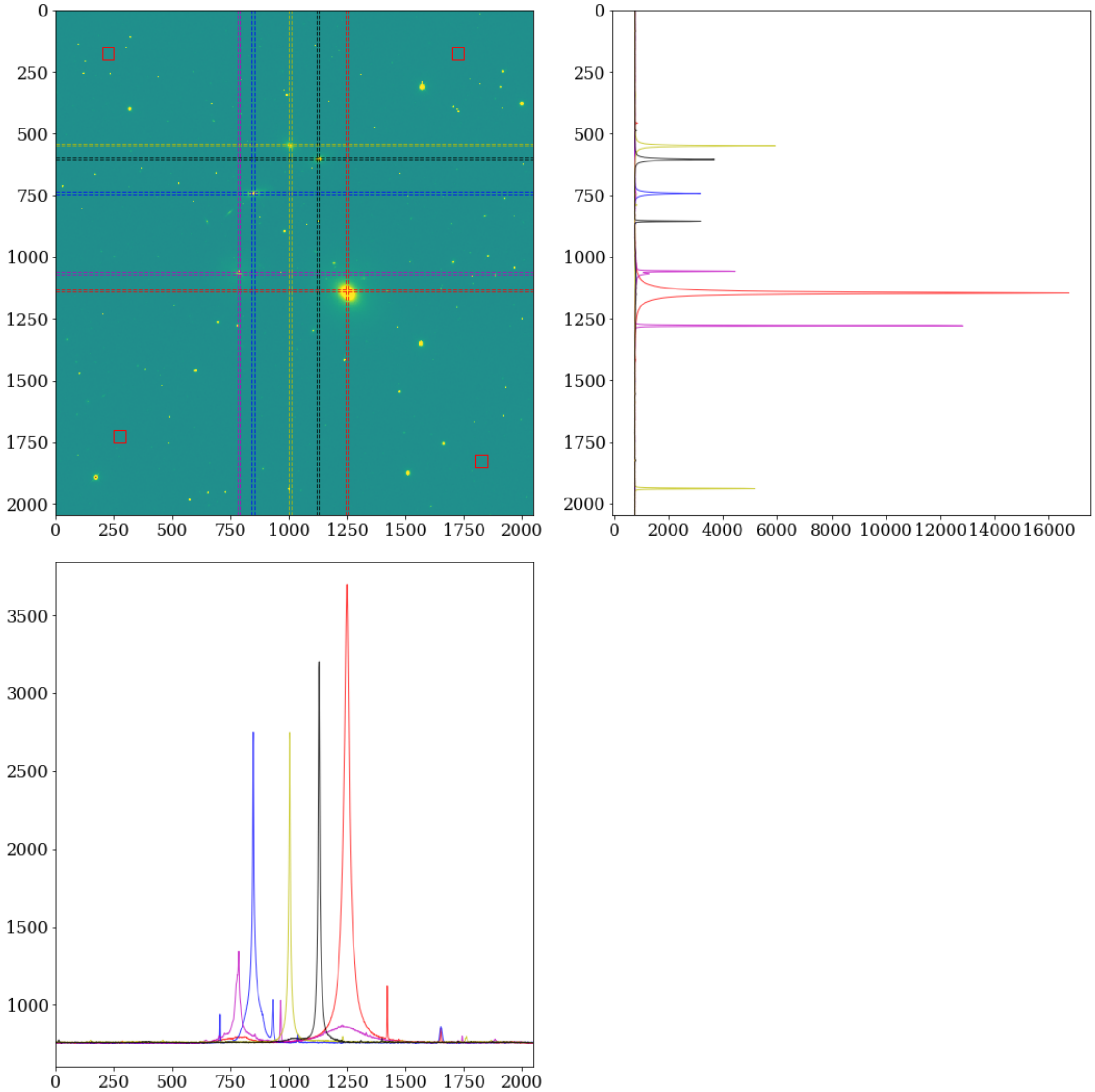

Figure 5. Image containing the Hickson Compact Group #22. The positions of 5 galaxies have been highlighted with row and column slices of a given colour and the boxes used to determine the sky level are shown in red.

