

NIR Image Reduction of NICFPS APO Data of SACS X-Ray Detected Galaxy Clusters

Angelina Azzo and Dr. Dai

What is a Galaxy Cluster?

- A structure that has hundred to thousands of galaxies that are together through gravity that have the mass of around 10^{14} solar masses.
- Mostly made up of dark matter, hot gases, and stars/galaxies.



<https://www.universetoday.com/30522/galaxy-cluster/>

Why? And Where we are getting the data

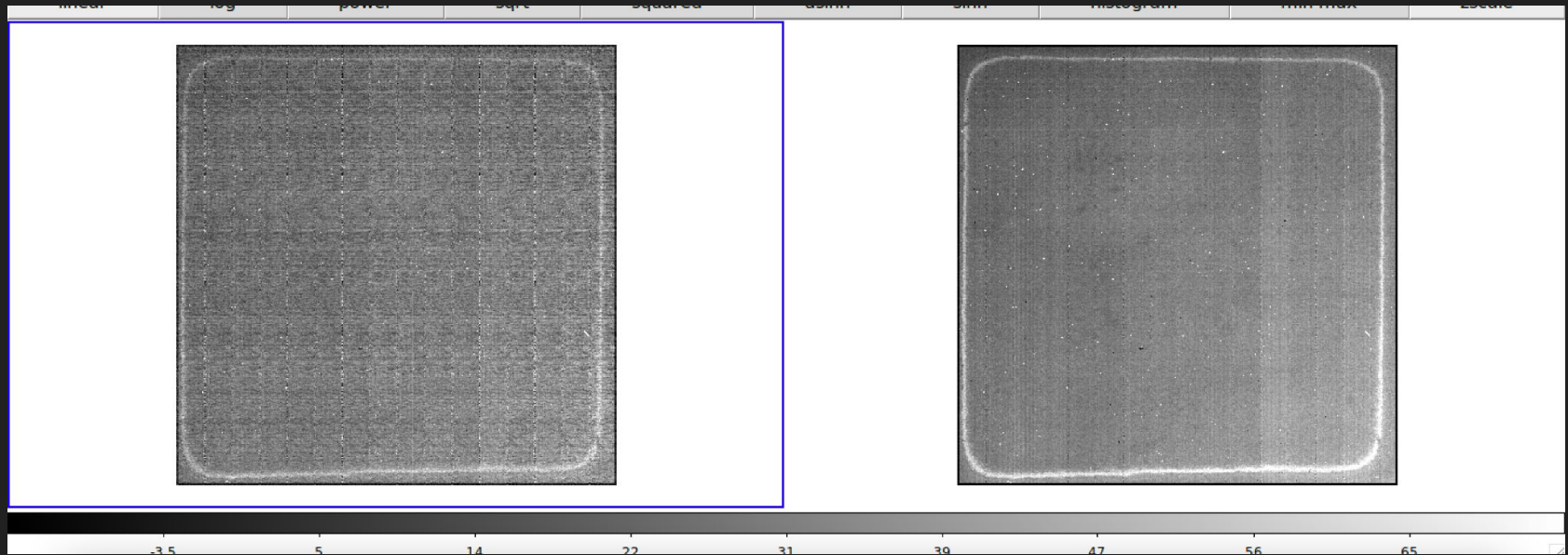
- Learn about how the galaxy cluster formation
- To learn more about galaxy formation, and evolution
- Find out more about dark matter.

Where?

- Apache Point Observatory
- APR (Astrophysical Research Consortium) a 3.5 meter telescope
- The telescope uses a NICFPS. NICFPS is a near infrared camera and Fabry Perot Spectrometer.

