ASP3231 Project

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The object we observed for our project was NCG 2808

This Jupyter notebook contains our bias, dark and flat images and subtractions

We have completed all logbooks together, rather than delegating

Bias, Dark and Flat

In [1]:

```
# Importing appropriate libraries
import numpy as np
import astropy
import ccdproc
from ccdproc import CCDData, combiner
from astropy import units as u
import matplotlib.pyplot as plt
from matplotlib.colors import LogNorm
import gc
gc.enable()
```

Bias images

We have four bias images at zero second exposures to process

In [3]:

```
# Read in the bias images for processing
images = ccdproc.ImageFileCollection(".")
```

In [4]:

```
# Filter and list the bias images
biases = [ CCDData.read(fn, unit = "adu") for fn in images.files_filtered(PICTTYPE =
print(len(biases), ' bias images loaded')
for fn in images.files_filtered( PICTTYPE = 2 ):
    print(fn)
```

```
WARNING: FITSFixedWarning: 'obsfix' made the change 'Set OBSGEO-X to -
4130881.901 from OBSGEO-[LBH].
Set OBSGEO-Y to  2896022.315 from OBSGEO-[LBH].
Set OBSGEO-Z to -3889419.901 from OBSGEO-[LBH]'. [astropy.wcs.wcs]
WARNING:astropy:FITSFixedWarning: 'obsfix' made the change 'Set OBSGEO
-X to -4130881.901 from OBSGEO-[LBH].
Set OBSGEO-Y to  2896022.315 from OBSGEO-[LBH].
Set OBSGEO-Z to -3889419.901 from OBSGEO-[LBH]'.

4  bias images loaded
Bias_00002569.fits
Bias_00002570.fits
Bias_00002571.fits
Bias_00002572.fits
```

In [5]:

```
# We should print some example pixel values as well as the statistics
# (so that we can ensure everything is running smoothly and as expectes after we com
print(biases[0])
print('Min:', np.min(biases[0]))
print('Max:', np.max(biases[0]))
print('Mean:', np.mean(biases[0]))
print('Std:', np.std(biases[0]))
```

```
[[2073 2120 2057 ... 2118 2107 2152]
 [2187 2131 2113 ... 2142 2142 2117]
 [2198 2154 2118 ... 2082 2164 2159]
 ...
 [2197 2217 2137 ... 2197 2110 2130]
 [2150 2213 2170 ... 2127 2168 2166]
 [2211 2191 2163 ... 2112 2158 2149]]
Min: 1945
Max: 2274
Mean: 2088.2256752395206
Std: 33.1356946142231
```

We can see here that the mean pixel value is 2088

In [6]:

```
# Combine images together using median combine and print the image statistics for co
bias_median = ccdproc.Combiner(biases, dtype=np.float32).median_combine()
print('Image statistics for the median bias')
thisimage=bias_median
print('Min:', np.min(thisimage))
print('Max:', np.max(thisimage))
print('Median:', np.median(thisimage))
print('Std Dev:', np.std(thisimage))
```

```
Image statistics for the median bias
Min: 1996.5
Max: 2217.5
Median: 2085.5
Std Dev: 21.45785903930664
```

```
/Users/monica/opt/anaconda3/envs/obsastro2020/lib/python3.7/site-packa
ges/numpy/core/fromnumeric.py:745: UserWarning: Warning: 'partition' w
ill ignore the 'mask' of the MaskedArray.
  a.partition(kth, axis=axis, kind=kind, order=order)
```

In [7]:

```
# Write the bias median to an output FITS flie and remove the others from the noteboo
bias_median.write("bias_median_project.fits")
```

In [8]:

```
del(biases)
collected = gc.collect()
print('Check garbage collection', collected)
```

```
Check garbage collection 420
```

Dark images

In [9]:

```
# Filter and define the dark images and print the statistics for the first image
images = ccdproc.ImageFileCollection(".",glob_include = 'Dark_5*')
for fn in images.files_filtered(PICTTYPE = 3):
    print(fn)
darks = [ CCDData.read(fn, unit = "adu") for fn in images.files_filtered(PICTTYPE =
```

```
Dark_5.000secs00002819.fits
Dark_5.000secs00002820.fits
Dark_5.000secs00002821.fits
Dark_5.000secs00002822.fits
Dark_5.000secs00002823.fits
Dark_5.000secs00002824.fits
```

In [11]:

```
print('Statistics for first dark image')
print('Min:', np.min(darks[0]))
print('Max:', np.max(darks[0]))
print('Mean:', np.mean(darks[0]))
print('Std:', np.std(darks[0]))
```

```
Statistics for first dark image
Min: 1918
Max: 8141
Mean: 2085.0404994822475
Std: 34.34004881817512
```

In [12]:

```
# Subtracting the bias from the dark DO NOT RUN AGAIN
for idx, thisimage in enumerate(darks):
    darks[idx] = ccdproc.subtract_bias(thisimage, bias_median)
```

In [13]:

```
# Combine processed dark images together using median combine and print statistics
dark_median = ccdproc.Combiner(darks, dtype=np.float32).median_combine()

# Printing stats
print('Min:', np.min(dark_median[0]))
print('Max:', np.max(dark_median[0]))
print('Mean:', np.mean(dark_median[0]))
print('Std:', np.std(dark_median[0]))
```

```
Min: -75.5
Max: 140.5
Mean: 3.147324
Std: 28.959247589111328
```

Low counts are to be expected as the images were taken with shutter on

In [14]:

```
# Add keywords for the header
print(dark_median.header)
dark_median.meta.update(EXPTIME = 5)
dark_median.meta.update(TELESCOP = 'C11')
dark_median.meta.update(OBJECT = 'Dark_Median')
```

```
OrderedDict([('NCOMBINE', 6)])
```

In [15]:

```
# Writing the dark median combine to an output file
dark_median.write("darkmedian.fits")

# Remove individuals from notebook
del(darks)
collected = gc.collect()
print('Check garbage collection', collected)
```

```
Check garbage collection 640
```

Flat images

Each filter will have its own flat images, so we need to do this for I, V and R

V band flats

In [28]:

```
# Filter the V band images
images = ccdproc.ImageFileCollection(".",glob_include = 'Flat_V_*')
for fn in images.files_filtered(PICTTYPE = 4):
    print(fn)
flats = [ CCDData.read(fn, unit = "adu") for fn in images.files_filtered(PICTTYPE =
```

