- Using UVIT/FUV-Grating for Spectroscopy

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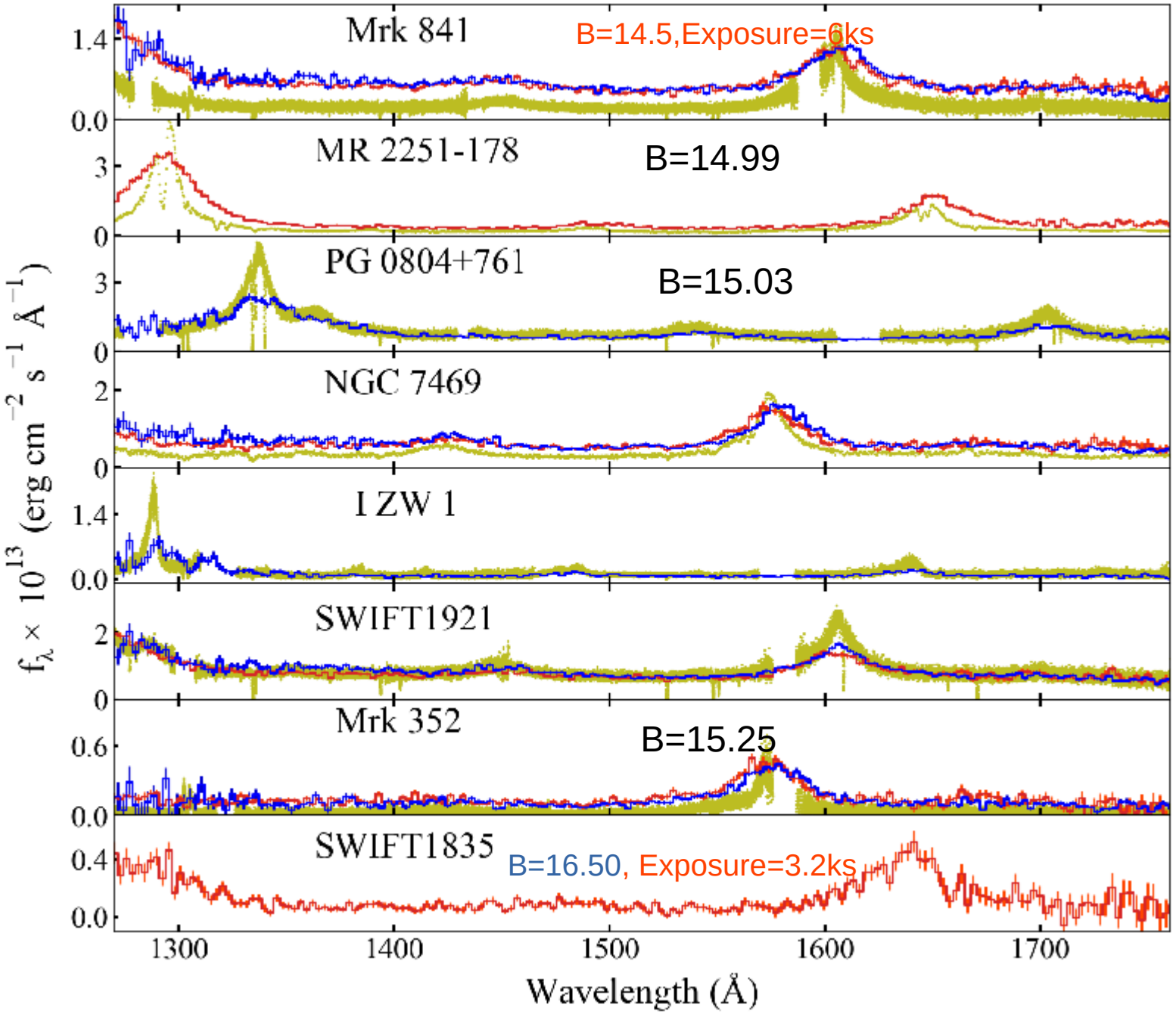
UVIT Gratings

Parameter	FUV-Grating1	FUV-Grating2	NUV-Grating
Filter Wheel Slot number	4	6	4
IDs in APPS	4 - grating1 (FUV)	6 - grating2 (FUV)	4 - grating (NUV)
IDs in CCDLAB	FUV_Grating1	FUV_Grating2	NUV_Grating
This paper	FUV-G1	FUV-G2	NUV-G
IDs in Tandon *et al.* (2020)	FUV1	FUV2	NUV
IDs in Tandon *et al.* (2017)	2nd FUV grating (#66126)	1st FUV grating (#63771)	NUV grating (#66125)
IDs in UVIT Pipeline	F4	F6	F4
$m = -1$ peak λ	–	–	2100Å
$m = -2$ peak λ	~ 1400Å	~ 1500Å	–
Spectral resolution (FWHM)	14.6Å	14.6Å	33Å

