lec20-images1-RyanSponzilli

November 5, 2024

1 ASTR 310 Lecture 20 - Images 1

1.0.1 Exercise 1: read an image, create a cutout, and examine histogram

Download the file `ibkf10020_drz.fits` from the Canvas site. This is a Hubble Space Telescope Wide Field Camera 3 (WFC3) image of the remnant of supernova 1987a in the "wide H + [N II]" filter (F657N).

1.) Read in the file and store the first image as a `CCDData` object. The image header has `BUNIT = 'ELECTRONS/S'`, but this doesn't correspond to a valid AstroPy unit, so set the unit to `1/s`. [3 pts]

[2]:
```python
from astropy.nddata import CCDData
import matplotlib.pyplot as plt
from astropy.nddata import Cutout2D
from astropy.coordinates import SkyCoord
import astropy.units as u
import numpy as np
```

[3]:
```python
img = CCDData.read("ibkf10020_drz.fits", unit='1/s')
```

```
INFO: first HDU with data is extension 1. [astropy.nddata.ccddata]
INFO: using the unit 1/s passed to the FITS reader instead of the unit
ELECTRONS/S in the FITS file. [astropy.nddata.ccddata]

WARNING: FITSFixedWarning: 'datfix' made the change 'Set MJD-OBS to 55566.000000
from DATE-OBS'. [astropy.wcs.wcs]
```

2.) Cut out a 2 by 2.5 arcsec region around the coordinates RA = 05h35m28.09s, Dec = -69d16m10.85s. [2 pts]

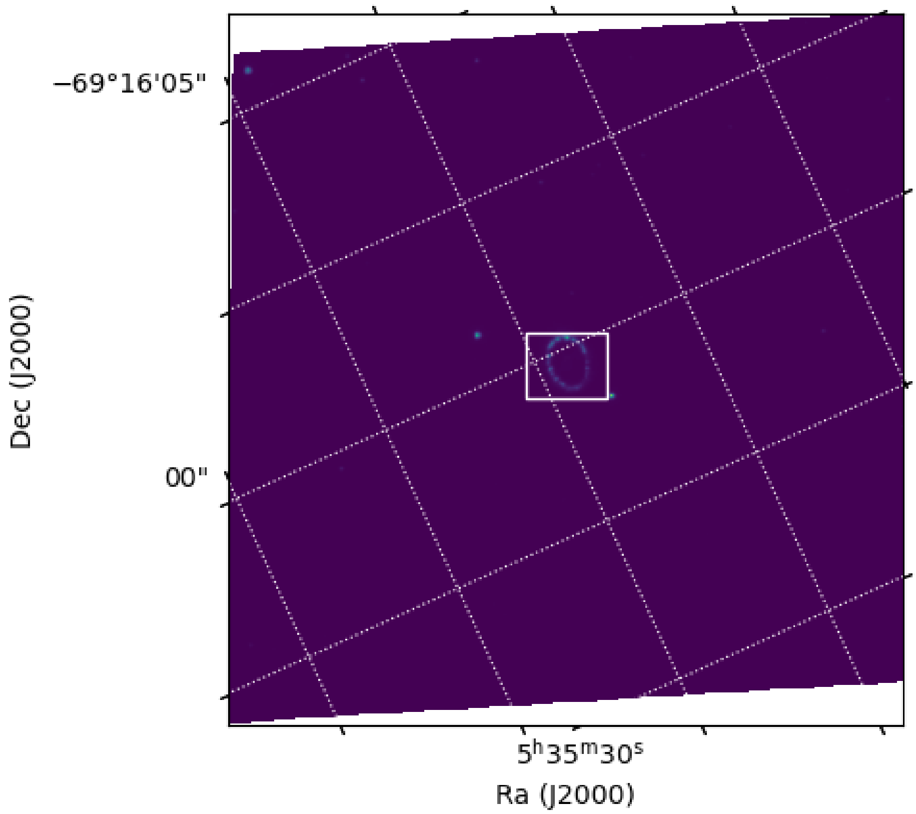
[4]:
```python
plt.subplot(projection=img.wcs)
plt.imshow(img, origin='lower')
plt.grid(color='white', ls='dotted')
plt.xlabel("Ra (J2000)")
plt.ylabel("Dec (J2000)")

center = SkyCoord('05h35m28.09s -69d16m10.85s')
size = np.array([2, 2.5]) * u.arcsec

cut = Cutout2D(img.data, center, size, wcs=img.wcs)
```

```
cut.plot_on_original(color='white')
```

[4]: <WCSAxes: >



3.) Now plot two histograms of the cutout data values. You will need to flatten or ravel the 2D array into a 1D array to get what we want out of `plt.hist()`. The first histogram plot should be based on the raw data values (call them X), and the second should be based on

$$Y = \frac{\log(1000X + 1)}{\log 1001}$$

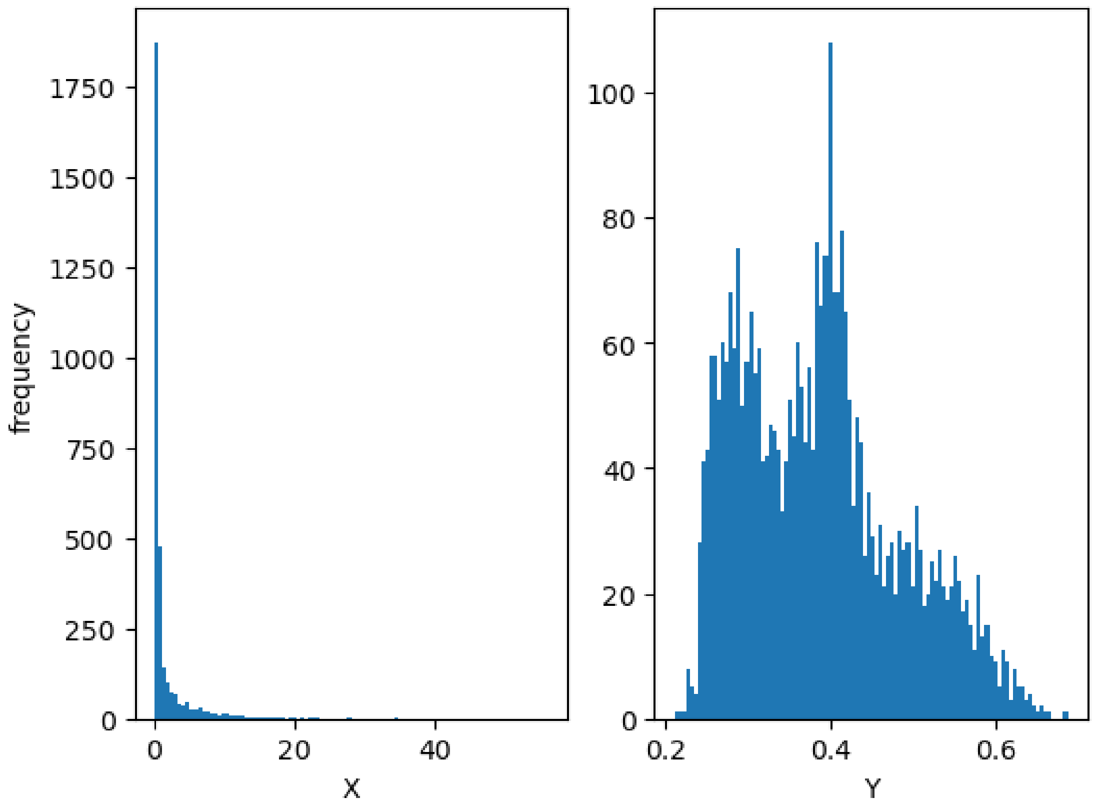
Use 100 bins. [5 pts]

[5]:
```
x = cut.data.flatten()
y = np.log10(1000*x + 1) / np.log(1001)

fig = plt.Figure()
ax = fig.subplots(1,2)
ax[0].hist(x, bins=100)
ax[0].set_xlabel("X")
ax[0].set_ylabel("frequency")
```

```
ax[1].hist(y, bins=100)
ax[1].set_xlabel("Y")
fig
```

[5]:



1.0.2 Exercise 2: plot the image and cutout

Plot the image using the correct WCS, using a logarithmic stretch. Plot the outline of the cutout region on the main image and display the cutout in its own subplot. You should be able to produce a plot like the one in the lecture slides pdf. [6 pts]

[30]:

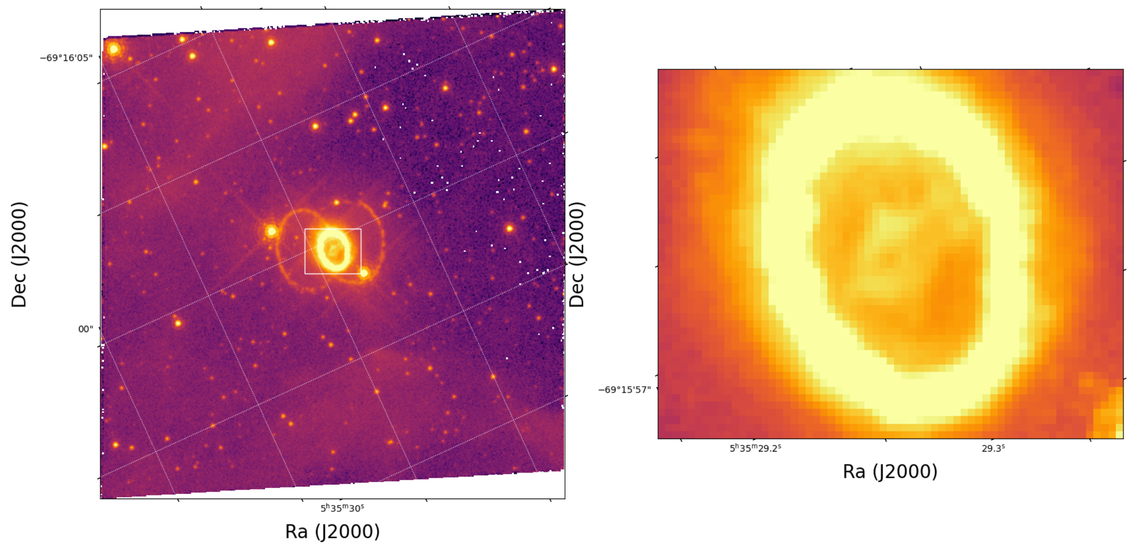
```
fig2 = plt.figure(figsize=(20,20))
ax1 = fig2.add_subplot(121, projection=img.wcs)

ax1.imshow(np.log10(img.data), origin='lower', vmin=-3, vmax=0.2,␣
 ↪cmap='inferno')
ax1.grid(color='white', ls='dotted')
ax1.set_xlabel("Ra (J2000)", fontdict={'fontsize': 20})
ax1.set_ylabel("Dec (J2000)", fontdict={'fontsize': 20})
cut.plot_on_original(color='white')

ax2 = fig2.add_subplot(122, projection=img.wcs)
```

```
ax2.imshow(np.log10(cut.data), vmin=-3, vmax=0.2, cmap='inferno')
ax2.set_xlabel("Ra (J2000)", fontdict={'fontsize': 20})
ax2.set_ylabel("Dec (J2000)", fontdict={'fontsize': 20})
```

```
/var/folders/41/_gkgvhb94wd4156zplzr4cg00000gn/T/ipykernel_67797/839084728.py:4:
RuntimeWarning: invalid value encountered in log10
  ax1.imshow(np.log10(img.data), origin='lower', vmin=-3, vmax=0.2,
cmap='inferno')
```



1.0.3 Exercise 3: further analysis

Take the cutout data from the SN1987a image and perform the following analysis on the unstretched cutout data.
1.) Create a calibrated copy of the cutout region: convert the cutout data to erg cm^{-2} s^{-1} Å^{-1} $pixel^{-1}$ by multiplying by the image header's `PHOTFLAM` value, which is given in `erg/cm^2/Angstrom` per electron (see note on exercise 1).

2.) Compute and print the sum of the pixels in the cutout region with values greater than `PHOTFLAM`. This is a crude estimate of the flux in the bright inner ring. You should get something like this:

total flux in ring = 9.978624e-15 erg/s/cm^2/Angstrom

[4 pts]

[45]:
```
photflam = img.header['PHOTFLAM']

calibrated = cut.data * photflam

total_flux = np.sum(calibrated[calibrated > photflam]) * u.erg / u.second / u.
  ↪cm**2 / u.Angstrom
```

```python
print(f"total flux in ring = {total_flux}")
```

```
total flux in ring = 9.97224763703286e-15 erg / (Angstrom s cm2)
```