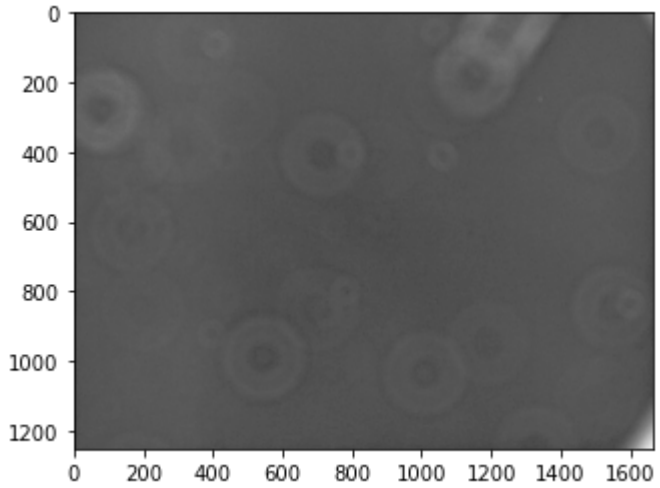
```
Flat_V_1.000secs00002618.fits
Flat_V_1.000secs00002619.fits
Flat_V_1.000secs00002620.fits
Flat_V_1.000secs00002621.fits
Flat_V_1.000secs00002622.fits
Flat_V_1.000secs00002623.fits
Flat_V_1.000secs00002624.fits
Flat_V_1.000secs00002625.fits
Flat_V_1.000secs00002626.fits
Flat_V_1.000secs00002627.fits
Flat_V_1.000secs00002628.fits
Flat_V_1.000secs00002629.fits
Flat_V_1.000secs00002630.fits
Flat_V_1.000secs00002631.fits
Flat_V_1.000secs00002632.fits
Flat_V_1.000secs00002633.fits
Flat_V_1.000secs00002634.fits
Flat_V_1.000secs00002635.fits
Flat_V_1.000secs00002636.fits
```

In [29]:

```
# Print the first V band flat
plt.imshow(flats[0], cmap='Greys', norm=LogNorm())

# Print statistics for it
print('Min:', np.min(flats[0]))
print('Max:', np.max(flats[0]))
print('Mean:', np.mean(flats[0]))
print('Std:', np.std(flats[0]))
```

```
Min: 8348
Max: 13125
Mean: 11624.241412897512
Std: 185.92191062611423
```



In [30]:

```
# Process V band flat images with bias
for idx, thisimage in enumerate(flats):
    flats[idx] = ccdproc.subtract_bias(thisimage, bias_median)

# Subtract dark image from V flat
for idx, thisimage in enumerate(flats):
    flats[idx] = ccdproc.subtract_dark(thisimage, dark_median, exposure_time = 'EXPT
                                       exposure_unit = u.second, scale = True)
```

In [31]:

```
# Print the mean vlaues
for thisimage in flats:
    print('Median:', np.ma.median(thisimage.data))
```

```
Median: 9545.39999999851
Median: 9446.599999904633
Median: 9349.0
Median: 9250.399999976158
Median: 9151.200000047684
Median: 9053.799999952316
Median: 8958.099999904633
Median: 8862.400000095367
Median: 8767.399999976158
Median: 8675.799999952316
Median: 8580.800000011921
Median: 8490.299999713898
Median: 8400.5
Median: 8311.599999964237
Median: 8223.299999713898
Median: 8136.700000047684
Median: 8049.800000190735
Median: 7962.099999904633
Median: 7877.5
```

In [32]:

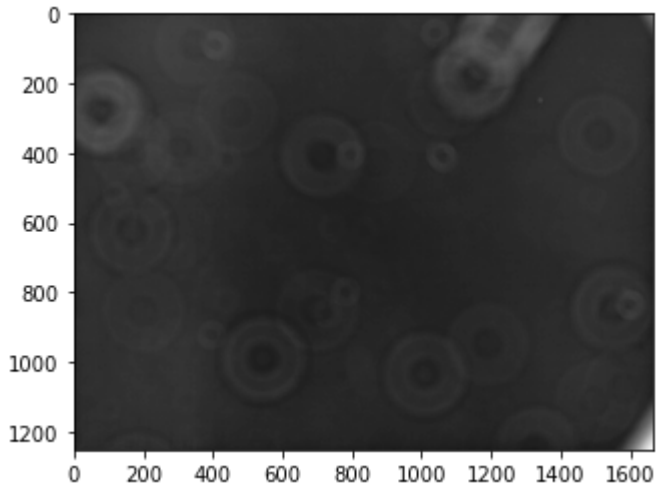
```
# Make normalised copies of the flat field images, and combine them together
tempimages = flats.copy()
for idx, thisimage in enumerate(tempimages):
    m = 1.0 / np.ma.median(tempimages[idx])
    tempimages[idx] = tempimages[idx].multiply(m * u.adu)
FlatV_median = ccdproc.Combiner(tempimages, dtype=np.float32).median_combine()
```

In [33]:

```
# Print the processed V band flat
plt.imshow(FlatV_median, cmap='Greys', norm=LogNorm())
```

Out[33]:

```
<matplotlib.image.AxesImage at 0x7fc70870a210>
```



In [35]:

```
print(FlatV_median.header)
FlatV_median.meta.update(EXPTIME = 3)
FlatV_median.meta.update(TELESCOP = 'C11')
FlatV_median.meta.update(OBJECT = 'FlatV_Median')
```

```
OrderedDict([('NCOMBINE', 80), ('EXPTIME', 3), ('TELESCOP', 'C11'),
('OBJECT', 'FlatV_Median')])
```

In [36]:

```
# Write the image to output file
FlatV_median.write("FlatV_median.fits")
```

In [37]:

```
del(flats)
del(tempimages)
collected = gc.collect()
print('Check garbage collection', collected)
```

```
Check garbage collection 3314
```

I band flats

In [39]:

```
images = ccdproc.ImageFileCollection(".",glob_include = 'Flat_I_*')
for fn in images.files_filtered(PICTTYPE = 4):
    print(fn)
flats = [ CCDData.read(fn, unit = "adu") for fn in images.files_filtered(PICTTYPE =
```

```
Flat_I_5.000secs00002778.fits
Flat_I_5.000secs00002779.fits
Flat_I_5.000secs00002780.fits
Flat_I_5.000secs00002781.fits
Flat_I_5.000secs00002782.fits
Flat_I_5.000secs00002783.fits
Flat_I_5.000secs00002784.fits
Flat_I_5.000secs00002785.fits
Flat_I_5.000secs00002786.fits
Flat_I_5.000secs00002787.fits
Flat_I_5.000secs00002788.fits
Flat_I_5.000secs00002789.fits
Flat_I_5.000secs00002790.fits
Flat_I_5.000secs00002791.fits
Flat_I_5.000secs00002792.fits
Flat_I_5.000secs00002793.fits
Flat_I_5.000secs00002794.fits
Flat_I_5.000secs00002795.fits
Flat_I_5.000secs00002796.fits
Flat_I_5.000secs00002797.fits
```

