ASTR 8060
Homework 5

Learning Goals: Practice image combination, compute gain from calibration images.

For the following tasks, document each step as best you can with text and by graphical representation in a Jupyter notebook. Turn in plots and quantitative notes, along with your reasoning for each step. Think of these as guidelines for assessing astronomical data, rather than an exact to-do list. Be creative and careful in your in-depth analysis of the data.

1. Examine your individual flat field images for the V filter. Are there significant artifacts? How might we combine the frames into a master flat field frame to get rid of these artifacts? Compare the average light levels in your V flats and say how this will impact your combine strategy (hint: you will want to scale your flat field images to a common level, and then combine using some weighting to account for the fact that some flats have higher signal than others–it world be inappropriate to give them all equal weight). After scaling to a common mean, discuss the advantages and disadvantages of making a master flat field image from:

   - A straight average of all V flat frames
   - A straight median of all V flat frames
   - An average where outlier pixels are rejected if they are more than 3σ from the mean
   - An average where outlier pixels are rejected and the weighted mean is obtained by weighting each image by the mean counts in the original image. This way, bright flats field exposures with higher count rates are given more weight than flats with low light levels.

   Which of these strategies, if any, is the best? Or is some combination the right approach? Show plots and metrics like RMS to defend your conclusions.

2. Combine your flat field images to make a master flat for all filters using the strategy that you arrived at above.

3. Normalize your master flat field image for each filter so that it has a mean of 1 (i.e., find the mean in the image and divide by that mean) This way, when you divide your images by your master flat field image, you don't lose track of your photon statistics.

4. Divide all your science frames by your normalized flat field.

5. Compute the gain and read noise for this CCD using a couple of the flat field images and bias images, as described in Howell's Handbook of CCD Astronomy and in class notes. Decide, by examination, what sections of each image you should use to determine these values (using the whole frame is probably not a good idea, why?). NOTE: The flat-field images, F, that are used for this procedure should already be flat-fielded using a normalized master flat. Otherwise, the sigma term will contain contributions both from Poisson noise AND from pixel-to-pixel sensitivity fluctuations, and be too large, leading to an unrealistically small gain.