AST 337
Spring 2009

Name:_____

EXERCISE 3: CCD DATA REDUCTION

Due Tuesday, 10 March 2009

In this exercise we'll reduce the data we took on 17 February of M42, producing nice, clean 3-color images. This is a generic, straightforward, and basic example of CCD data reduction that has many, many applications in astronomy.

Refer to

- the *Basic CCD Data Reduction Guide*,
- the *STL6303 CCD Guide* and
- the observing log sheets

…available on the class website as you follow the procedure and answer the questions below.

1. Login to one of the class imacs (or remotely to urania), start up terminal and/or X11, download the data from our 12" run, and start up IDL:

% ast337data
% ast337idl

   How many images are there in the whole run? How many are data, how many calibration? How big is each one (in MB)?

2. Optional (should already be done by instructors for these data): Change data from 16-bit unsigned integer to 32-bit floating point, and edit header to reflect changes:

   IDL> smith_clean

3. Examine a bias frame using *atv*. What is the mean bias level in ADU? What is the rms in a small patch of a bias frame?

4. Subtract one bias frame from another and save the result as a new image. What is the rms in a small patch of the new difference frame? What is the *read noise* you derive (= $\sigma/\sqrt{2}$, where σ is the rms in the difference frame)?

5. Make a master bias frame and **subtract** it from all the raw data – science, darks, and flats (but not bias). Examine the bias-subtracted science frames.

    - How do they look before vs. after bias subtraction?
    - What is the mean sky background level in ADU in a bias-subtracted science frame?
    - What is the FWHM in pixels AND arcseconds of faint stars in the science frames?
    - What is the FHWM of bright stars in the science frames?

6. **Optional**: Make a master dark frame, normalize it, and **subtract** it from the flat and science frames AFTER scaling the dark to the same exposure time as the flat and science frames. For the CCD temperature used to take these data, what is the dark current rate in e^{-} $pixel^{-1}$ sec^{-1}?

7. **Optional:** Make a master flat field frame for each filter used (*B,V,R*), normalize it so that its mean=1.0, and **divide** it into the science frames taken with the same filter. What does the flat field frame look like? What is the mean level of the flat before normalizing? What do the data frames look like after applying the flat field?

8. Blink through the 3 frames in *atv*. Are they all perfectly aligned, or are there offsets? If there are offsets, how big are the offsets in pixels? How many arcseconds does that correspond to?

9. Align and combine the three images into a single 3-color RGB image using *threecolor*. Save your image as JPEG format, and turn in either a hard copy or electronic version with this assignment.