In [41]:

```
# Process I band flat images with bias
for idx, thisimage in enumerate(flats):
    flats[idx] = ccdproc.subtract_bias(thisimage, bias_median)

# Subtract dark image from I band flat
for idx, thisimage in enumerate(flats):
    flats[idx] = ccdproc.subtract_dark(thisimage, dark_median, exposure_time = 'EXPT
                                       exposure_unit = u.second, scale = True)
```

In [42]:

```
# Print the median vlaues
for thisimage in flats:
    print('Median:', np.ma.median(thisimage.data))
```

```
Median: 1076.5
Median: 1054.0
Median: 1029.5
Median: 1005.0
Median: 982.0
Median: 957.5
Median: 935.0
Median: 913.5
Median: 891.5
Median: 869.5
Median: 849.5
Median: 828.0
Median: 808.0
Median: 789.5
Median: 770.0
Median: 752.5
Median: 735.5
Median: 717.5
Median: 701.5
Median: 685.0
```

In [43]:

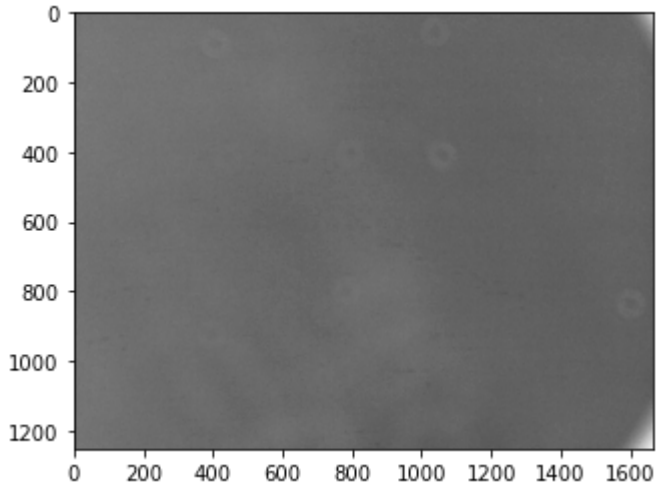
```
# Make normalised copies of the flat field images, and combine them together
tempimages = flats.copy()
for idx, thisimage in enumerate(tempimages):
    m = 1.0 / np.ma.median(tempimages[idx])
    tempimages[idx] = tempimages[idx].multiply(m * u.adu)
FlatI_median = ccdproc.Combiner(tempimages, dtype=np.float32).median_combine()
```

In [44]:

```
# Print the processed I band flat
plt.imshow(FlatI_median, cmap='Greys', norm=LogNorm())
```

Out[44]:

```
<matplotlib.image.AxesImage at 0x7fc6e341d1d0>
```



In [45]:

```
# Write the image to output file -- correcting for mislabelled file
FlatV_median.write("FlatI_median.fits")
```

In [46]:

```
del(flats)
del(tempimages)
collected = gc.collect()
print('Check garbage collection', collected)
```

```
Check garbage collection 120
```

R band flats

In [47]:

```
images = ccdproc.ImageFileCollection(".",glob_include = 'Flat_R_*')
for fn in images.files_filtered(PICTTYPE = 4):
    print(fn)
flats = [ CCDData.read(fn, unit = "adu") for fn in images.files_filtered(PICTTYPE =
```

```
Flat_R_3.000secs00002738.fits
Flat_R_3.000secs00002739.fits
Flat_R_3.000secs00002740.fits
Flat_R_3.000secs00002741.fits
Flat_R_3.000secs00002742.fits
Flat_R_3.000secs00002743.fits
Flat_R_3.000secs00002744.fits
Flat_R_3.000secs00002745.fits
Flat_R_3.000secs00002746.fits
Flat_R_3.000secs00002747.fits
Flat_R_3.000secs00002748.fits
Flat_R_3.000secs00002749.fits
Flat_R_3.000secs00002750.fits
Flat_R_3.000secs00002751.fits
Flat_R_3.000secs00002752.fits
Flat_R_3.000secs00002753.fits
Flat_R_3.000secs00002754.fits
Flat_R_3.000secs00002755.fits
Flat_R_3.000secs00002756.fits
Flat_R_3.000secs00002757.fits
Flat_R_5.000secs00002758.fits
Flat_R_5.000secs00002759.fits
Flat_R_5.000secs00002760.fits
Flat_R_5.000secs00002761.fits
Flat_R_5.000secs00002762.fits
Flat_R_5.000secs00002763.fits
Flat_R_5.000secs00002764.fits
Flat_R_5.000secs00002765.fits
Flat_R_5.000secs00002766.fits
Flat_R_5.000secs00002767.fits
Flat_R_5.000secs00002768.fits
Flat_R_5.000secs00002769.fits
Flat_R_5.000secs00002770.fits
Flat_R_5.000secs00002771.fits
Flat_R_5.000secs00002772.fits
Flat_R_5.000secs00002773.fits
Flat_R_5.000secs00002774.fits
Flat_R_5.000secs00002775.fits
Flat_R_5.000secs00002776.fits
Flat_R_5.000secs00002777.fits
```

In [48]:

```
# Process R band flat images with bias
for idx, thisimage in enumerate(flats):
    flats[idx] = ccdproc.subtract_bias(thisimage, bias_median)

# Subtract dark image from R band flat
for idx, thisimage in enumerate(flats):
    flats[idx] = ccdproc.subtract_dark(thisimage, dark_median, exposure_time = 'EXPT
                                       exposure_unit = u.second, scale = True)
```

In [49]:

```
# Print the median vlaues
for thisimage in flats:
    print('Median:', np.ma.median(thisimage.data))
```

```
Median: 2286.8000000715256
Median: 2246.800000011921
Median: 2207.7999992370605
Median: 2168.7000007629395
Median: 2130.8999996185303
Median: 2093.7000007629395
Median: 2057.0
Median: 2017.8999996185303
Median: 1981.1000001430511
Median: 1944.8000001907349
Median: 1910.8000001907349
Median: 1877.3000001907349
Median: 1844.6999998092651
Median: 1812.9000000953674
Median: 1782.1000003814697
Median: 1751.7000007629395
Median: 1720.7999992370605
Median: 1691.0
Median: 1661.5
Median: 1633.5
Median: 1993.0
Median: 1946.0
Median: 1900.5
Median: 1855.0
Median: 1812.0
Median: 1770.0
Median: 1730.5
Median: 1689.0
Median: 1651.5
Median: 1615.0
Median: 1578.0
Median: 1543.0
Median: 1507.5
Median: 1475.5
Median: 1442.5
Median: 1410.5
Median: 1379.5
Median: 1349.5
Median: 1320.5
Median: 1292.0
```

