MONDAY, 5/06/2019

Today, we have to go back and re-collect data because we did not get any of our images to show saturation.

CCD Project due on Monday, May 13!

CCDs & Data Reduction

- What do we want to know about the devices we're using and why?
  - **Full well -** what is the max number of electrons a pixel can hold? This is a function of a pixel size - so bigger pixels (binned!) can hold more charge
  - **System gain constant - electrons per DN**
  - **Read noise -** "voltage uncertainty" (when measuring electrons moving through pixels)
  - **Charge Transfer Efficiency (CTE) -** how efficiently we can move charge from pixel to pixel; usually very high, 0.9999999995 or more
  - **Dark current -** caused by thermal charge generation, reduced by cooling
  - **Quantum Efficiency -** How efficiently the CCD detects light
- How do we measure these values?
  - **Full well -** using a photon transfer curve
  - **System gain constant** - PTC also
  - **Read noise -** calculation sigma (standard deviation) of bias. (In DN). Make sure to use "clean" parts of the chip
  - **Charge Transfer Efficiency (CTE) -** using an Fe55 x-ray source
  - **Dark current -** by taking dark frames
  - **Quantum Efficiency -** flats will well calibrated and controlled illumination

- Photon Transfer Curves
  - They show different regimes, where different kinds of noise dominates our detector
  - They let us know which portion of our CCD is giving us this linear behavior
  - When you're read noise dominated, it's not ideal; can't remove it (you want to be in regimes where you have more signal and this place doesn't have that)
  - Shot noise, the arrival time of photons
  - Once you reach full well, there is a turnover in saturation
- ADU Saturation
  - In a CCD, we have to convert from analog to digital signals
  - The ADC is the electronic component that performs that operation. Each ADC has a defined number of bits
  - You can get ADU saturation when you're ADC stops being able to count
- PTC: Theory vs. Data (linearity)
  - Non-linear regime means when saturation is approaching
  - Dark current can be useful in finding weird patterns

- Noise
    - THree knids of noise dominated at different regimes, and we remove/adjust to improve our ability to go from what we've measured to what was emitted. We can make estimated for our S/N in these different regimes
    - Read noise - remove with bias, not ideal, S/N ~S *
    - Shot/photon noise - "bright" objects (S/N ~ sqrt(S*))
    - Pattern noise - removed with flats (artifacts both physical and electronic)
    - S = signals, N = noise, S* = signal for the object, SS = sky signal, T = time, DC = dark current, R = read noise, G = gain
- CCD Equation:
    - $$\frac{S}{N} = \frac{S_*}{\sqrt{S_* + n_{pix}(1 + n_{pix}/n_{sky})(S_s + t * dc + R^2 + G^2\sigma_f^2)}}$$
    - Unit of S/N is in electrons
    - In [31]:
```
t = 300 # seconds
R = 6 # e- RMS
dc = 10/3600 # dark rate, e-/pix/hour --> converted to 10/36000 e-/sec
S_s = 604*2 #ADU
r_in = 20
r_out = 30
Sstar = 6487*2
n_pix = np.pi*25
n_sky = np.pi*(30**2-20**2)
square = (math.sqrt(Sstar+n_pix*(1+n_pix/n_sky)*(S_s+t*dc+R**2)))

S_N = Sstar/(square)
S_N
```
      Out[31]: 38.153637092614
- Bias Subtraction
    - If we go down to zero, we will have a negative and positive number
    - We have to use an excess bit, just to replace the negative value
    - The bias is a function of read out, not of time
- Flat fields
    - Not perfectly flat
    - We are trying to measure pixel to pixel variation
    - It is an image illuminated evenly by light
    - Pixel response is a function of wavelength - so we need flats for each filter we are using for data
- Darks
    - CCDs, even when cooled, generate a small amount of thermal current. This scales with time. Often it is a small effect, and people skip darks. Darks also can show large scale pattern noise (in this case caused by poor cooling link behind the CCD)

WEDNESDAY, 5/08/2019

Data Reduction

- Install python package CCDProc

Download the data of your choice:
Useful commands -

- get filename
- mget something*.fits

An example:

get M51*.fits

I couldn't unzip the tar file so I had to use another computer to unzip and send it to my personal computer. That seemed to work!

Out of focus = delightful donuts
Big donuts = dust, not in a focused plane
See them in the sky flats and the dome flats

Create a "master" bias, flat set, and darks
Finding the median of the bias image and subtract one bias value
io.fits helps us retain the header information, when we write new files, we want to carry over the header info (a way to attach notes about the contents)

You can create a fits file from scratch and give it a header

numpy.median can be used to compute the pixel to pixel master image.

FRIDAY, 5/10/2019

Fits & Flats

- HCG 79 = Hickson Compact Group 79
- When you're looking for RA and Dec, the image will be focused on the very center point of the image
- Better to use ned coordinates instead of wiki
- Overscan is that really big line that tends to appear in the center of the screen
- Cosmic rays are around the dark bands at the edge of the images
- Cosmic rays = high energy particles, crashing through our CCDs, look like streaks or many tiny dots

Vignetting

- This area isn't getting as much light as it should be, or as the center, because something in the instrumental isn't right?

Single slit spectra-graph - some images we get of galaxies will look shaky with multiple lines, almost like an instrumental error but what it is, is a “single slit spectra-graph”.
For a spectra graph, light is dispersed through some element.

- Not scientific data
- It’s very difficult to understand what you are looking at for spectra graphs
- You can use filters with spectra graphs, but in general we don’t

Sometimes people will use OH lines to calibrate with
Infrared varies a lot in terms of time and other stuff, is a hassle

- They must also be very very cold, their optics must also be cold

Out of focus star:
If you see a donut looking thing in the middle of the image, it is an out of focus star, don’t use that data!

Note: CCD report is due on monday, may 13! :O
Draft 1 due for the project !!! on monday, may 20!