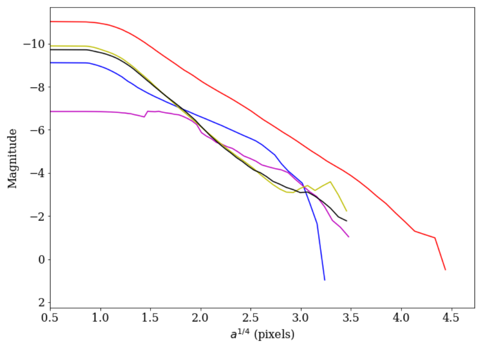

Figure 6. Surface brightness profiles of the 5 brightest galaxies in H22. Lines are coloured to match with the isophotal colours of each galaxy in Figure 5.

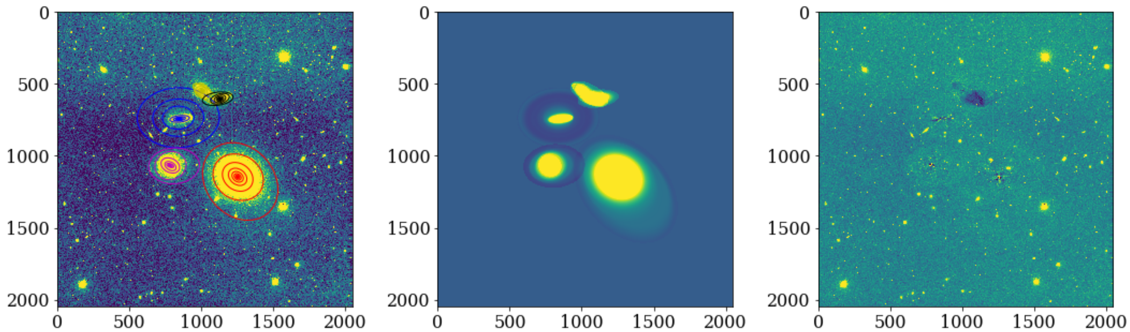

Figure 7. Left: sky-subtracted H22 image with best-fitting isophotal ellipsed superimposed. Middle: sum of the model galaxies generated from isophotal ellipses. Right: residual plot generated by subtracting the middle image from the left image.

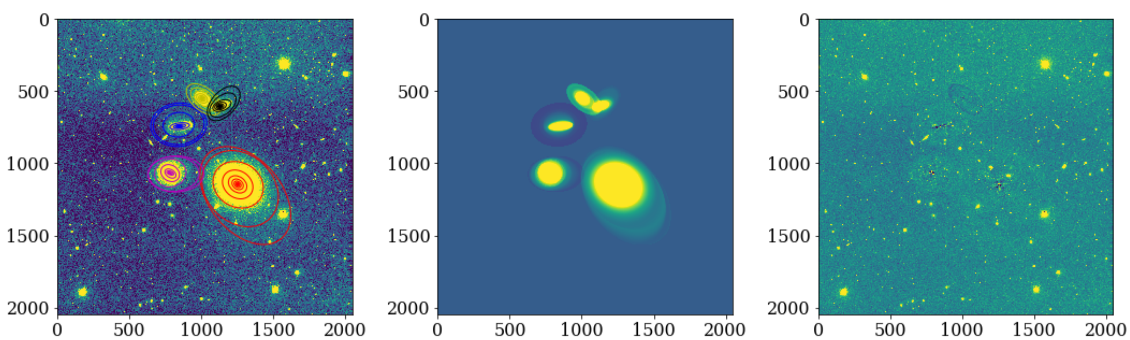

Figure 8. Same as Figure 7 but following an iterative fitting scheme where brighter galaxy models are subtracted from the data before fitting subsequent galaxies.