In [50]:

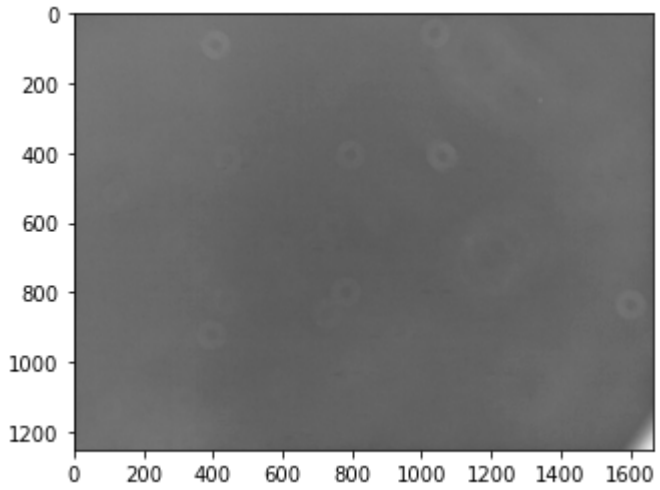
```
# Make normalised copies of the flat field images, and combine them together
tempimages = flats.copy()
for idx, thisimage in enumerate(tempimages):
    m = 1.0 / np.ma.median(tempimages[idx])
    tempimages[idx] = tempimages[idx].multiply(m * u.adu)
FlatR_median = ccdproc.Combiner(tempimages, dtype=np.float32).median_combine()
```

In [51]:

```
# Print the processed R band flat
plt.imshow(FlatR_median, cmap='Greys', norm=LogNorm())
```

Out[51]:

```
<matplotlib.image.AxesImage at 0x7fc70867c090>
```



In [52]:

```
# Write the image to output file
FlatR_median.write("FlatR_median.fits")
```

In [53]:

```
del(flats)
del(tempimages)
collected = gc.collect()
print('Check garbage collection', collected)
```

```
Check garbage collection 196
```

Now we can process the science images using these flat, bias, and dark medians

V band

In [54]:

```
# Load the V band science images
images = ccdproc.ImageFileCollection(".",glob_include = '*_V_*')
for fn in images.files_filtered(PICTTYPE = 1):
    print(fn)
scim = [CCDData.read(fn, unit = "adu") for fn in images.files_filtered(PICTTYPE = 1)
```

```
NGC_2808_V_00002817.fits
NGC_2808_V_00002829.fits
NGC_2808_V_00002830.fits
NGC_2808_V_00002831.fits
NGC_2808_V_00002848.fits
NGC_2808_V_00002849.fits
NGC_2808_V_00002850.fits
NGC_2808_V_00002851.fits
NGC_2808_V_00002852.fits
NGC_2808_V_00002853.fits
NGC_2808_V_00002854.fits
NGC_2808_V_00002855.fits
NGC_2808_V_00002856.fits
NGC_2808_V_00002857.fits
NGC_2808_V_00002868.fits
NGC_2808_V_00002869.fits
NGC_2808_V_00002870.fits
NGC_2808_V_00002871.fits
NGC_2808_V_00002872.fits
NGC_2808_V_00002873.fits
NGC_2808_V_00002874.fits
NGC_2808_V_00002875.fits
NGC_2808_V_00002876.fits
NGC_2808_V_00002877.fits
NGC_2808_V_00002898.fits
NGC_2808_V_00002899.fits
NGC_2808_V_00002900.fits
NGC_2808_V_00002901.fits
NGC_2808_V_00002902.fits
NGC_2808_V_00002903.fits
NGC_2808_V_00002904.fits
NGC_2808_V_00002905.fits
NGC_2808_V_00002906.fits
NGC_2808_V_00002907.fits
```

In [55]:

```
# process the images using the bias, dark and flat combines created earlier
# here we subtract bias, subtract dark, and flat from the V band science images
# DO NOT RUN AGAIN!
print(scim[0][:,0])

for idx, thisimage in enumerate(scim):
    scim[idx] = ccdproc.subtract_bias(thisimage, bias_median)
print(scim[0][:,0])

for idx, thisimage in enumerate(scim):
    scim[idx] = ccdproc.subtract_dark(thisimage, dark_median, exposure_time = 'EXPTI
                                      exposure_unit = u.second, scale = True)
print(scim[0][:,0])

for idx, thisimage in enumerate(scim):
    scim[idx] = ccdproc.flat_correct(thisimage, FlatV_median)
print(scim[0][:,0])


# printing the first column of the first image allows us to check that the counts ar
```

