Easy IMA Viewer

Learning Goals

This notebook is intended to be a resouce for newer users of WFC3/IR data.

- Learn about the IMA file type.
- Download an IMA from MAST.
- Visualize the different reads of the IMA.
- Save the plotted reads as individual images, an animated GIF, or both.

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Introduction

The WFC3 calibration pipline (calwf3) produces many different types of FITS files for each observation. The **intermediate MultiAccum** (IMA) file type is unique to the IR detector, and it is produced after all calibrations are applied (dark subtraction, linearity correction, flat fielding, etc.) to each of the individual readouts of the IR dataset. Since the reads are kept in separate extensions of the IMA, it is possible to see how the observation developed over exposure time, thus making it a valuable resource especially in cases of image anomalies, potential guide star failures, satellite trails, etc. However, IMA files can be confusing to inspect, largely due to the order of the FITS extensions and the possible extension types.

This notebook leverages a set of functions, imported as a package, that allow for interactive visualization of an IMA file through Jupyter Widgets. You will be able to easily plot, customize, and save both static plots and animated GIFs (Graphics Interchange Format).

1. Imports

Please see the `README.md` file for package specifications and instructions for creating a virtual environment.

This notebook uses the following libraries:

- *astropy.io fits* for accessing FITS files
- *astroquery.mast Observations* for downloading data from MAST
- *imageio* to make and save animated GIFs
- *ipympl* as a matplotlib backend to enable interactive widgets
- *IPython.display* to display widgets and other components
- *ipywidgets* to make widgets for plotting
- *matplotlib pyplot* for plotting data
- *matplotlib.ticker* to configure tick locating and formatting
- *matplotlib.colors* to normalize images
- *numpy* for calculating limit percentiles
- *os* for verifying and creating paths
- *shutil* for moving files

In [1]:
```
from astropy.io import fits
from astroquery.mast import Observations
import imageio.v2 as imageio
from IPython.display import display
from ipywidgets import interact, interactive, Layout
import ipywidgets as widgets
import matplotlib
import matplotlib.pyplot as plt
import matplotlib.ticker as tick
from matplotlib.colors import Normalize
import numpy as np
import os
import shutil
%matplotlib ipympl

from ima_tools import make_interactive_plot, gif_settings_widgets, make_frames, make_gif
```

2. Display IMA files

In this section, we will download an IMA file (if needed), create an interactive plot of the IMA file, and then save the output as frames and a composite animated GIF.

2.1 Data

If you already have an IMA file you'd like to visualize, you can define the path to the file in the cell below.

In [2]:
```
#filepath = path/to/file_ima.fits
```

If you've defined a path in the cell above, you can now skip to the next subsection.

Otherwise, continue on to download a file from MAST.

Let's download the IMA for a particular observation, which has a rootname or observation ID of `idpq32w0q` .

Importantly, even if we know the observation ID, if the particular observation is part of an association, the `query_criteria` function will not be able to find the exact observation.

In [3]:
```
obs_id = 'idpq32w0q'

obs = Observations.query_criteria(obs_id=obs_id)
print(len(obs))
```

```
0
```

```
WARNING: NoResultsWarning: Query returned no results. [astroquery.mast.discovery_portal]
```

Instead, we can use the first six characters, which uniquely represent the instrument identifier, program ID, and the visit number. To that, we add a wildcard character so that we get a list of observations from the same instrument, program, and visit as our intended observation, `idpq32w0q` .

You can read more about the HST file naming conventions here (https://archive.stsci.edu/hlsp/ipppssoot.html).

In [4]:
```
obs = Observations.query_criteria(obs_id=obs_id[:6]+'*')
print(len(obs))
```

```
3
```

Now we can access the products for these three observations in the same visit. We'll nest a couple of functions here, but read the documentation (https://astroquery.readthedocs.io/en/latest/mast/mast.html) if you'd like to learn more about the `astroquery.mast` library.

For this step, we set `productSubGroupDescription` to only return to us IMA files. Also in this step, we can precisely specify our observation ID.

In [5]:
```
prods = Observations.filter_products(Observations.get_product_list(obs),
                                     productSubGroupDescription='IMA',
                                     obs_id='idpq32w0q')
prods
```

Out[5]: *Table masked=True length=1*

obsID	obs_collection	dataproduct_type	obs_id	description	type	dataURI	productType	productGroupDescription	productSubGroupDescri
str8	str3	str5	str35	str62	str1	str67	str9	str28	
26190073	HST	image	idpq32w0q	DADS IMA file - Intermediate Mult-Accum WFC3/NICMOS	S	mast:HST/product/idpq32w0q_ima.fits	AUXILIARY	--	

We'll now be able to download our file to the current working directory.