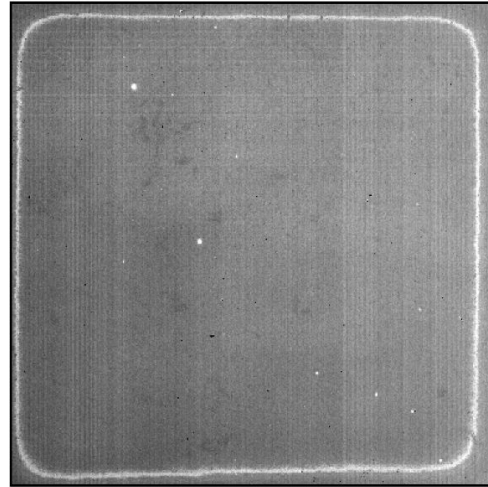
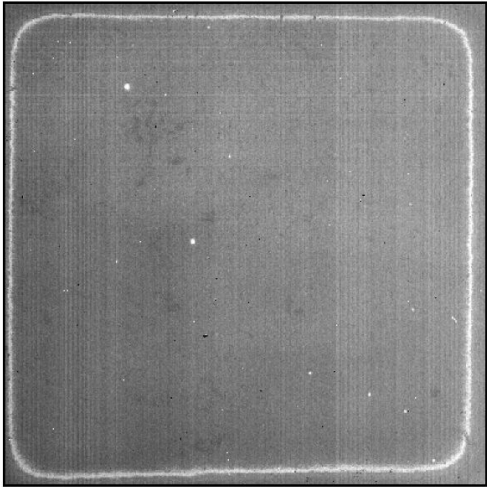
Dark Combine

- IRAF = General Image Reduction and Analysis
- Dark frames
- Typically around 10-20 images per combine.



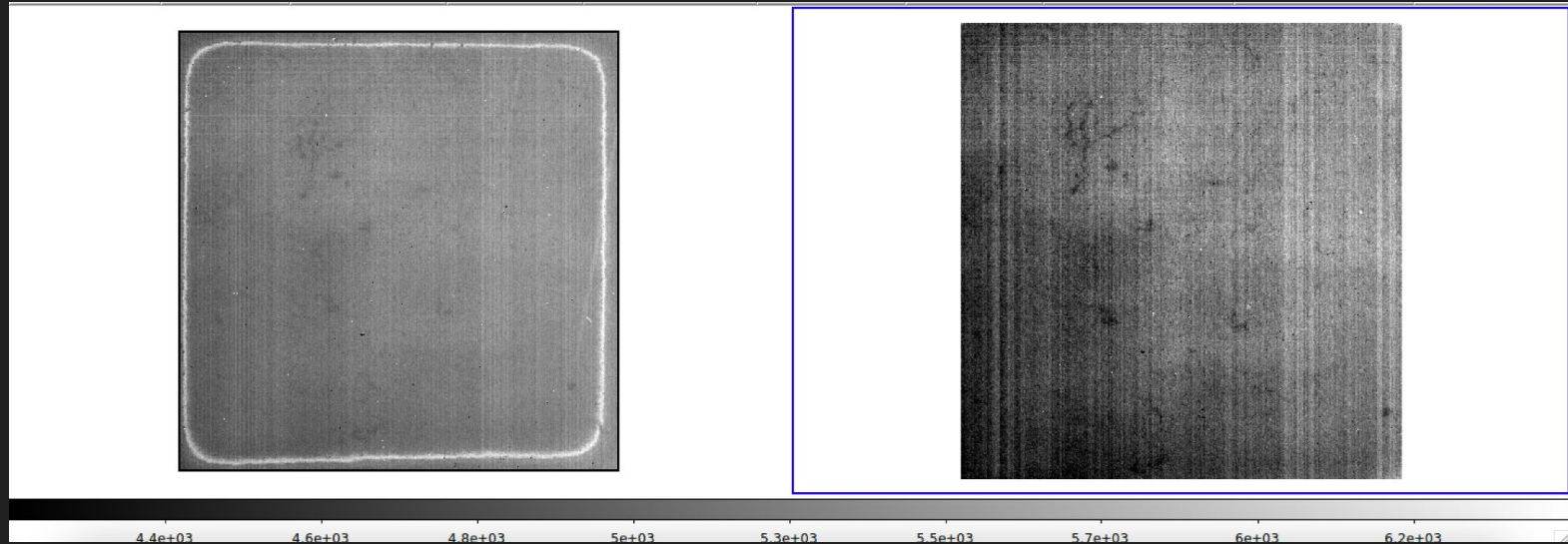
Correcting Dark using ccdproc

- In this process, we are removing the dark current and we subtract the combined dark frames.