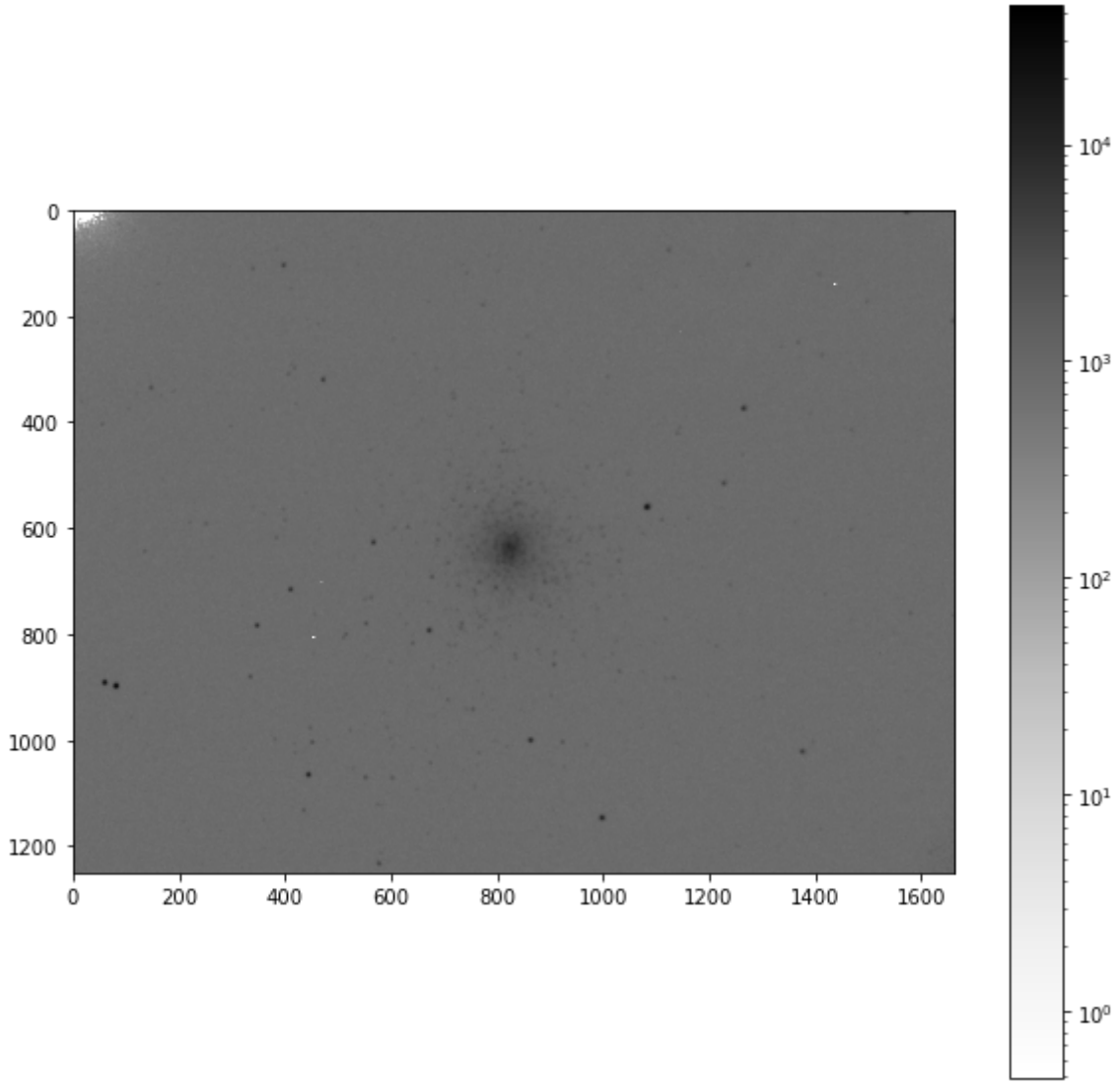
```
[2315 2346 2264 ... 2243 2269 2152]
[225.5 184.   80.  ...  58.5 127.5  -8. ]
[ 93.5  90.5  39.5 ...  81.  105.5 -15. ]
[ 91.54356722  89.75512285  39.52775884 ...  79.9169034  103.97845233
 -14.80145816]
```

In [57]:

```
#Print a processed V band image
fig, ax = plt.subplots(figsize = (10,10))
plt.imshow(scim[5], cmap='Greys', norm = LogNorm())
plt.colorbar()
```

Out[57]:

```
<matplotlib.colorbar.Colorbar at 0x7fc46e3b8dd0>
```



In [58]:

```
# save processed images
newname = []
for fn in images.files_filtered(PICTTYPE = 1):
    newname.extend(["proc_" + fn ])

print(newname)
for idx, thisimage in enumerate(scim):
    tempimages = [thisimage]
    temp = ccdproc.Combiner(tempimages,dtype=np.float32).median_combine()
    temp.meta = thisimage.meta
    temp.write(newname[idx])
```

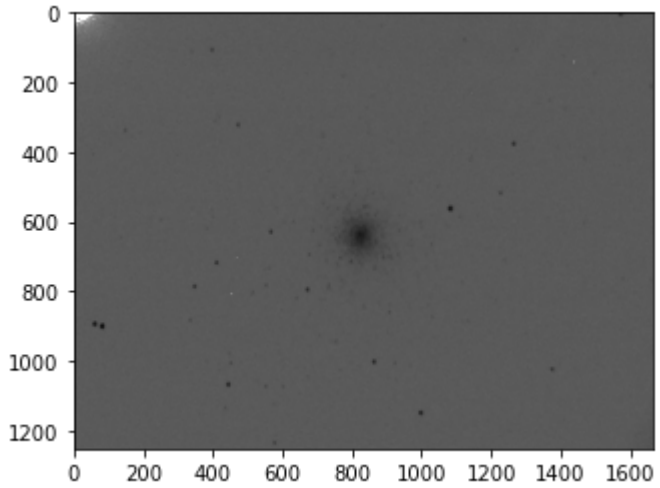
```
['proc_NGC_2808_V_00002817.fits', 'proc_NGC_2808_V_00002829.fits', 'pr
oc_NGC_2808_V_00002830.fits', 'proc_NGC_2808_V_00002831.fits', 'proc_N
GC_2808_V_00002848.fits', 'proc_NGC_2808_V_00002849.fits', 'proc_NGC_2
808_V_00002850.fits', 'proc_NGC_2808_V_00002851.fits', 'proc_NGC_2808_
V_00002852.fits', 'proc_NGC_2808_V_00002853.fits', 'proc_NGC_2808_V_00
002854.fits', 'proc_NGC_2808_V_00002855.fits', 'proc_NGC_2808_V_000028
56.fits', 'proc_NGC_2808_V_00002857.fits', 'proc_NGC_2808_V_00002868.f
its', 'proc_NGC_2808_V_00002869.fits', 'proc_NGC_2808_V_00002870.fit
s', 'proc_NGC_2808_V_00002871.fits', 'proc_NGC_2808_V_00002872.fits',
'proc_NGC_2808_V_00002873.fits', 'proc_NGC_2808_V_00002874.fits', 'pro
c_NGC_2808_V_00002875.fits', 'proc_NGC_2808_V_00002876.fits', 'proc_NG
C_2808_V_00002877.fits', 'proc_NGC_2808_V_00002898.fits', 'proc_NGC_28
08_V_00002899.fits', 'proc_NGC_2808_V_00002900.fits', 'proc_NGC_2808_V
_00002901.fits', 'proc_NGC_2808_V_00002902.fits', 'proc_NGC_2808_V_000
02903.fits', 'proc_NGC_2808_V_00002904.fits', 'proc_NGC_2808_V_0000290
5.fits', 'proc_NGC_2808_V_00002906.fits', 'proc_NGC_2808_V_00002907.fi
ts']
```