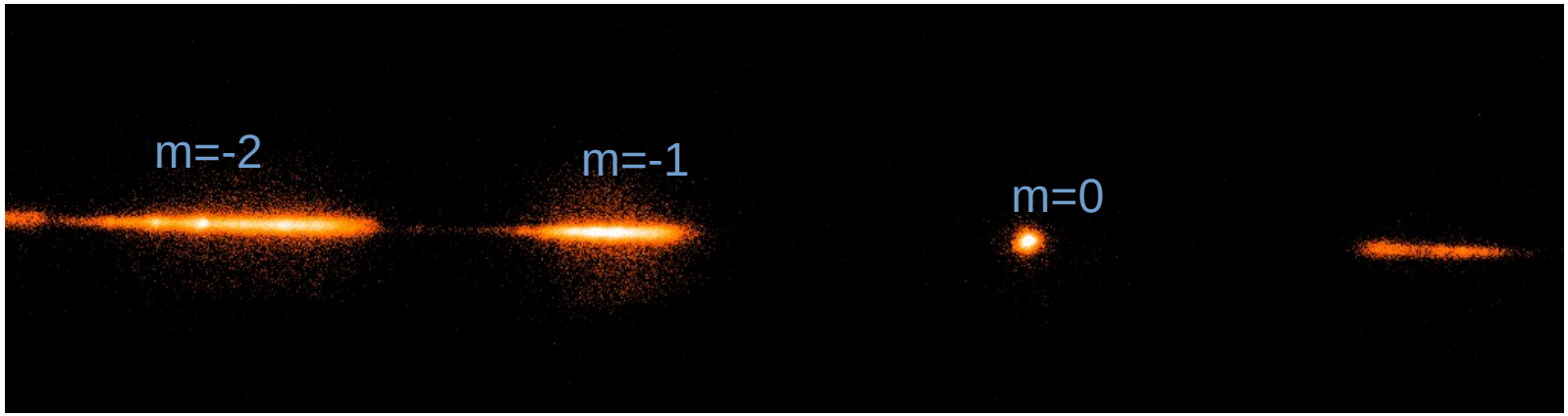
Useful for a variety of sources such as hot stars, interacting binaries, WD, CV, AGN, PN, XRB, etc.

Dewangan 2021, Tandon et al. 2017,2020

NUV channel not available, no need to configure.

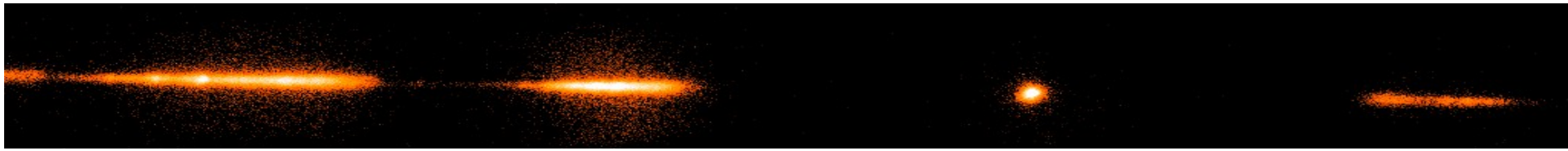

Mrk 841
B=14.5,Exposure=6ks
MR 2251-178
B=14.99
PG 0804+761
B=15.03
NGC 7469
I ZW 1
SWIFT1921
Mrk 352
B=15.25
SWIFT1835
B=16.50, Exposure=3.2ks
Red: FUV-G1
Blue: FUV-G2
Olive: HST
Shrabani Kumar + GCD et al.
$f_\lambda \times 10^{13}$ (erg cm^{-2} s^{-1} Å^{-1})
Wavelength (Å)
1300
1400
1500
1600
1700