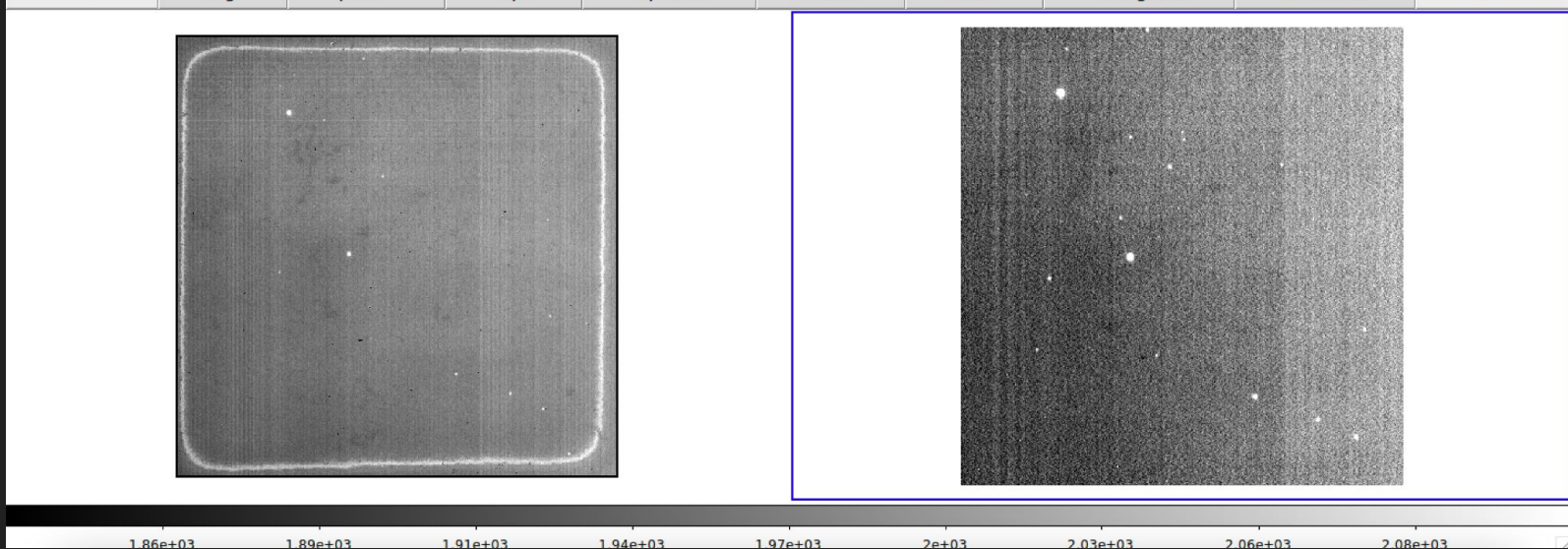
Flat Combine

- Flat images/flat combine
 - Remove the dark shadows caused by dust motes
- Minimum number of files is 4 to combine but typically we have at least 10 files.



