Split4

December 6, 2020

1 Recalibrate a raw image which has been split into 4 sections of data to see if all of the spectra look the same

[1]:
```
import os
os.getcwd()
```

[1]: '/Users/long/Projects/wzsge/Recal'

[2]:
```
os.environ['cdbs']= '/grp/hst/cdbs'
os.environ['oref']='/grp/hst/cdbs/oref/'

# print(os.environ)
```

[3]:
```
from astropy.io import fits
filename='split4.fits'
raw=fits.open(filename)
raw.info()
```

```
Filename: split4.fits
No.    Name      Ver    Type      Cards   Dimensions   Format
  0  PRIMARY       1 PrimaryHDU     215   ()
  1  SCI           1 ImageHDU       138   (1024, 1024)   float64
  2  ERR           1 ImageHDU       138   (1024, 1024)   float64
  3  DQ            1 ImageHDU       139   ()
  4  SCI           2 ImageHDU       138   (1024, 1024)   float64
  5  ERR           2 ImageHDU       138   (1024, 1024)   float64
  6  DQ            2 ImageHDU       139   ()
  7  SCI           3 ImageHDU       138   (1024, 1024)   float64
  8  ERR           3 ImageHDU       138   (1024, 1024)   float64
  9  DQ            3 ImageHDU       139   ()
 10  SCI           4 ImageHDU       138   (1024, 1024)   float64
 11  ERR           4 ImageHDU       138   (1024, 1024)   float64
 12  DQ            4 ImageHDU       139   ()
```