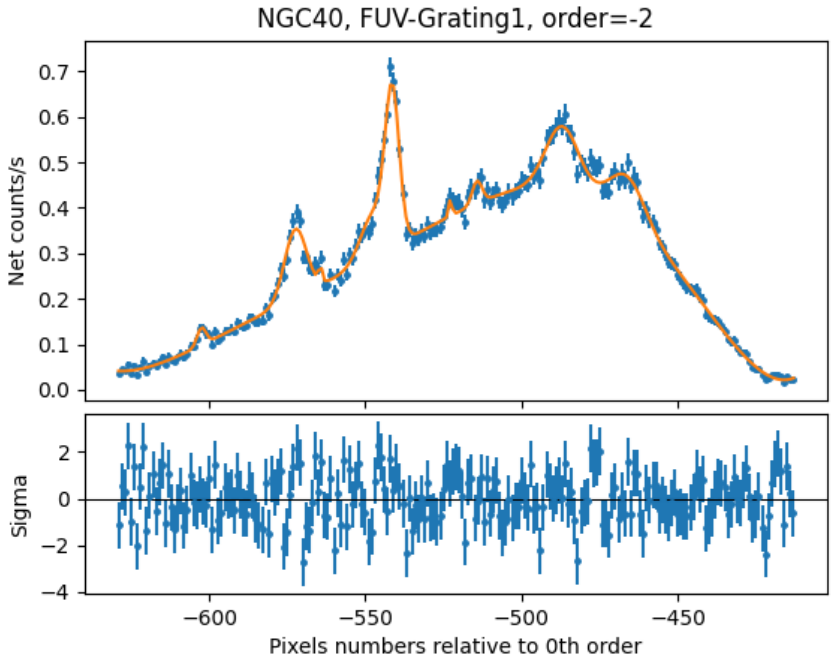
UVIT Grating Data

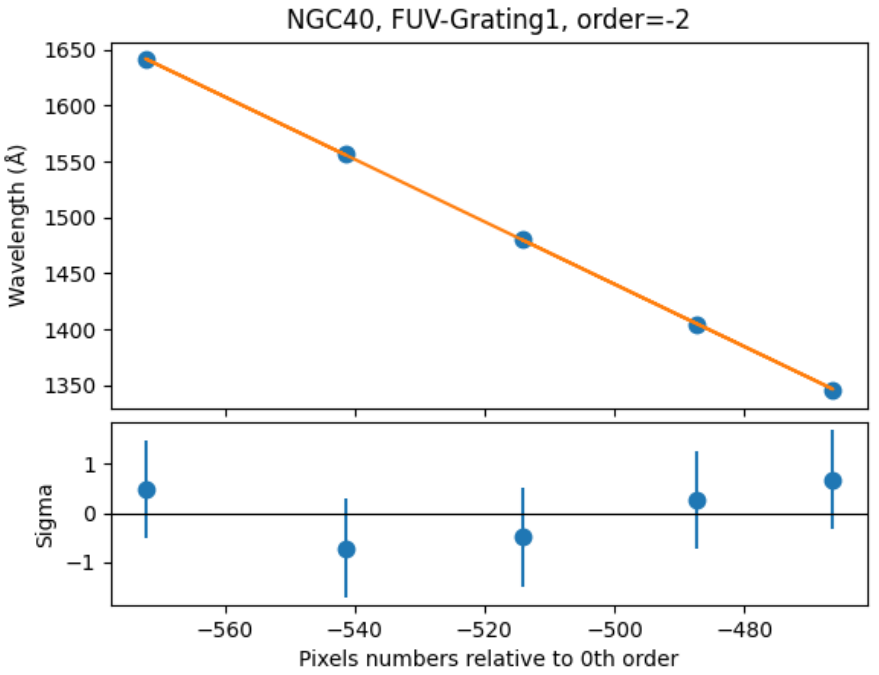


- Merged Level2 image (CCDLAB) in detector coordinates
- Identify 0, -1, -2 orders spectra of the target of interest
- Extract 1d spectrum (Dispersion axis slightly tilted wrt to X-axis (NUV-grating, FUV-grating1) or Y-axis (FUV-grating2)
- Counts Vs pixel numbers

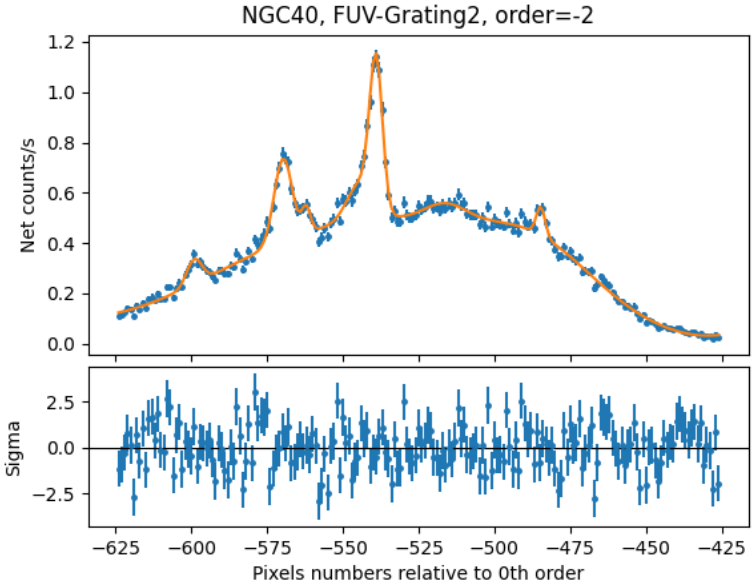
FUV-Grating1 order=-2: Wavelength calibration

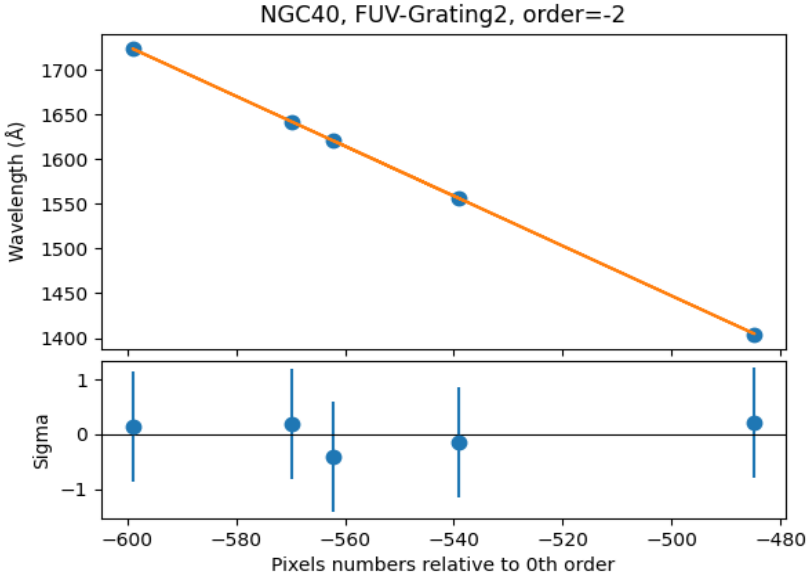


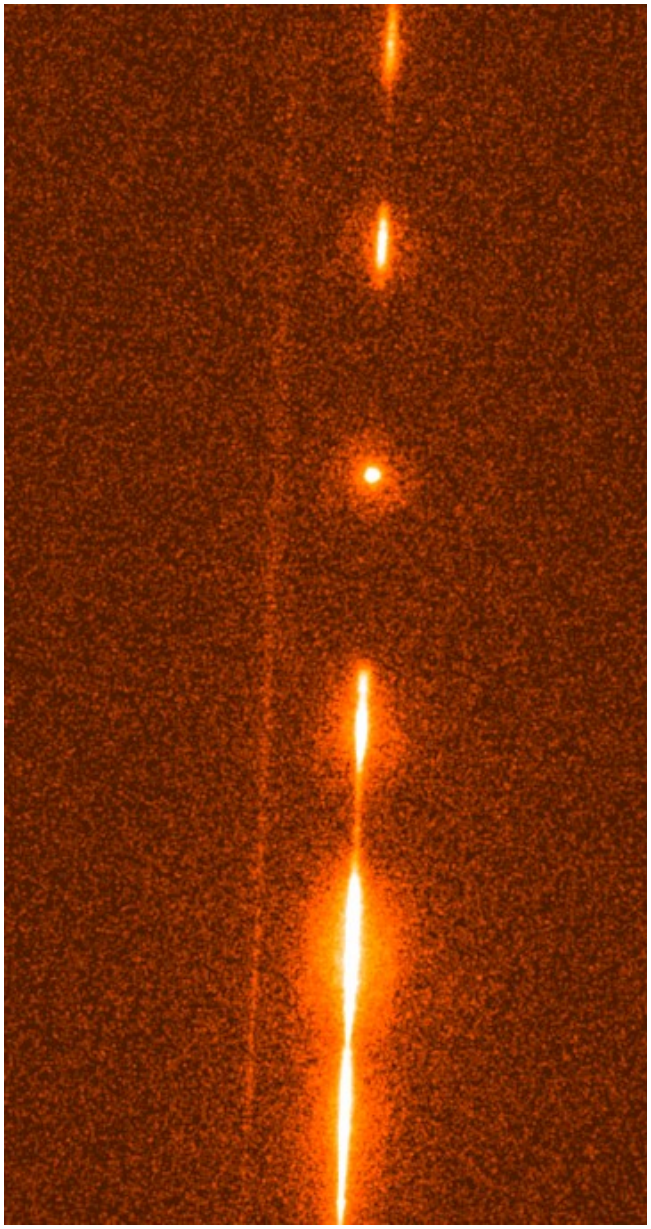




FUV-Grating2 order=-2: Wavelength calibration







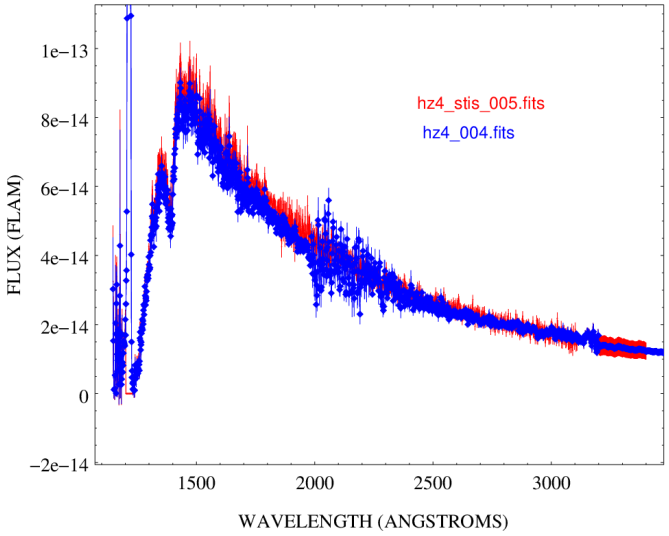
Effective Area & Flux Calibration

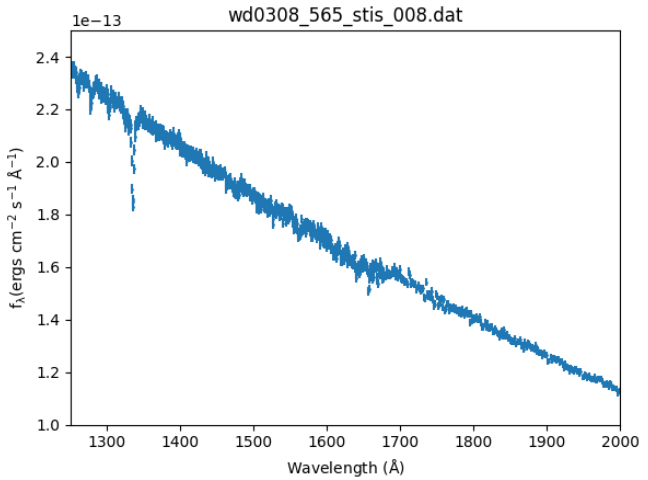
Use spectrophotometric standard such as a hot WD HZ4 or WD0305-564 with featureless spectra

$$C(X) = \int R_{X\lambda} A_\lambda f_\lambda \left(\frac{\lambda}{hc}\right) d\lambda$$