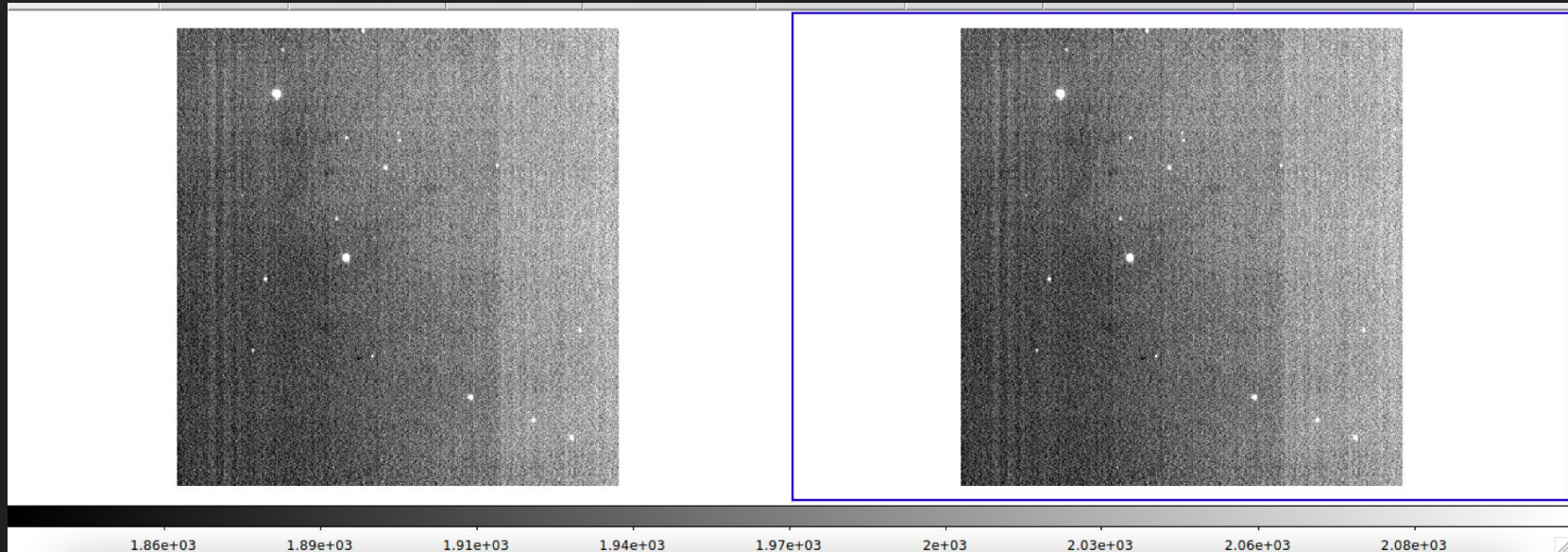
Flat Correction Using ccdproc

- Normalized the image based on the combined flat frame and take off the edges.



Craverage

- Remove all of the cosmic rays in the images



Starfind

- In this program of iraf, it is finding all of the stars and tells you where to find them.

```
# Image: cfd_nicfps-d3-run9.0683.fits  Output: cfd_nicfps-d3-run9.0683.fits.obj.1
# Detection Parameters
#   Hwhmsf: 5.000 (pixels)  Threshold: 100. (ADU)  Npixmap: 5
#   Datamin: INDEF (ADU)  Datamax: INDEF (ADU)
#   Fradius: 2.5 (HWHM)  Sepmin: 5. (HWHM)
# Selection Parameters
#   Maglo: INDEF  Maghi: INDEF
#   Roundlo: 0.000  Roundhi: 0.200
#   Sharplo: 0.500  Sharphi: 2.000
# Columns
#   1: X      2: Y
#   3: Wx     4: Wy
#   5: Mag    6: Area
#   7: Hwhm  8: Roundness
#   9: Pa    10: Sharpness

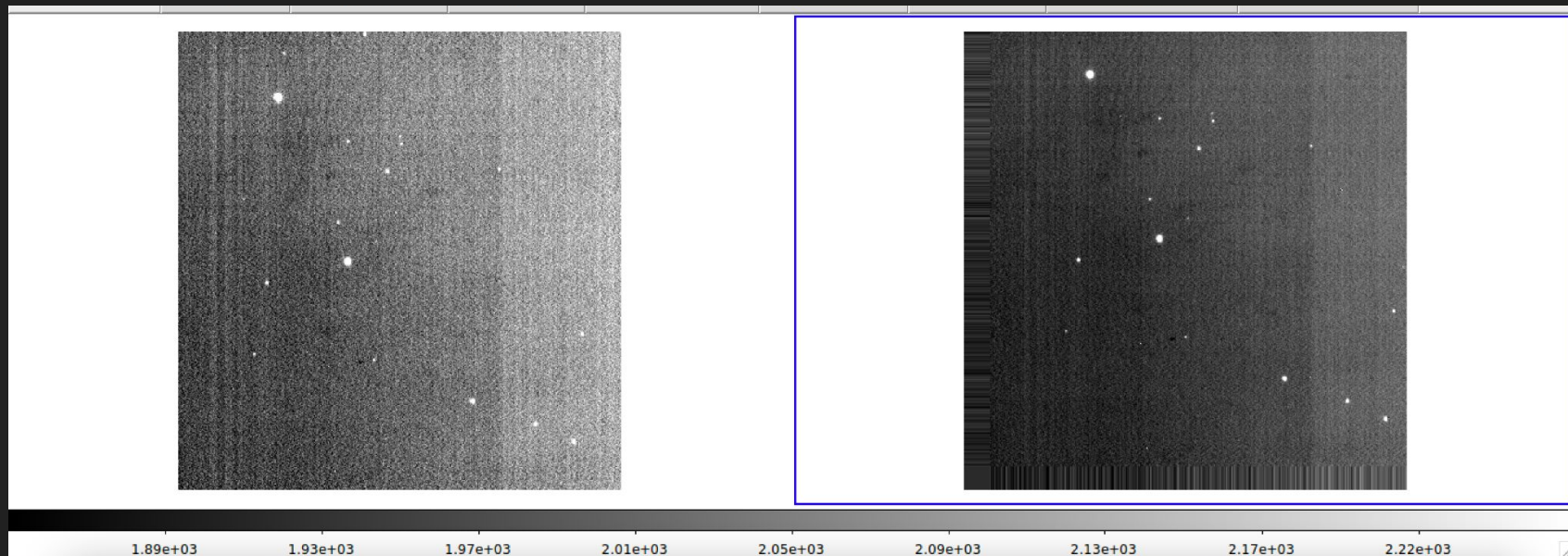
787.780   96.021   103.6249   71.955042  -12.06   328   3.23   0.041   153.5   0.646   1
711.743   131.556   103.60633   71.957736  -11.86   303   3.15   0.066   91.0   0.629   2
586.618   176.568   103.57577   71.961147  -12.54   359   2.83   0.121   97.9   0.565   3
390.843   258.282   103.52792   71.967328  -10.18   255   5.69   0.056   96.0   1.138   4
152.440   270.281   103.46963   71.968225  -9.94    242   5.58   0.090   37.5   1.117   5
804.146   310.718   103.62898   71.971267  -11.06   249   3.59   0.024   67.8   0.717   6
176.906   411.909   103.47558   71.978931  -11.38   333   4.07   0.086   106.7   0.815   7
319.635   533.118   103.51048   71.988099  -10.39   276   5.01   0.117   1.7    1.002   8
416.096   633.923   103.53409   71.995719  -11.28   321   3.87   0.027   155.7   0.773   9
641.306   639.180   103.58924   71.996109  -10.07   257   5.60   0.142   94.7   1.121   10
444.216   688.189   103.54098   71.999821  -10.38   294   5.51   0.152   84.1   1.102   11
339.096   693.754   103.51524   72.000241  -10.58   297   5.06   0.118   80.1   1.013   12
199.902   781.069   103.48113   72.006834  -14.61   449   2.77   0.143   95.8   0.554   13
211.739   869.148   103.48401   72.013492  -10.49   274   4.91   0.112   70.6   0.982   14

~
~
~
~
```