[4]:
```
header=raw[0].header
q=repr(header)
```

```python
print(q)
xh=open('repro_headr.txt','w')
xh.write(q)
xh.close()
```

```
SIMPLE  =                    T / conforms to FITS standard
BITPIX  =                    8 / array data type
NAXIS   =                    0 / number of array dimensions
EXTEND  =                    T
NEXTEND =                   12 / Number of standard extensions
DATE    = '2020-12-06T18:03:51' / Date FITS file was generated
FILENAME= 'split4.fits'        / name of file
FILETYPE= 'SCI      '          / type of data found in data file

TELESCOP= 'HST'                / telescope used to acquire data
INSTRUME= 'STIS  '             / identifier for instrument used to acquire data
EQUINOX =               2000.0 / equinox of celestial coord. system

              / DATA DESCRIPTION KEYWORDS

ROOTNAME= 'o6j712040                         ' / rootname of the observation set
PRIMESI = 'STIS  '             / instrument designated as prime

              / TARGET INFORMATION

TARGNAME= 'WZSGE                         ' / proposer's target name
RA_TARG =   3.019016666667E+02 / right ascension of the target (deg) (J2000)
DEC_TARG=   1.770427777778E+01 / declination of the target (deg) (J2000)

              / PROPOSAL INFORMATION

PROPOSID=                 9287 / PEP proposal identifier
LINENUM = '12.020          '   / proposal logsheet line number
PR_INV_L= 'Knigge                        ' / last name of principal investigator
PR_INV_F= 'Christian           ' / first name of principal investigator
PR_INV_M= '                    ' / middle name / initial of principal investigat

              / SUMMARY EXPOSURE INFORMATION

TDATEOBS= '2001-08-08'         / UT date of start of first exposure in file
TTIMEOBS= '19:35:04'           / UT start time of first exposure in file
TEXPSTRT=     52129.8160280462 / start time (MJD) of 1st exposure in file
TEXPEND =     52129.8490164649 / end time (MJD) of last exposure in the file
TEXPTIME=    2850.199624999999 / total exposure time (seconds)
QUALCOM1= '1 RECENTERING(S) OCCURRED, FOR A DURATION OF 3.0 SECONDS.         '
QUALCOM2= 'ENGINEERING TELEMETRY UNAVAILABLE FOR 34.12 SECONDS.              '
QUALCOM3= '                                                                  '
```

```
QUALITY = 'RECENTER; TM_GAP                                                     '

              / TARGET OFFSETS (POSTARGS)

POSTARG1=             0.000000 / POSTARG in axis 1 direction
POSTARG2=             0.000000 / POSTARG in axis 2 direction

              / DIAGNOSTIC KEYWORDS

OVERFLOW=                    0 / Number of science data overflows
OPUS_VER= 'HSTDP 2018_2a     ' / data processing software system version
CAL_VER = '                        ' / CALSTIS code version
PROCTIME=   5.830455291667E+04 / Pipeline processing time (MJD)
CSYS_VER= 'hstdp-2018.1'       / Calibration software system version id

              / SCIENCE INSTRUMENT CONFIGURATION

CFSTATUS= 'SUPPORTED  '        / configuration status (support., avail., eng.)
OBSTYPE = 'SPECTROSCOPIC '     / observation type - imaging or spectroscopic
OBSMODE = 'TIME-TAG  '         / operating mode
PHOTMODE= '                                                   ' / observation con
SCLAMP  = 'NONE          '     / lamp status, NONE or name of lamp which is on
LAMPSET = '0.0   '             / spectral cal lamp current value (milliamps)
NRPTEXP =                    4 / number of repeat exposures in set: default 1
SUBARRAY=                    F / data from a subarray (T) or full frame (F)
DETECTOR= 'FUV-MAMA  '         / detector in use: NUV-MAMA, FUV-MAMA, or CCD
OPT_ELEM= 'E140M   '           / optical element in use
APERTURE= '0.2X0.06        '   / aperture name
PROPAPER= '0.2X0.06        '   / proposed aperture name
FILTER  = 'Clear             ' / filter in use
APER_FOV= '0.2x0.063       '   / aperture field of view
CENWAVE =                 1425 / central wavelength of spectrum
REPELLER= 'ON '                / repeller voltage: applies only to fuv-mama

              / MAMA OFFSETS

MOFFSET1=                    3 / axis 1 MAMA offset (low-res pixels)
MOFFSET2=                  -17 / axis 2 MAMA offset (low-res pixels)

              / LOCAL RATE CHECK IMAGE

LRC_XSTS=                    T / Local Rate check image exists (T/F)
LRC_FAIL=                    F / Local Rate Check Failed (T/F)

              / READOUT DEFINITION PARAMETERS

CENTERA1=                  513 / subarray axis1 center pt in unbinned dect. pix
CENTERA2=                  513 / subarray axis2 center pt in unbinned dect. pix
```

```
SIZAXIS1=                 1024 / subarray axis1 size in unbinned detector pixels
SIZAXIS2=                 1024 / subarray axis2 size in unbinned detector pixels
BINAXIS1=                    2 / axis1 data bin size in unbinned detector pixels
BINAXIS2=                    2 / axis2 data bin size in unbinned detector pixels

              / CALIBRATION SWITCHES: PERFORM, OMIT, COMPLETE

DQICORR = 'PERFORM '           / data quality initialization
RPTCORR = 'OMIT    '           / add individual repeat observations
DOPPCORR= 'PERFORM '           / convolve ref. files with orbital Doppler shift
LORSCORR= 'COMPLETE'           / Convert MAMA data to Lo-Res before processing
GLINCORR= 'PERFORM '           / correct for global detector non-linearities
LFLGCORR= 'PERFORM '           / flag pixels for local and global nonlinearities
DARKCORR= 'PERFORM '           / Subtract dark image
FLATCORR= 'PERFORM '           / flat field data
STATFLAG=                    T / Calculate statistics?
WAVECORR= 'PERFORM '           / use wavecal to adjust wavelength zeropoint