$$C_X = \sum_\lambda R_{X\lambda} A_\lambda f_\lambda \frac{\lambda}{hc}$$

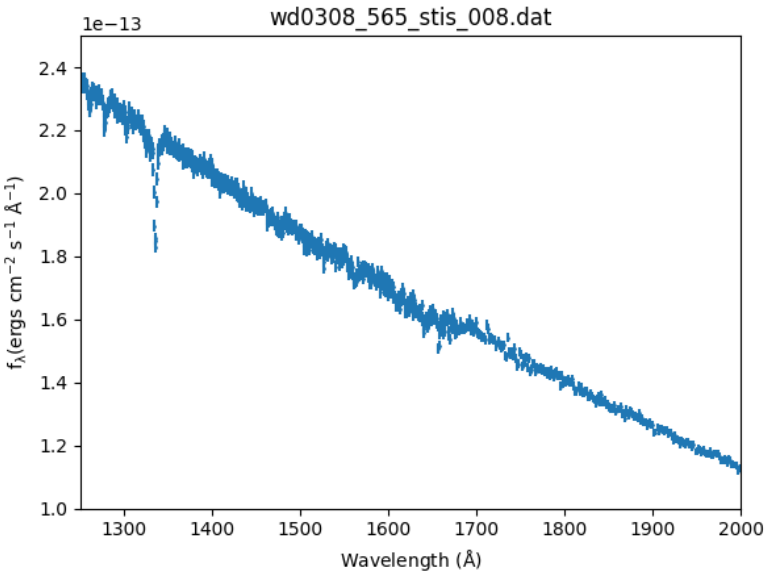
$$f_\lambda = \frac{C_\lambda (hc/\lambda)}{A_\lambda}$$

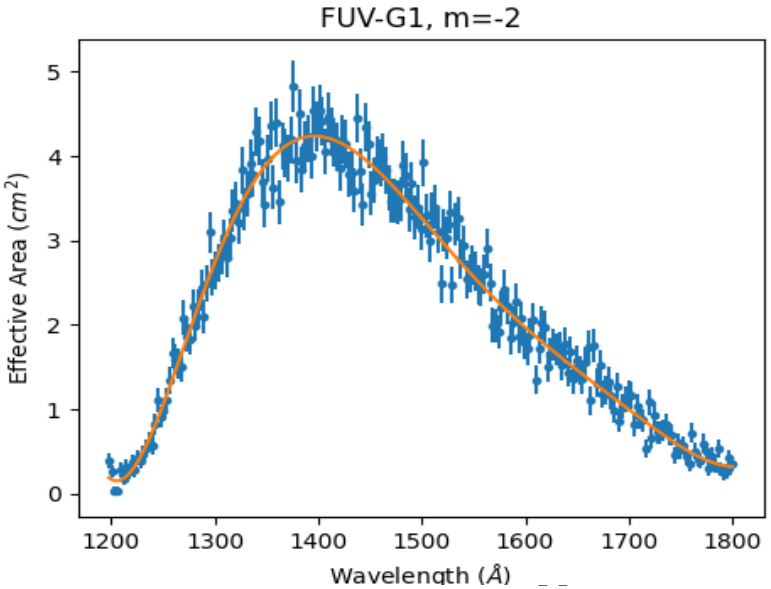




FUV-Grating1 order=-2: Effective area and flux calibration

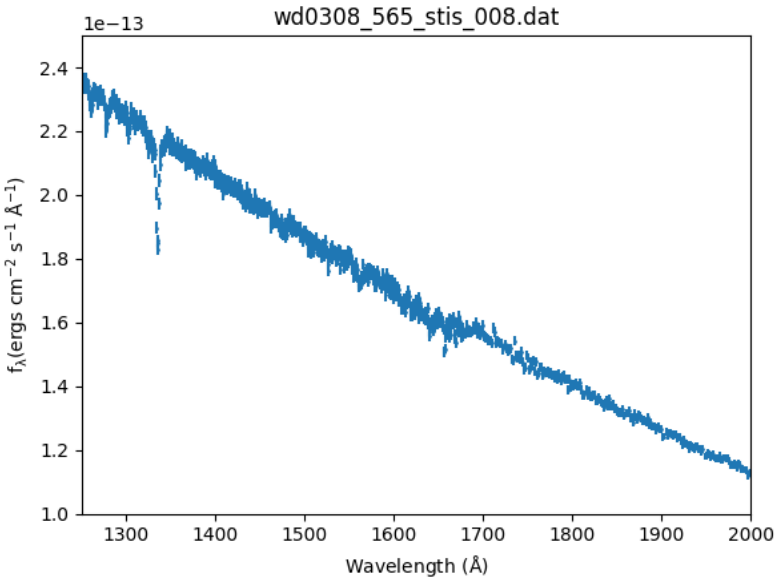
Nov 2022 Calibration

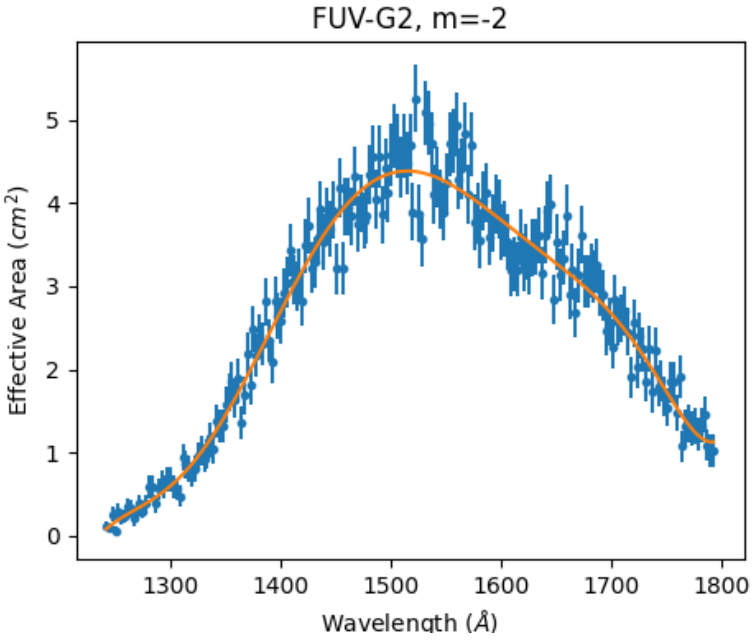




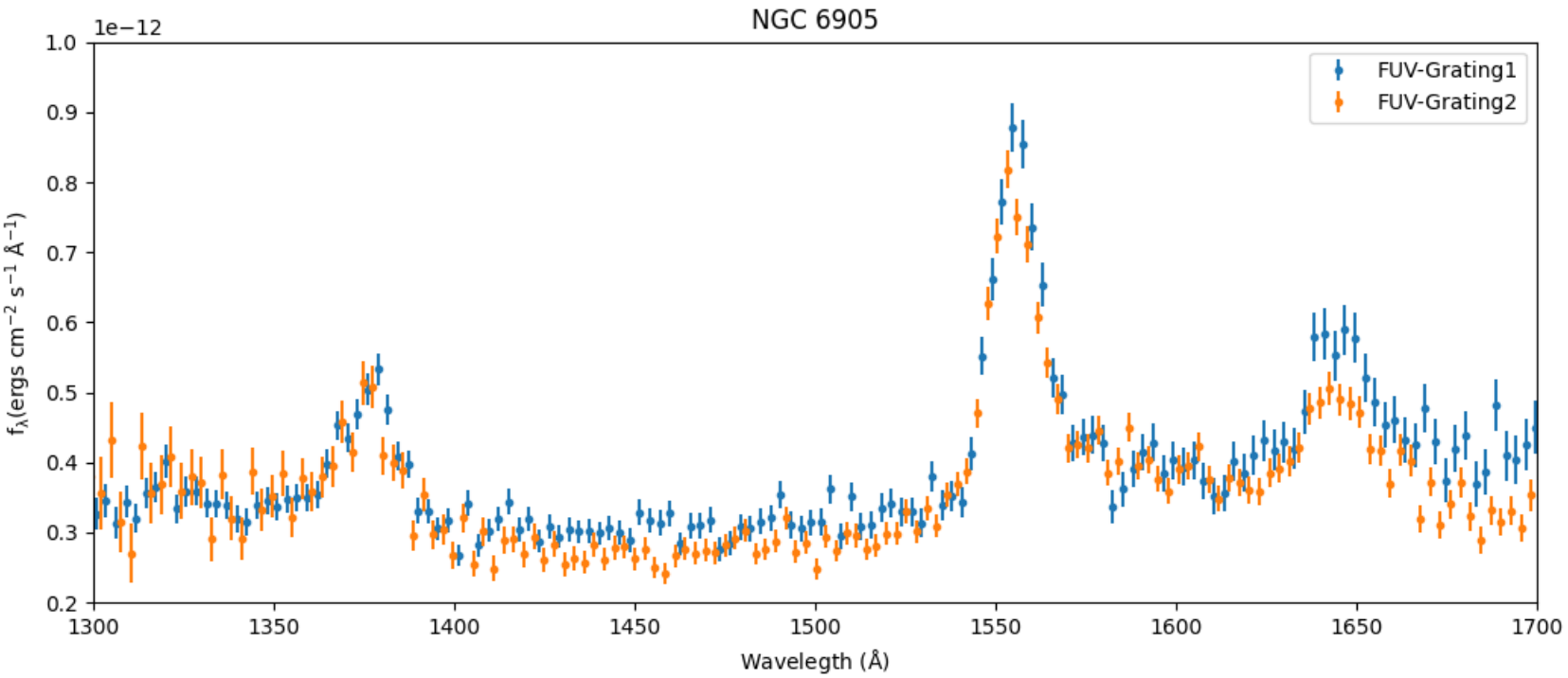
FUV-Grating2 order=-2: Effective area and flux calibration

Nov 2022 Calibration

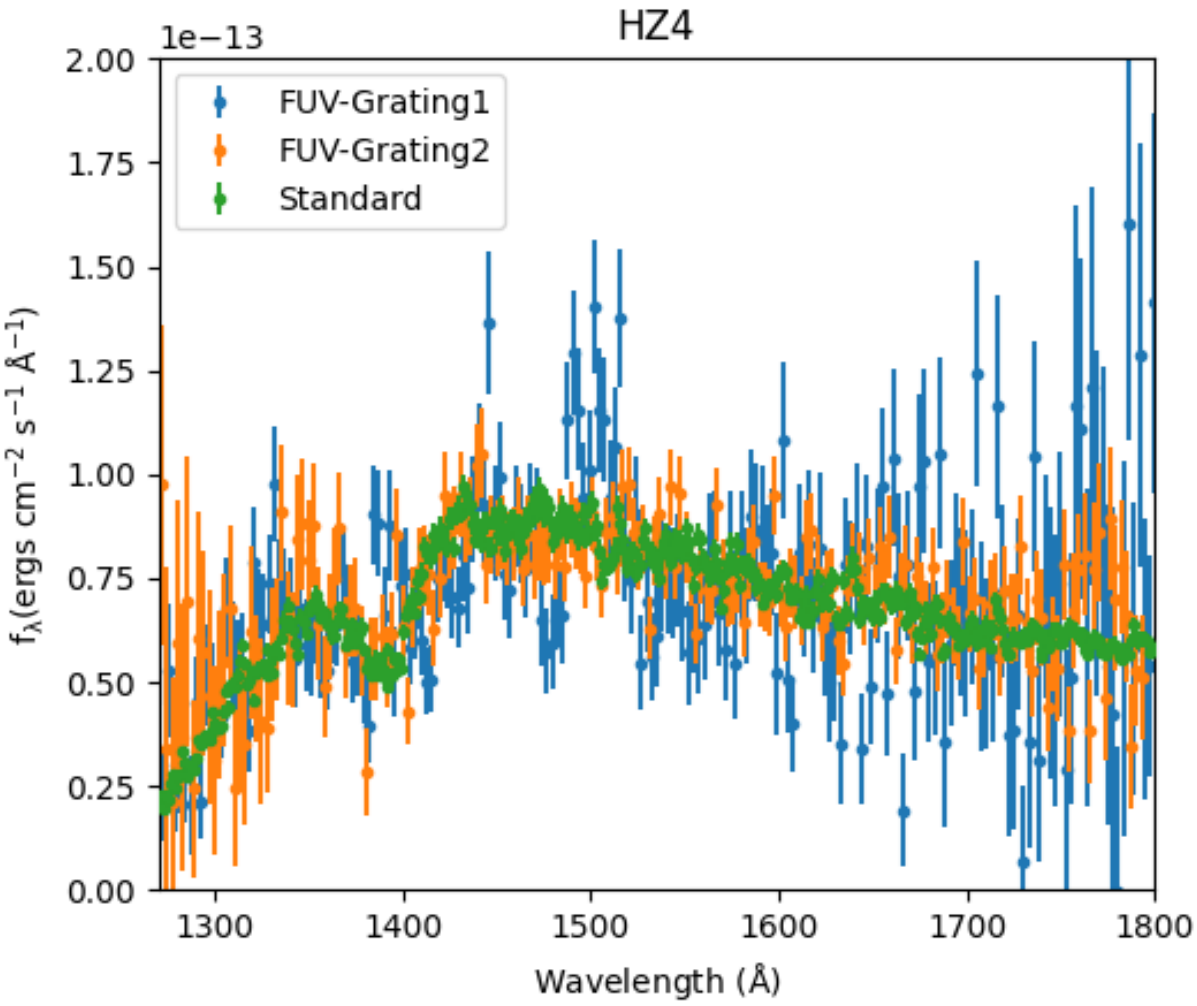




Checking Wavelength Calibration : NGC6905



Checking flux calibration: HZ4



Grating spectral response

$$D(I) = T \int R(I,E)A(E)f(E)dE + B(I)$$

T : Exposure time

R(I,E) : redistribution matrix (pixel no. => channel I)

UVIT gratings - Gaussian response to delta function

FWHM: 38.4A (NUV-grating), 16A(FUV-grating1), 14A(FUV-grating2)

A(E) : energy-dependent effective area of the telescope and detector system (in cm2), Effective area curves derived for the gratings

f(E): Source spectrum (in photons/cm2/s/keV)

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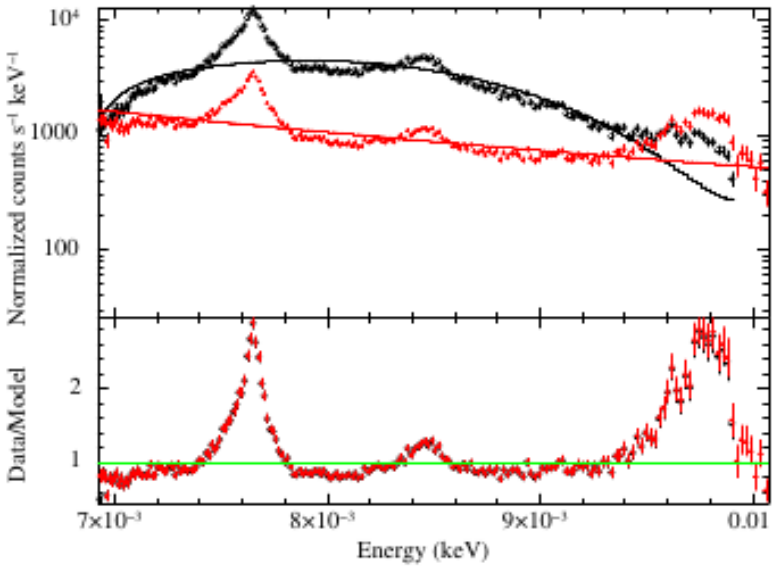
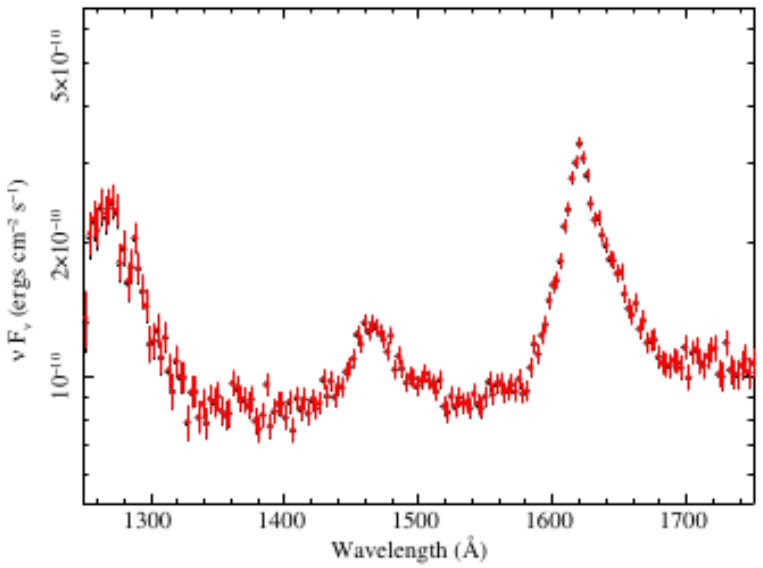
Spectral fitting: Fluxed Vs PHA spectrum

Fairall 9





UVITTools.jl: A julia package for UVIT/Grating Analysis (Dewangan, 2021, JAA)

Simulating FUV Grating spectra

Spectral response files (includes effective area):

FUV/Grating1, m=-2 : fuv_grating1_m2_12nov22.rmf

FUV/Grating2, m=-2 : fuv_grating2_m2_12nov22.rmf

Background files

FUV/Grating1, m=-2 : FUV_Grating1_m2_bgd.pha

FUV/Grating2, m=-2 : FUV_Grating2_m2_bgd.pha

Spectral simulations with xspec in the same way as the X-ray spectra

1. Define a source model e.g., blackbody for a hot WD

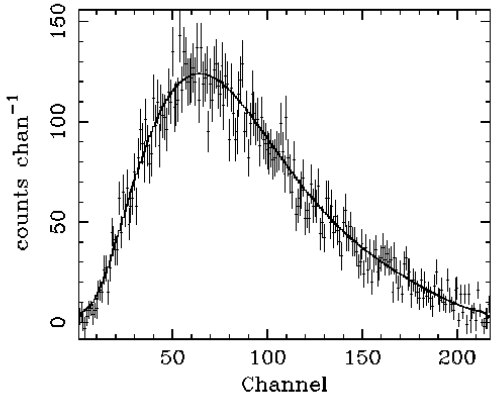
2. UV spectra suffer from extinction, use a reddening model such as "redden" or "uvred" for the Galactic extinction. Need E(B-V) from literuture or Convert from Galactic column.

3. Use the grating response and background to simulate a spectrum.

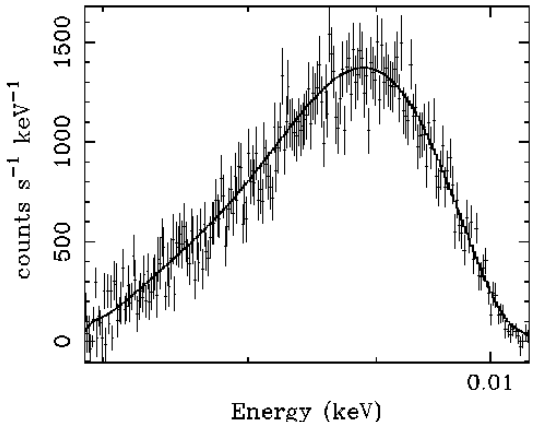
An example Spectral simulation

XSPEC12>model uvred * bbody
Model uvred<1>*bbody<2> Source No.: 1 Active/On
Model Model Component Parameter Unit Value
par comp

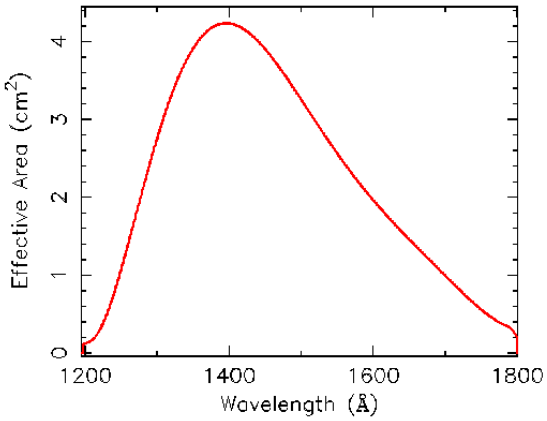
1	1	uvred	E_BmV		4.00000E-02 +/- 0.0
2	2	bbody	kT	keV	1.00000E-02 +/- 0.0
3	2	bbody	norm		1.00000E-02 +/- 0.0



XSPEC12>fakeit FUV_Grating1_m2_bgd.pha
For fake spectrum #1 response file is needed: fuv_grating1_m2_12nov22.rmf
...and ancillary file:
Use counting statistics in creating fake data? (y):
Input optional fake file prefix:
Fake data file name (fuv_grating1_m2_12nov22.fak): mysource_fuvg1_spec.fak
Exposure time, correction norm, bkg exposure time (3856.29, 1.00000, 3856.29): 5000,1,5000



XSPEC12>show rates
Spectral Data File: mysource_fuvg1_spec.fak
Assigned to Data Group 1 and Plot Group 1
Net count rate (cts/s) for Spectrum:1 2.514e+00 +/- 2.474e-02 (90.2 % total)
Spectral data counts: 13933
Model predicted rate: 2.56165
XSPEC12>flux 0.007 0.010
Model Flux 0.95018 photons (1.2983e-11 ergs/cm^2/s) range (0.0070000 -



Thank You