In [6]:
```
downloads = Observations.download_products(prods)
downloads
```

```
Downloading URL https://mast.stsci.edu/api/v0.1/Download/file?uri=mast:HST/product/idpq32w0q_ima.fits (https://mast.stsci.edu/api/v0.1/Download/file?uri=mast:HST/product/idpq32w0q_ima.fits) to ./mastDownload/HST/idpq32w0q/idpq32w0q_ima.fits ... [Done]
```

Out[6]: *Table length=1*

Local Path	Status	Message	URL
str47	str8	object	object
./mastDownload/HST/idpq32w0q/idpq32w0q_ima.fits	COMPLETE	None	None

The subdirectories made as part of this step are a bit cumbersome when we only have one file, so let's clean it up.

In [7]:
```
downloaded_location = downloads['Local Path'][0]

# move file to current working directory
new_location = shutil.move(downloaded_location, os.getcwd())

# now that there aren't any files, we can remove the default mastDownload directory
shutil.rmtree('mastDownload')

# set filepath variable
filepath = f'{obs_id}_ima.fits'

# double-check that the file was successfully moved
os.path.exists(filepath)
```

Out[7]: `True`

Now we're ready to visualize.

2.2 Create IMA viewer

Running the cell below will create a simple, interactive viewer so that you can inspect your IMA.

- Using the controls at the top, you can scrub through the different extensions in chronological order, change the colormap, and adjust the scaling percentiles.
- The default extension type is "SCI" for science. To view the error extensions, set `ext_type` to "ERR". To view the data quality flags extensions, set `ext_type` to "DQ".
- As you pan your cursor over the plot, the pixel location (in x and y coordinates) and value update at the bottom.
- You can use the plotting controls on the left to pan and zoom, as well as to save the current plot as a static image.

There is an abrupt change within this exposure. See if you can figure out what it is.

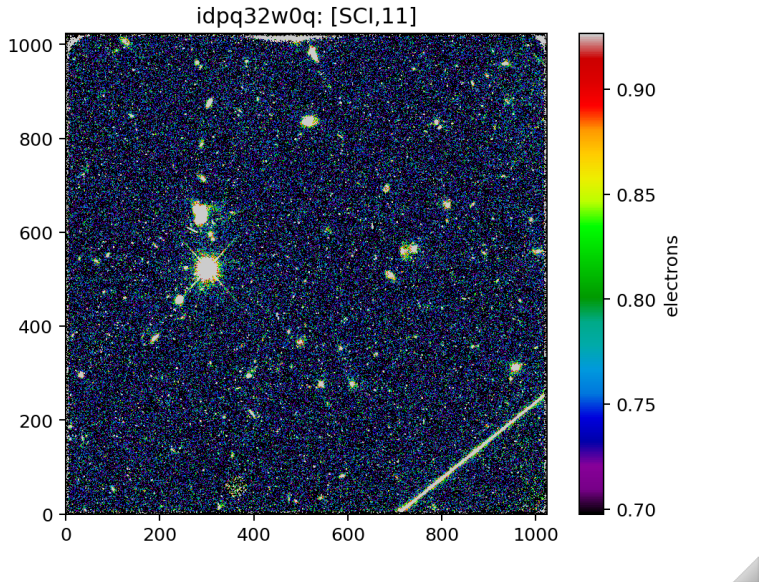
In [8]:
```
1 plot = make_interactive_plot(filepath, ext_type='SCI')
```

Colormap: nipy_spectral

Extension: 11

Scaling (%): 50.0 – 94.3

Figure 1



2.3 Save files

Running the cell below will generate options for saving your IMA as frames, a GIF, or both. The limits, colormap, scaling, etc. will reflect whatever is currently set above.

In [9]:
```
1 gif_setup = gif_settings_widgets(plot)
```

Do you want to create a GIF? Make GIF

Make GIF from: PNG frames

Do you want to save the individual frames?

Save JPG frames

Save PNG frames

Making GIF from PNG frames, and saving individual frames as JPG and PNG files.

Set a name for the image frames. This will also be the name of the directory in which these frames will be saved. You may specify absolute or relative paths if you do not want to save in your current working directory.

GIF name: idpq32w0q_0-1023_0-1023

Default directory "idpq32w0q_0-1023_0-1023" will be created.

Do you want to loop your frames in the GIF? Maximum possible iterations is 10.

Loop GIF

Iterations: 5

Do you want to adjust the duration of each frame? Default is 0.1 seconds (10 frames per second).

Duration (s): 0.11

When the IMA viewer and the widget settings are to your liking, run the following two cells to

1. Make the frames.
2. Make the gif.

In [10]:
```
gif_frames = make_frames(plot, gif_setup)
```

```
Made new directory: idpq32w0q_0-1023_0-1023
```

In [11]:
```
make_gif(gif_frames, gif_setup)
```

```
GIF saved.
```

3. Conclusions

Thank you for walking through this notebook! You have:

- learned about the format and purpose of IMA files
- examined different reads of an IMA file
- created image frames and/or GIFs for a particular customized view.

Congratulations, you have completed the notebook.

Additional Resources

Below are some additional resources that may be helpful. Please send any questions through the HST Help Desk (https://stsci.service-now.com/hst).

- Types of WFC3 Files (https://hst-docs.stsci.edu/wfc3dhb/chapter-2-wfc3-data-structure/2-1-types-of-wfc3-files)

About this Notebook

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In [ ]:
```
```