Using python to find the offset of the two images

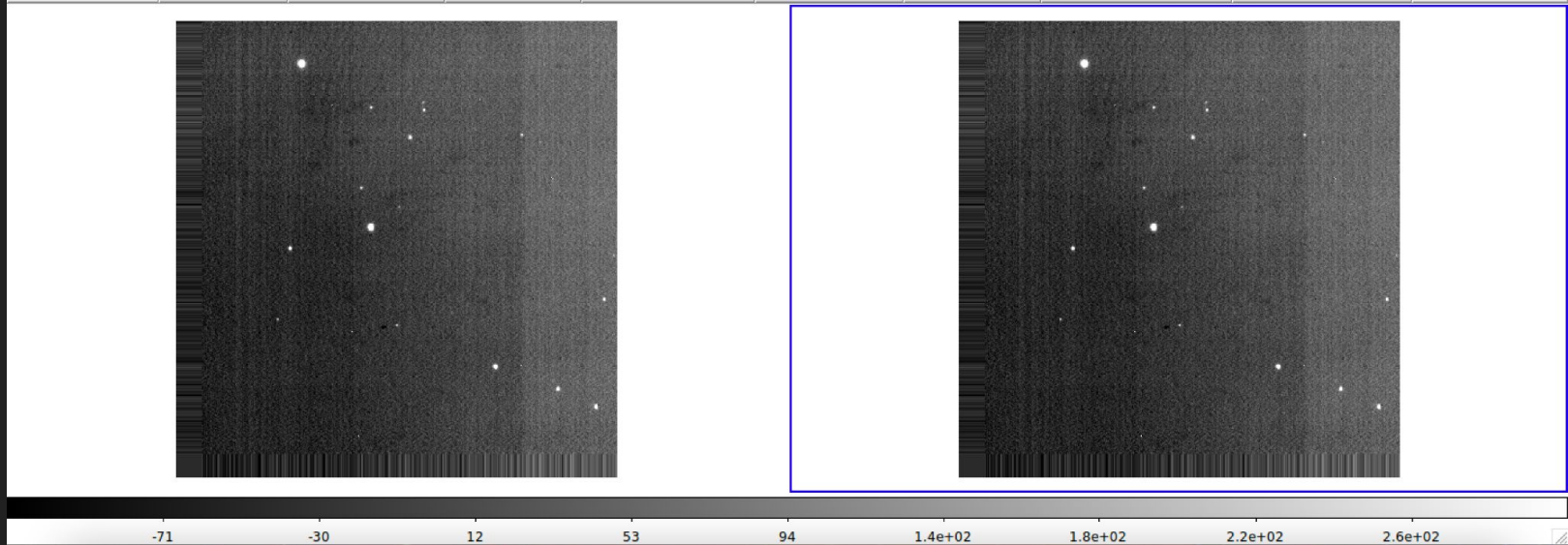
- In this program we took the two images and matched the stars and found the offset from the two images.
- It finds all of the offsets so that we can shift the images in the next step.

Before The Images are Shifted.



Shifted images

- In this process, we confirm that all the images are shifted to the correct offset.



Median combine and taking away the sky value

- Using a median combine for the target images.

The screenshot displays the interface of an astronomical software package. At the top left, a metadata table provides the following information:

Object	Value		
fk5	α	6:54:06.217	δ +71:59:28.58
Physical	X	483.354	Y 675.853
Image	X	419.354	Y 611.853
Frame 2	x	0.462	0.000 °

Below the metadata is a toolbar with the following categories and options:

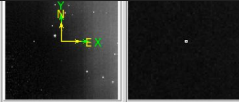
- file
- edit
- view: linear, log, power
- frame
- bin: sqrt
- zoom: squared
- scale: asinh
- color: sinh
- region: histogram
- wcs: min max
- analysis: zscale
- help

The main window shows two side-by-side images of a star field. The left image is heavily degraded with vertical streaks and noise. The right image, which is highlighted with a blue border, is a clean median-combined version of the same field. A small inset in the top right corner shows a coordinate system with 'N' (North) and 'E' (East) directions.

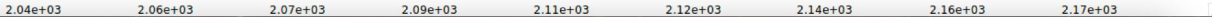
At the bottom of the window, a horizontal axis is labeled with numerical values: 8, 24, 41, 57, 73, 90, 106, 123, 139.

Returning the skyvalue

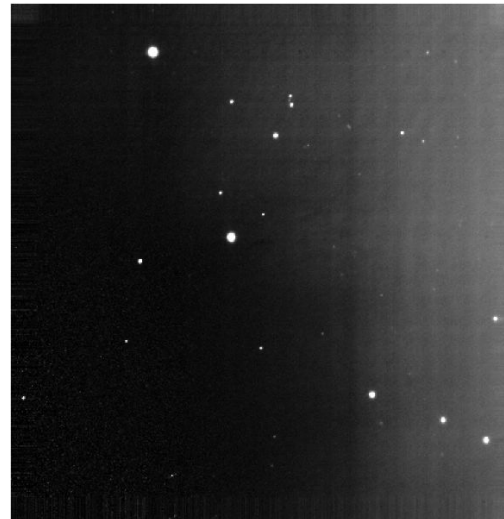
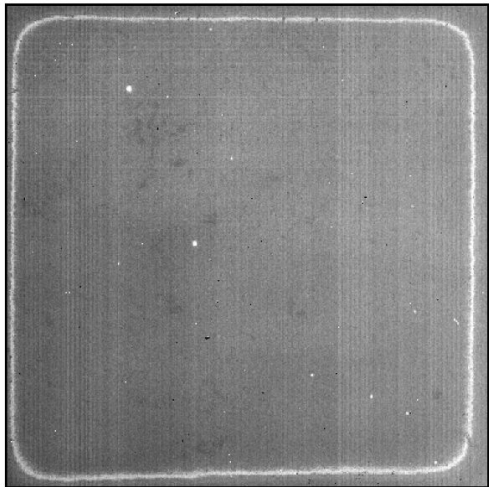
Value	2039.73	
fk5	α 6:53:56.808	δ +71:59:20.91
Physical	X 323.172	Y 647.713
Image	X 259.172	Y 583.713
Frame 2	x 0.462	0.000 °



file	edit	view	frame	bin	zoom	scale	color	region	wcs	analysis	help
linear	log	power	sqrt	squared	asinh	sinh	histogram	min max	zscale		



Final Results



Reference Page

<https://www.apo.nmsu.edu/arc35m/Instruments/NICFPS/>

<https://iraf-community.github.io/doc/beguide.pdf>

<https://www.apo.nmsu.edu/>

<https://www.universetoday.com/30522/galaxy-cluster/>