In [60]:

```
plt.imshow(temp, cmap='Greys', norm=LogNorm())
```

Out[60]:

```
<matplotlib.image.AxesImage at 0x7fc462a72c90>
```



R band

In [61]:

```
# Load the R band science images
images = ccdproc.ImageFileCollection(".",glob_include = '*_R_*')
for fn in images.files_filtered(PICTTYPE = 1):
    print(fn)
scim = [CCDData.read(fn, unit = "adu") for fn in images.files_filtered(PICTTYPE = 1)
```

```
NGC_2808_R_00002815.fits
NGC_2808_R_00002816.fits
NGC_2808_R_00002832.fits
NGC_2808_R_00002833.fits
NGC_2808_R_00002834.fits
NGC_2808_R_00002858.fits
NGC_2808_R_00002859.fits
NGC_2808_R_00002860.fits
NGC_2808_R_00002861.fits
NGC_2808_R_00002862.fits
NGC_2808_R_00002863.fits
NGC_2808_R_00002864.fits
NGC_2808_R_00002865.fits
NGC_2808_R_00002866.fits
NGC_2808_R_00002867.fits
NGC_2808_R_00002888.fits
NGC_2808_R_00002889.fits
NGC_2808_R_00002890.fits
NGC_2808_R_00002891.fits
NGC_2808_R_00002892.fits
NGC_2808_R_00002893.fits
NGC_2808_R_00002894.fits
NGC_2808_R_00002895.fits
NGC_2808_R_00002896.fits
NGC_2808_R_00002897.fits
```

In [62]:

```
# Process R band images with the bias, dark and flat images
print(scim[0][:,0])

for idx, thisimage in enumerate(scim):
    scim[idx] = ccdproc.subtract_bias(thisimage, bias_median)
print(scim[0][:,0])

for idx, thisimage in enumerate(scim):
    scim[idx] = ccdproc.subtract_dark(thisimage, dark_median, exposure_time ='EXPTIM
                                      exposure_unit = u.second, scale = True)
print(scim[0][:,0])

for idx, thisimage in enumerate(scim):
    scim[idx] = ccdproc.flat_correct(thisimage, FlatR_median)
print(scim[0][:,0])
```

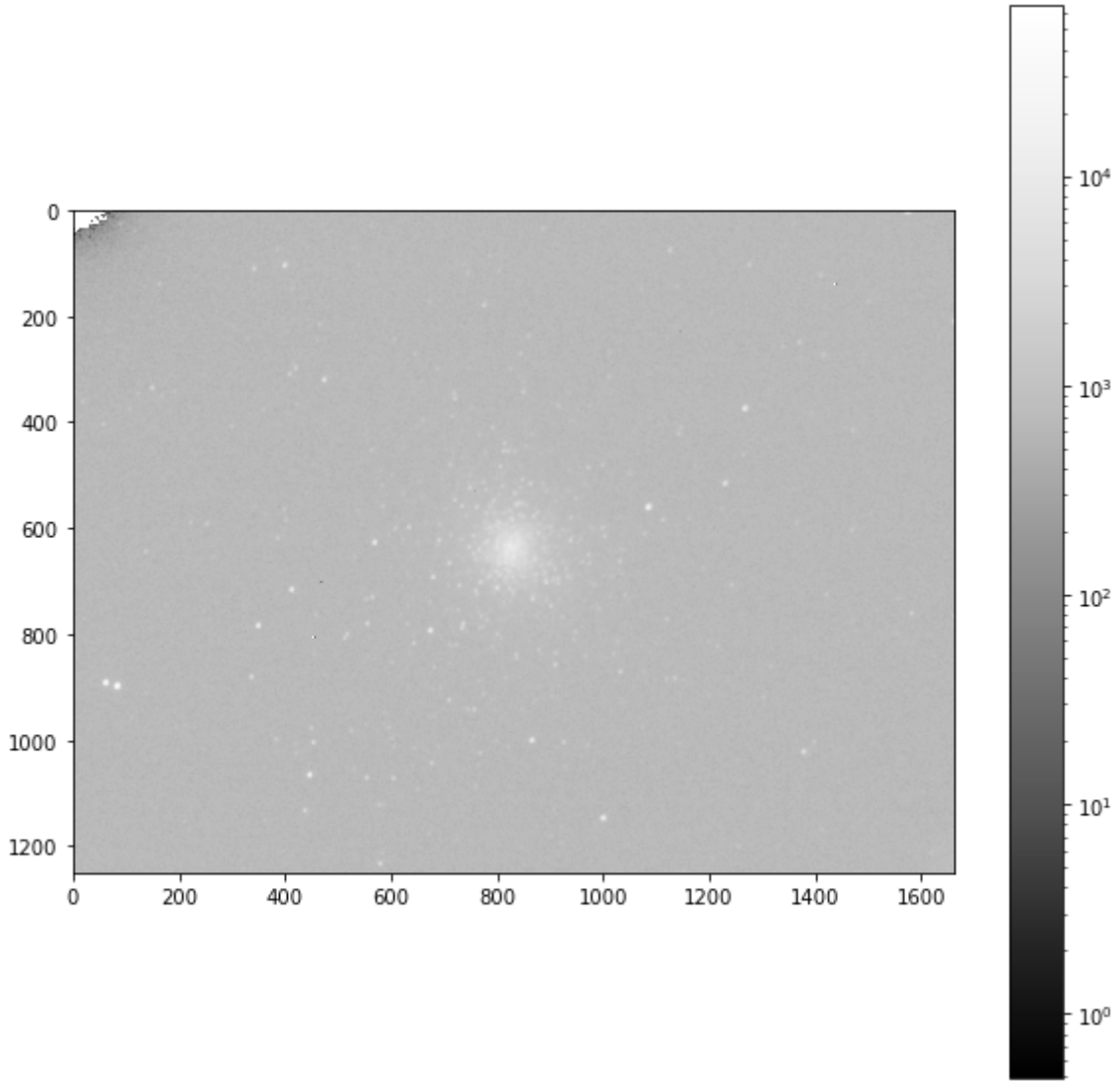
```
[2222 2228 2275 ... 2216 2207 2223]
[132.5  66.   91.  ...  31.5  65.5  63. ]
[53.29999542  9.89999771 66.69999886 ... 45.00000095 52.29999924
 58.79999971]
[53.14304854  9.93993884 67.09732653 ... 45.7394398  52.77456471
 59.84365651]
```

In [63]:

```
#Print a processed R band image
fig, ax = plt.subplots(figsize = (10,10))
plt.imshow(scim[6], cmap='Greys_r', norm = LogNorm())
plt.colorbar()
```