X1DCORR = 'PERFORM '           / Perform 1-D spectral extraction
BACKCORR= 'PERFORM '           / subtract background (sky and interorder)
HELCORR = 'PERFORM '           / convert to heliocenttric wavelengths
DISPCORR= 'PERFORM '           / apply 2-dimensional dispersion solutions
FLUXCORR= 'PERFORM '           / convert to absolute flux units
X2DCORR = 'OMIT    '           / rectify 2-D spectral image
SC2DCORR= 'PERFORM '           / 2-D scattered light correction algorithm

              / CALIBRATION REFERENCE FILES

BPIXTAB = 'oref$uce15153o_bpx.fits' / bad pixel table
DARKFILE= 'oref$q591955po_drk.fits' / dark image file name
PFLTFILE= 'oref$mbj1658bo_pfl.fits' / pixel to pixel flat field file name
LFLTFILE= 'oref$m1b2139mo_lfl.fits' / low order flat
PHOTTAB = 'oref$qb319512o_pht.fits' / Photometric throughput table
IMPHTTAB= 'oref$y2i1649no_imp.fits' / Imaging photometric table
APERTAB = 'oref$y2r1559to_apt.fits' / relative aperture throughput table
MLINTAB = 'oref$j9r16559o_lin.fits' / MAMA linearity correction table
WAVECAL = 'o6j712040_wav.fits     ' / wavecal image file name
APDESTAB= 'oref$16j16005o_apd.fits' / aperture description table
SPTRCTAB= 'oref$q8l14504o_1dt.fits' / spectrum trace table
DISPTAB = 'oref$m7p16110o_dsp.fits' / dispersion coefficient table
INANGTAB= 'oref$h1v1541eo_iac.fits' / incidence angle correction table
LAMPTAB = 'oref$l421050oo_lmp.fits' / template calibration lamp spectra table
SDCTAB  = 'oref$16j1600ao_sdc.fits' / 2-D spatial distortion correction table
XTRACTAB= 'oref$n7p10323o_1dx.fits' / parameters for 1-D spectral extraction tab
PCTAB   = 'oref$y2r16001o_pct.fits' / Photometry correction table
MOFFTAB = 'oref$h4s1350io_moc.fits' / MAMA offsets table
WCPTAB  = 'oref$16j1600co_wcp.fits' / wavecal parameters table
CDSTAB  = 'oref$k8m09584o_cds.fits' / Cross-Disperser Scattering table
ECHSCTAB= 'oref$k8m09585o_ech.fits' / Echelle Scattering table
```

```
EXSTAB  = 'oref$k8m09586o_exs.fits' / Echelle Cross-Dispersion Scattering table
RIPTAB  = 'oref$k8m09588o_rip.fits' / Echelle Ripple table
HALOTAB = 'oref$k8m09587o_hal.fits' / Detector Halo table
TELTAB  = 'oref$k8m0958ao_tel.fits' / Telescope Point Spread Function table
SRWTAB  = 'oref$k8m09589o_srw.fits' / Scattering Reference Wavelengths table
TDSTAB  = 'oref$q9s1550ko_tds.fits' / time-dependent sensitivity algorithm used
TDCTAB  = 'N/A     '           / Coefficient table for NUV MAMA dark scalin
GACTAB  = 'N/A     '           / grating-aperture correction table

              / TIME-TAG OPTIONAL PARAMETERS

BUFFTIME=                 99.0 / Read-out time for internal data buffer
TTAGBADC=                    1 / corrupt finetime count
TTAGROVR=                 3273 / finetime rollover count
TTAGBADF=                  723 / finetime dropback count
TTAGFULL=                    0 / total overflow count
TTAGNSTP=                    0 / negative time step count

              / TARGET ACQUISITION DATASET IDENTIFIERS

ACQNAME = 'o6j712PZ% '         / rootname of acquisition exposure
ACQTYPE = '                '    / type of acquisition
PEAKNAM1= 'o6j712Q0% '         / rootname of 1st peakup exposure
PEAKNAM2= 'o6j712Q1% '         / rootname of 2nd peakup exposure

              / OTFR KEYWORDS

T_SGSTAR= 'F                 ' / OMS calculated guide star control

              / PATTERN KEYWORDS

PATTERN1= 'NONE                    ' / primary pattern type
P1_SHAPE= '                  ' / primary pattern shape
P1_PURPS= '          '         / primary pattern purpose
P1_NPTS =                    0 / number of points in primary pattern
P1_PSPAC=             0.000000 / point spacing for primary pattern (arc-sec)
P1_LSPAC=             0.000000 / line spacing for primary pattern (arc-sec)
P1_ANGLE=             0.000000 / angle between sides of parallelogram patt (deg)
P1_FRAME= '         '          / coordinate frame of primary pattern
P1_ORINT=             0.000000 / orientation of pattern to coordinate frame (deg
P1_CENTR= '   '                / center pattern relative to pointing (yes/no)

              / ARCHIVE SEARCH KEYWORDS

BANDWID =                595.0 / bandwidth of the data
SPECRES =              45800.0 / approx. resolving power at central wavelength
CENTRWV =               1425.0 / central wavelength of the data
MINWAVE =               1140.0 / minimum wavelength in spectrum
```

```
MAXWAVE =               1735.0 / maximum wavelength in spectrum
PLATESC =               0.0145 / plate scale (arcsec/pixel)

              / PAPER PRODUCT SUPPORT KEYWORDS

PROPTTL1= 'STIS Ultraviolet Observations of the Death Star in Outburst         '
OBSET_ID= '12'                 / observation set id
TARDESCR= 'STAR;DWARF NOVA                                                     '
MTFLAG  = ' '                  / moving target flag; T if it is a moving target
PARALLAX=   0.000000000000E+00 / target parallax from proposal
MU_RA   =   0.000000000000E+00 / target proper motion from proposal (degrees RA)
MU_DEC  =   0.000000000000E+00 / target proper motion from proposal (deg. DEC)
MU_EPOCH= 'J2000.0'            / epoch of proper motion from proposal

              / ASSOCIATION KEYWORDS

ASN_ID  = 'O6J712040 '         / unique identifier assigned to association
ASN_TAB = 'o6j712040_asn.fits     ' / name of the association table

              / POINTING INFORMATION

PA_V3   =           333.908295 / position angle of V3-axis of HST (deg)
CRDS_CTX= 'hst_0656.pmap'
CRDS_VER= '7.1.5, 7.1.5, 3548bc1'
BIASFILE= 'N/A     '
CCDTAB  = 'N/A     '
CRREJTAB= 'N/A     '
IDCTAB  = 'N/A     '
ORIGIN  = 'stistools inttag.py'
```

