CCD Characterization data reduction

This handout lists the steps to be followed for analysis of data taken for CCD Characterization. Refer to the handouts given earlier.

A) Data Folder
   1. Create a folder with your name and in Desktop (e.g. Tej_CCD)
   2. Copy all the relevant files taken during the CCD lab to this folder

B) Start IRAF
   1. Open a terminal.
   2. By default you should be in the home directory. You can check this by typing **pwd**. This command is to find the **p**resent **w**orking **d**irectory. Check also that the IRAF file login.cl is there in the home directory. This can be done by typing **ls login.cl**. If not then ask the tutor for the login directory. Ensure that you start IRAF from the IRAF login directory that contains the login.cl file.
   3. Type **ds9 &**. This will open an image display window titled SAOimage.
   4. Type **xgterm &**. This command will open a new terminal.
   5. You have to work in this xgterm terminal now.
   6. In this new xg terminal type **cl**. This will start IRAF.
   7. To go to your data folder you need to change the directory.
      (a) Type **cd** and press enter. This will take you to the home directory.
      (b) From the home directory type **cd Desktop**. This takes you to the Desktop.
      (c) From Desktop type **cd <your folder>** (e.g cd Tej_CCD). This takes you to your data folder.
   8. Now you have IRAF running, you are in your data folder and also the image tool is running.

C) Rename data files
   1. Files stored with the CCD data acquisition software have the extension .fit. You need to change the extension to .fits.
      (a) Create a list file. For this type **ls *.fit > list1.** This creates a text file list1. If you open this file you will see that it lists the files (one per line). Open the file and check.
      (b) In the IRAF window type **epar rename**. This opens a file showing the parameters for this task. epar corresponds to edit parameter. Now edit as follows. Press enter after entering each parameter
         i. files = @list1
         ii. newname = fits
         iii. field = extn
         iv. You will have to press enter after entering values in each line.
         v. It is possible that the rename epar file shows you these parameters already modified. This is because the previous set of students would have done it. You can leave it as it is and proceed but incase you are interested then type **unlearn rename**. This sets it to the default parameter values. Now proceed with the steps i. to iii.

vi. After editing the parameter type **:go** and press enter. This saves the parameters and runs the task.
vii. Check in the folder and you will see that the file extensions have been changed to .fits.

D) Cosmic Ray Removal
1. During the duration of exposure (true in the case of bias frames also which are zero exposure frames) cosmic rays hit random pixels. These need to be removed.
2. For this make another list file of the fits images – **ls *.fits > list2**
3. You need to go to the task cosmicrays. For this type in sequence **noao** then **imred** then **crutil**.
4. Type **unlearn cosmicrays**
5. Type **epar cosmicrays** and edit the following parameters
   (a) input = @list2
   (b) output = cr //@list2
   (c) interac = no
6. Remember to press enter after editing each line.
7. Type **:go** for the task to run. This takes a while so be patient.
8. Check in your folder for files generated with prefix cr. These are cosmic ray corrected files. You can open images in SAOimage to check files with and without cosmic ray correction. The procedure for opening and using SAOimage is explained separately at the end of this document.

E) Check for Bias drifts
1. This involves checking the image statistics of the bias frames.
2. Make a list file of all bias frames – **ls cr*bias*.fits > biasframes**
3. Obtain the image statistics by using the task imstat
   (a) Type **epar imstat** and edit the following parameter.
      i. images = @biasframes
   (b) Type **:go**
   (c) The image statistics will be listed
4. I**n your report make a table of the mean value of the bias images and comment on the bias drift.**
5. **If you have taken bias measurements at different operating temperatures then include that in the table to see the variation (if any) with temperature.**

F) Generate Master Bias Frame
1. This involves taking an average of all the bias frames.
2. Use the list file of all bias frames – **biasframes**
3. Type **epar imcombine** and edit the following parameters
   (a) input = @biasframes
   (b) output = masterbias
   (c) combine = average
4. Type **:go**
5. Check in your folder for the generated file masterbias.fits
6. Make sure you use the bias frames at the same operating temperature to generate the masterbias frame.

G) Bias Subtraction

1. This masterbias has to be subtracted from all frames.
2. Create a list file of all cosmicrays corrected files – **ls cr*.fits > datafiles**
3. Manually remove the bias files from this list.
4. Type **epar imarith** and edit the following parameters
   (a) operand1 = @datafiles
   (b) op = -
   (c) operand2 = masterbias
   (d) result = bs_//@datafiles
5. Check in the folder for bias subtracted files created with prefix bs.
6. Make sure you subtract the masterbias frame from other frames taken at the same operating temperature.

H) Read Noise

1. Read noise is determined by examining the cosmic ray corrected, bias subtracted read noise frames. Follow same procedure as in (E) to get the rms values in the read noise frames.
2. **Determine the average read noise for this CCD and include in report.**
3. **Your report should have a table with the read noise measurements. Comment on the variation with exposure time.**

I) Dark Current

1. Dark current is determined from the cosmicrays corrected, bias subtracted dark frames.
2. Follow same procedure as in (E) to get the mean value of the dark frames.
3. **Your report should include a table listing the mean values of the dark frames.**
4. **Your report should include a plot of the measured mean values as a function of the exposure time. The linear fit discussed below should be included in the plot.**
5. **Perform a linear fit (you can use any software for this – e.g excel) and determine the dark current. The result of the fit should be included in the report. Also state the derived dark current clearly with units.**

J) Linearity and Gain

1. You would have obtained frames with different exposure time for linearity measurements.
2. Use the cosmic ray corrected, bias subtracted frames.
3. Determine the mean and the rms values of the frames following the procedure as in (E).
4. **Plot the mean value as a function of the exposure time.**
5. **In the plot indicate the data level upto which the response is linear.**
6. **Estimate the gain of the CCD from the plot of the mean as a function of the variance. Give proper units.**

K) Charge Transfer Efficiency

1. For this use the dark frames which are not corrected for cosmic rays. Subtract masterbias.
2. Identify cosmic ray hits. Cosmic ray hits with a few ten thousand data units are ideal for this calculation.
3. **Determine the data value of the cosmic ray hit, data value of the next pixel in the same row and the x value of the cosmic ray hit pixel.**
4. **Use the formula given in the CCD Characterization handout and calculate the CTE.**
5. **Atleast five measurements of the CTE should be made. All calculations are to be included in the report.**