Out[63]:

```
<matplotlib.colorbar.Colorbar at 0x7fc6e3493810>
```



In [64]:

```
# save processed images
newname = []
for fn in images.files_filtered(PICTTYPE = 1):
    newname.extend(["proc_" + fn ])

print(newname)
for idx, thisimage in enumerate(scim):
    tempimages = [thisimage]
    temp = ccdproc.Combiner(tempimages,dtype=np.float32).median_combine()
    temp.meta = thisimage.meta
    temp.write(newname[idx])
```

```
['proc_NGC_2808_R_00002815.fits', 'proc_NGC_2808_R_00002816.fits', 'pr
oc_NGC_2808_R_00002832.fits', 'proc_NGC_2808_R_00002833.fits', 'proc_N
GC_2808_R_00002834.fits', 'proc_NGC_2808_R_00002858.fits', 'proc_NGC_2
808_R_00002859.fits', 'proc_NGC_2808_R_00002860.fits', 'proc_NGC_2808_
R_00002861.fits', 'proc_NGC_2808_R_00002862.fits', 'proc_NGC_2808_R_00
002863.fits', 'proc_NGC_2808_R_00002864.fits', 'proc_NGC_2808_R_000028
65.fits', 'proc_NGC_2808_R_00002866.fits', 'proc_NGC_2808_R_00002867.f
its', 'proc_NGC_2808_R_00002888.fits', 'proc_NGC_2808_R_00002889.fit
s', 'proc_NGC_2808_R_00002890.fits', 'proc_NGC_2808_R_00002891.fits',
'proc_NGC_2808_R_00002892.fits', 'proc_NGC_2808_R_00002893.fits', 'pro
c_NGC_2808_R_00002894.fits', 'proc_NGC_2808_R_00002895.fits', 'proc_NG
C_2808_R_00002896.fits', 'proc_NGC_2808_R_00002897.fits']
```

In [65]:

```
del(tempimages)
collected = gc.collect()
print('Check garbage collection', collected)
```

```
Check garbage collection 2446
```

I band

In [66]:

```
# Load the I band science images
images = ccdproc.ImageFileCollection(".",glob_include = '*_I_*')
for fn in images.files_filtered(PICTTYPE = 1):
    print(fn)
scim = [CCDData.read(fn, unit = "adu") for fn in images.files_filtered(PICTTYPE = 1)
```

```
NGC_2808_I_00002826.fits
NGC_2808_I_00002835.fits
NGC_2808_I_00002836.fits
NGC_2808_I_00002837.fits
NGC_2808_I_00002838.fits
NGC_2808_I_00002839.fits
NGC_2808_I_00002840.fits
NGC_2808_I_00002841.fits
NGC_2808_I_00002842.fits
NGC_2808_I_00002843.fits
NGC_2808_I_00002844.fits
NGC_2808_I_00002845.fits
NGC_2808_I_00002846.fits
NGC_2808_I_00002847.fits
NGC_2808_I_00002878.fits
NGC_2808_I_00002879.fits
NGC_2808_I_00002880.fits
NGC_2808_I_00002881.fits
NGC_2808_I_00002882.fits
NGC_2808_I_00002883.fits
NGC_2808_I_00002884.fits
NGC_2808_I_00002885.fits
NGC_2808_I_00002886.fits
NGC_2808_I_00002887.fits
NGC_2808_I_00002908.fits
NGC_2808_I_00002909.fits
NGC_2808_I_00002910.fits
NGC_2808_I_00002911.fits
NGC_2808_I_00002912.fits
NGC_2808_I_00002913.fits
NGC_2808_I_00002918.fits
NGC_2808_I_00002919.fits
NGC_2808_I_00002920.fits
NGC_2808_I_00002921.fits
NGC_2808_I_00002922.fits
NGC_2808_I_00002923.fits
NGC_2808_I_00002924.fits
NGC_2808_I_00002925.fits
NGC_2808_I_00002926.fits
NGC_2808_I_00002927.fits
```

In [67]:

```
# Process the I band images with the bias, dark and flats
print(scim[0][:,0])

for idx, thisimage in enumerate(scim):
    scim[idx] = ccdproc.subtract_bias(thisimage, bias_median)
print(scim[0][:,0])

for idx, thisimage in enumerate(scim):
    scim[idx] = ccdproc.subtract_dark(thisimage, dark_median, exposure_time ='EXPTIM
                                      exposure_unit = u.second, scale = True)
print(scim[0][:,0])

for idx, thisimage in enumerate(scim):
    scim[idx] = ccdproc.flat_correct(thisimage, FlatR_median)
print(scim[0][:,0])
```