[5]:
```
def clean(root):
    import os

    if os.path.exists(root+'_flt.fits'):
        os.remove(root+'_flt.fits')
    if os.path.exists(root+'_x1d.fits'):
        os.remove(root+'_x1d.fits')
    if os.path.exists(root+'.trl'):
        os.remove(root+'.trl')
```

2 Now reprocess the data

[7]:
```
import stistools
root=filename.replace('split4.fits','')
clean(root)
stistools.calstis.calstis(filename,verbose=True,outroot=root,trailer=root+'.trl')
```

```
/Users/long/anaconda3/envs/astroconda/lib/python3.7/site-
packages/stsci/tools/nmpfit.py:10: UserWarning: NMPFIT is deprecated -
stsci.tools v 3.5 is the last version to contain it.
  warnings.warn("NMPFIT is deprecated - stsci.tools v 3.5 is the last version to
contain it.")
/Users/long/anaconda3/envs/astroconda/lib/python3.7/site-
packages/stsci/tools/gfit.py:20: UserWarning: GFIT is deprecated - stsci.tools v
3.4.12 is the last version to contain it.Use astropy.modeling instead.
  warnings.warn("GFIT is deprecated - stsci.tools v 3.4.12 is the last version
to contain it."
```

```
The following tasks in the stistools package can be run with TEAL:
   basic2d      calstis     ocrreject     wavecal        x1d          x2d
Running calstis on split4.fits
  ['cs0.e', '-v', 'split4.fits']
```

[7]: 0

3 Now plot the results

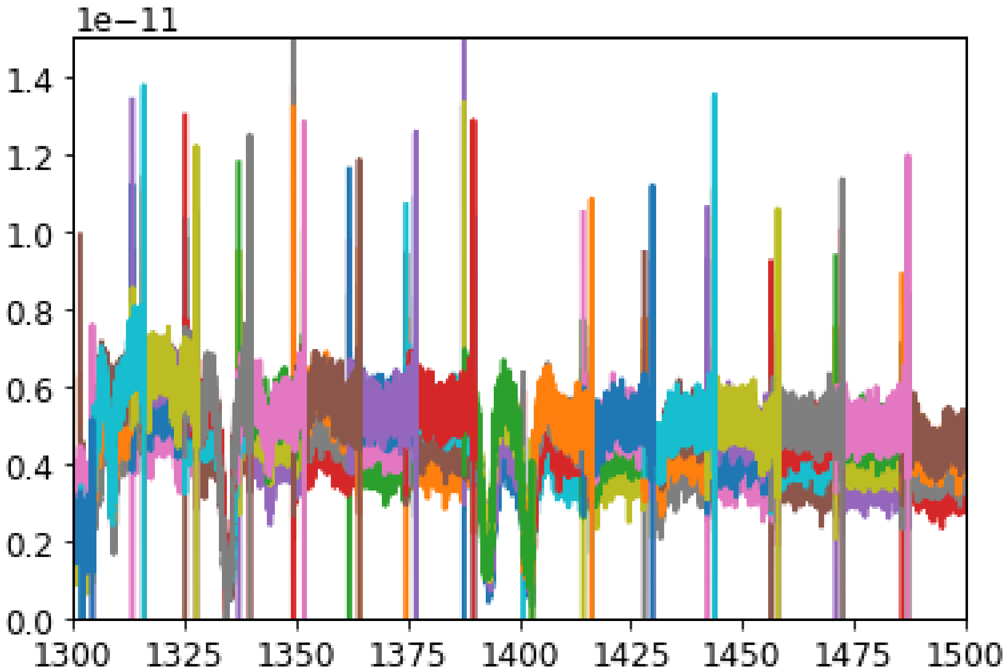
[66]:
```
x=fits.open('split4_x1d.fits')
x.info()
```

```
Filename: split4_x1d.fits
No.    Name      Ver    Type      Cards   Dimensions   Format
  0  PRIMARY       1 PrimaryHDU     301   ()
  1  SCI           1 BinTableHDU    168   44R x 19C   [1I, 1I, 1024D, 1024E,
1024E, 1024E, 1024E, 1024E, 1024E, 1024I, 1E, 1E, 1I, 1E, 1E, 1E, 1E, 1024E, 1E]
  2  SCI           2 BinTableHDU    168   44R x 19C   [1I, 1I, 1024D, 1024E,
1024E, 1024E, 1024E, 1024E, 1024E, 1024I, 1E, 1E, 1I, 1E, 1E, 1E, 1E, 1024E, 1E]
  3  SCI           3 BinTableHDU    168   44R x 19C   [1I, 1I, 1024D, 1024E,
1024E, 1024E, 1024E, 1024E, 1024E, 1024I, 1E, 1E, 1I, 1E, 1E, 1E, 1E, 1024E, 1E]
  4  SCI           4 BinTableHDU    168   44R x 19C   [1I, 1I, 1024D, 1024E,
1024E, 1024E, 1024E, 1024E, 1024E, 1024I, 1E, 1E, 1I, 1E, 1E, 1E, 1E, 1024E, 1E]
```

[67]:
```
import matplotlib.pyplot as pylab
def plotit(x,wmin=1300,wmax=1500,fmin=0,fmax=1.5e-11):

    j=1
    while j<len(x):
        tbdata=x[j].data

        i=0

        while i<len(tbdata['WAVELENGTH']):
            w=tbdata['WAVELENGTH'][i]
            f=tbdata['FLUX'][i]
```

```
            pylab.plot(w,f)
            i+=1

        j+=1
    pylab.axis((wmin,wmax,fmin,fmax))
```

[68]:
```
plotit(x)
```



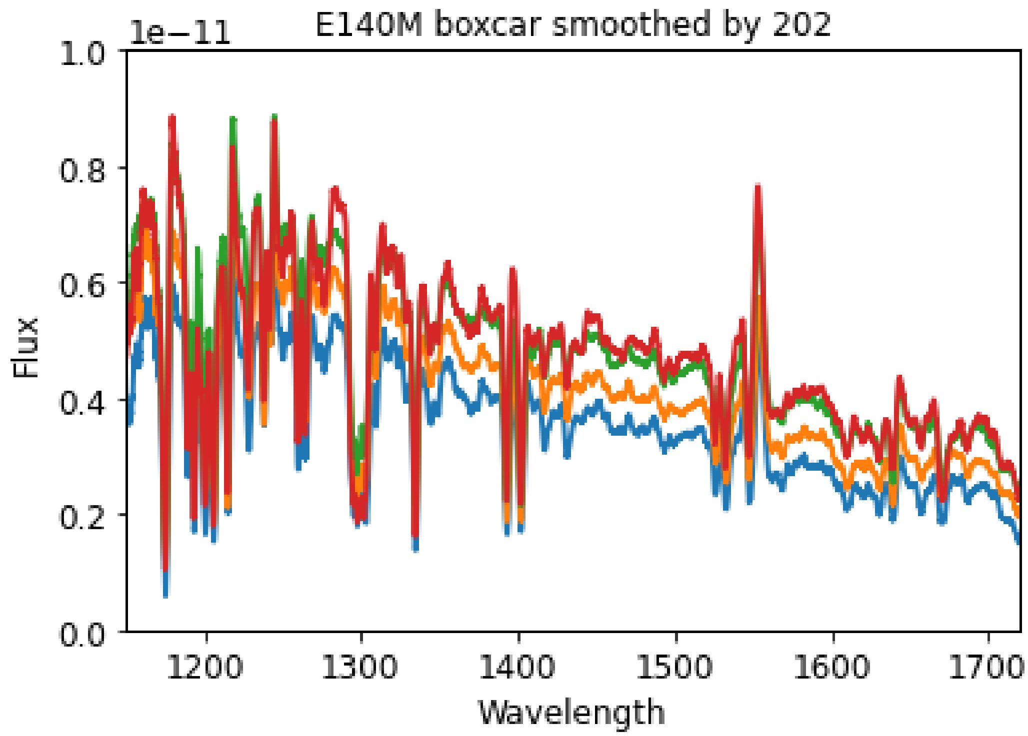
[69]:
```
from importlib import reload
from py_cv import echelle2ascii
reload(echelle2ascii)
```

[69]: <module 'py_cv.echelle2ascii' from '/Users/long/py_progs/py_cv/echelle2ascii.py'>

Plot my one d version of the E!40M spectrum

Recall that the green curve is my attempt at a post processing correction to remover the effects of the echlle orders.

[70]:
```
wmin=1150
wmax=1720
echelle2ascii.do_and_plot('split4_x1d.
↪fits',smooth=202,wmin=wmin,wmax=wmax,fmax=1e-11,fix=True)
pylab.savefig('split4.png')
```



The purpose of this exercise was to see if the spectra were identical up to a normalization. This looks True from what is above but we can do a little more analysis of this

[71]:
```
from scipy.signal import boxcar
from scipy.signal import convolve
from astropy.io import ascii
import matplotlib.pyplot as plt
import numpy as np
```

[72]:
```
x1=ascii.read('split4_x1d.001.txt')
x2=ascii.read('split4_x1d.002.txt')
x3=ascii.read('split4_x1d.003.txt')
x4=ascii.read('split4_x1d.004.txt')
```

[73]:
```
print(len(x1),len(x2),len(x3),len(x4))
```

```
38848 38848 38848 38848
```

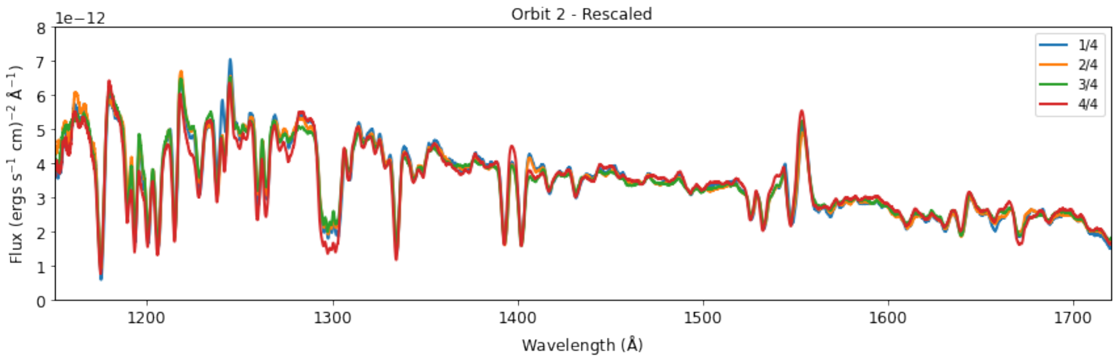
[74]:
```
smooth=201
f1=convolve(x1['FLUX'],boxcar(smooth)/float(smooth),mode='same')
f2=convolve(x2['FLUX'],boxcar(smooth)/float(smooth),mode='same')
f3=convolve(x3['FLUX'],boxcar(smooth)/float(smooth),mode='same')
f4=convolve(x4['FLUX'],boxcar(smooth)/float(smooth),mode='same')
```

[82]:
```
m1=np.median(f1)
m2=np.median(f2)
m3=np.median(f3)
m4=np.median(f4)
```

[83]:
```
print(m1,m2,m3,m4)
w=x1['WAVE']
```

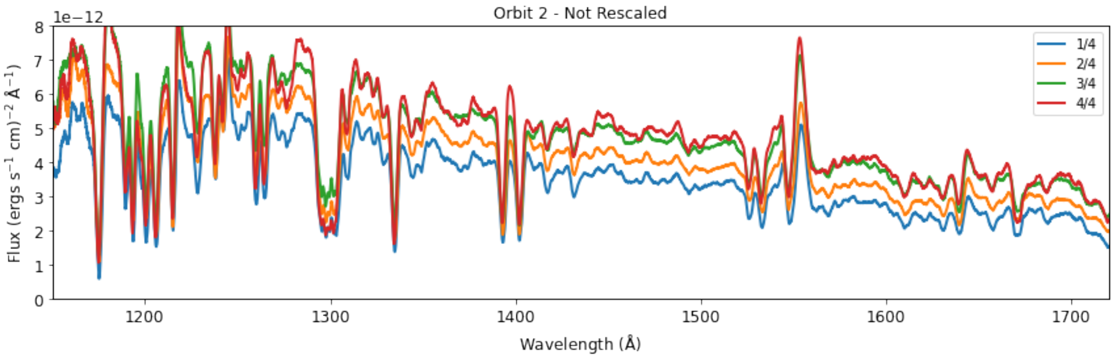
```
3.489246702674129e-12 4.0838590109452734e-12 4.747853291293533e-12
4.817776327114428e-12
```

[92]:
```
plt.figure(1,(12,4))
plt.plot(w,f1,label='1/4')
plt.plot(w,f2*m1/m2,label='2/4')
plt.plot(w,f3*m1/m3,label='3/4')
plt.plot(w,f4*m1/m4,label='4/4')
plt.legend()
plt.xlim(1150,1720)
plt.ylim(0,0.8e-11)
plt.xlabel(r'Wavelength ($\AA$)')
plt.ylabel(r'Flux (ergs s$^{-1}$ cm)$^{-2}$ $\AA^{-1}$)')
plt.title('Orbit 2 - Rescaled')
plt.tight_layout()
plt.savefig('compare4.png')
```



[91]:
```
plt.figure(1,(12,4))
plt.plot(w,f1,label='1/4')
plt.plot(w,f2,label='2/4')
plt.plot(w,f3,label='3/4')
plt.plot(w,f4,label='4/4')
plt.legend()
plt.xlim(1150,1720)
plt.ylim(0,0.8e-11)
plt.xlabel(r'Wavelength ($\AA$)')
```

```
plt.ylabel(r'Flux (ergs s$^{-1}$ cm)$^{-2}$ $\AA^{-1}$)')
plt.title('Orbit 2 - Not Rescaled')
plt.tight_layout()
plt.savefig('compare_orig4.png')
```



[ ]:

```

```