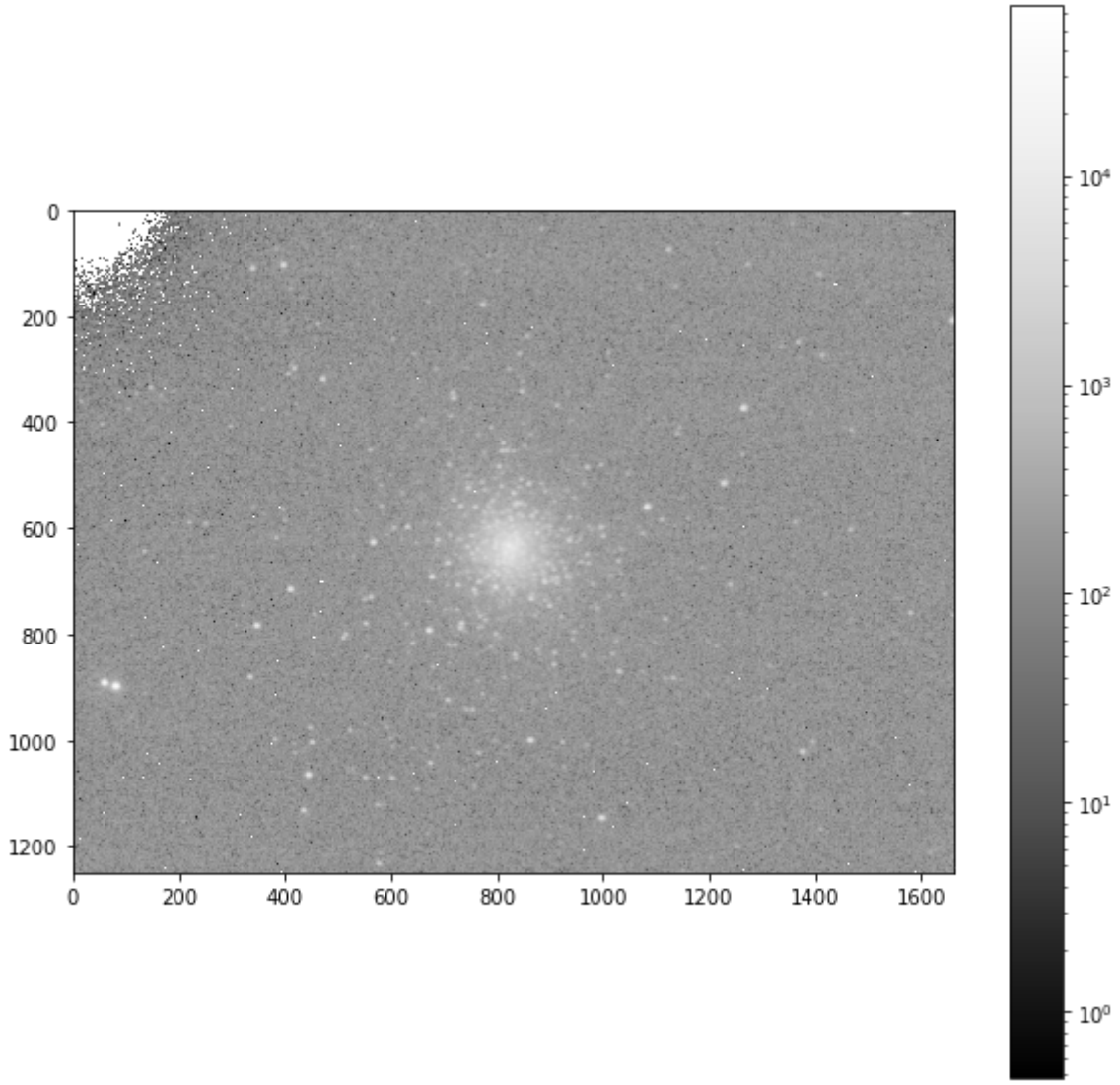
```
[2253 2293 2274 ... 2231 2179 2191]
[163.5 131.   90.  ...  46.5  37.5  31. ]
[31.5 37.5 49.5 ... 69.  15.5 24. ]
[31.40724527 37.6512922  49.79486837 ... 70.13380621 15.6406456
 24.42598237]
```

In [68]:

```
#Print a processed I band image
fig, ax = plt.subplots(figsize = (10,10))
plt.imshow(scim[7], cmap='Greys_r', norm = LogNorm())
plt.colorbar()
```

Out[68]:

```
<matplotlib.colorbar.Colorbar at 0x7fc46d0f1390>
```



In [69]:

```
# save processed images
newname = []
for fn in images.files_filtered(PICTTYPE = 1):
    newname.extend(["proc_" + fn ])

print(newname)
for idx, thisimage in enumerate(scim):
    tempimages = [thisimage]
    temp = ccdproc.Combiner(tempimages,dtype=np.float32).median_combine()
    temp.meta = thisimage.meta
    temp.write(newname[idx])
```

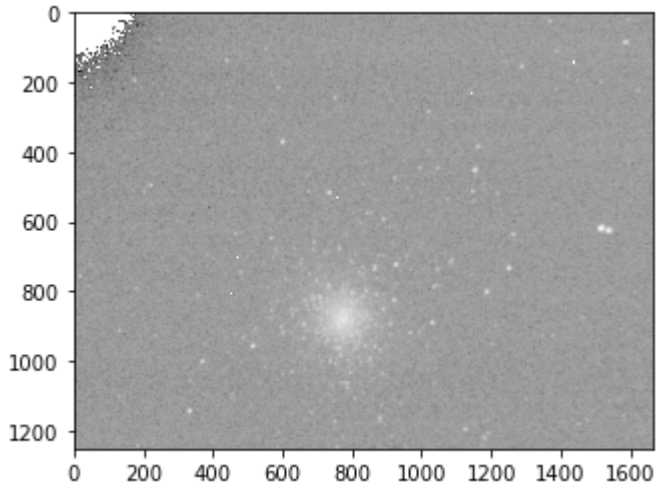
```
['proc_NGC_2808_I_00002826.fits', 'proc_NGC_2808_I_00002835.fits', 'pr
oc_NGC_2808_I_00002836.fits', 'proc_NGC_2808_I_00002837.fits', 'proc_N
GC_2808_I_00002838.fits', 'proc_NGC_2808_I_00002839.fits', 'proc_NGC_2
808_I_00002840.fits', 'proc_NGC_2808_I_00002841.fits', 'proc_NGC_2808_
I_00002842.fits', 'proc_NGC_2808_I_00002843.fits', 'proc_NGC_2808_I_00
002844.fits', 'proc_NGC_2808_I_00002845.fits', 'proc_NGC_2808_I_000028
46.fits', 'proc_NGC_2808_I_00002847.fits', 'proc_NGC_2808_I_00002878.f
its', 'proc_NGC_2808_I_00002879.fits', 'proc_NGC_2808_I_00002880.fit
s', 'proc_NGC_2808_I_00002881.fits', 'proc_NGC_2808_I_00002882.fits',
'proc_NGC_2808_I_00002883.fits', 'proc_NGC_2808_I_00002884.fits', 'pro
c_NGC_2808_I_00002885.fits', 'proc_NGC_2808_I_00002886.fits', 'proc_NG
C_2808_I_00002887.fits', 'proc_NGC_2808_I_00002908.fits', 'proc_NGC_28
08_I_00002909.fits', 'proc_NGC_2808_I_00002910.fits', 'proc_NGC_2808_I
_00002911.fits', 'proc_NGC_2808_I_00002912.fits', 'proc_NGC_2808_I_000
02913.fits', 'proc_NGC_2808_I_00002918.fits', 'proc_NGC_2808_I_0000291
9.fits', 'proc_NGC_2808_I_00002920.fits', 'proc_NGC_2808_I_00002921.fi
ts', 'proc_NGC_2808_I_00002922.fits', 'proc_NGC_2808_I_00002923.fits',
'proc_NGC_2808_I_00002924.fits', 'proc_NGC_2808_I_00002925.fits', 'pro
c_NGC_2808_I_00002926.fits', 'proc_NGC_2808_I_00002927.fits']
```

In [70]:

```
plt.imshow(temp, cmap='Greys_r', norm=LogNorm())
```

Out[70]:

```
<matplotlib.image.AxesImage at 0x7fc463d710d0>
```



In [71]:

```
del(tempimages)
collected = gc.collect()
print('Check garbage collection', collected)
```

```
Check garbage collection 2080
```

In [ ]: