UV Spectroscopy Scratch

Monday, July 25, 2016

Download the HST spectra for the UV SBHB project:
Proposal ID: 12299
https://archive.stsci.edu/proposal_search.php?id=12299&mission=hst

I requested all of the calibrated data.

Downloading the data:
Jess@ilarion:spec> ftp -i anonymous@stdatu.stsci.edu
(the -i prevents you having to say "y" to download each file with mget later)
ftp> cd /stage/anonymous/anonymous10163
ftp> ls
229 Entering Extended Passive Mode (|||60021|)
150 Opening ASCII mode data connection for file list
-rw-rw---- 1 48 400 11520 Jul 25 14:35 lbji01010_asn.fits
-rw-rw---- 1 48 400 100800 Jul 25 14:35 lbji01010_trl.fits
-rw-rw---- 1 48 400 1287360 Jul 25 14:35 lbji01010_x1dsum.fits
-rw-rw---- 1 48 400 1416960 Jul 25 14:35 lbji01010_x1dsum1.fits
-rw-rw---- 1 48 400 1416960 Jul 25 14:35 lbji01010_x1dsum2.fits
-rw-rw---- 1 48 400 1416960 Jul 25 14:35 lbji01010_x1dsum3.fits
-rw-rw---- 1 48 400 1416960 Jul 25 14:35 lbji01010_x1dsum4.fits
-rw-rw---- 1 48 400 21049920 Jul 25 14:48 lbji01njq_flt.fits
-rw-rw---- 1 48 400 316800 Jul 25 14:48 lbji01njq_spt.fits
-rw-rw---- 1 48 400 23040 Jul 25 14:48 lbji01njq_trl.fits
-rw-rw---- 1 48 400 1284480 Jul 25 14:35 lbji01noq_corrtag_a.fits
-rw-rw---- 1 48 400 567360 Jul 25 14:35 lbji01noq_corrtag_b.fits
-rw-rw---- 1 48 400 167820480 Jul 25 14:35 lbji01noq_flt_a.fits
-rw-rw---- 1 48 400 167820480 Jul 25 14:36 lbji01noq_flt_b.fits
-rw-rw---- 1 48 400 1356480 Jul 25 14:36 lbji01noq_lampflash.fits
ftp> mget *.fits

What are they sending me?
COS:
http://www.stsci.edu/hst/cos/documents/handbooks/datahandbook/ch2_cos_data3.html#475054

Final Data Products									
`fltsum`	image					•	•	47	Summed flat-fielded image (imaging only). ***Final calibrated association product for all COS imaging datasets***
`x1dsum`	table	•	•	•	•			46	Final combined 1-D extracted spectra for multiple exposures with the same grating, central wavelength and aperture combining all `FP-POS`. ***Final calibrated association product for all COS spectroscopic datasets.***

STIS:
http://www.stsci.edu/hst/stis/documents/handbooks/currentDHB/ch2_stis_data3.html#368063

Calibrated Data		
_flt	image	Flat-fielded science
_crj	image	Cosmic ray rejected, flat-fielded science (CCD data only)
_sfl	image	Summed flat-fielded science (MAMA data only)
_x1d	table	1-D extracted spectra for individual imsets: • Aperture extracted, background subtracted, flux and wavelength calibrated spectra
_x2d	image	2-D spectral and direct images for individual imsets: • Rectified, wavelength and flux calibrated first order spectra or • Geometrically corrected imaging data.
_sx1	table	1-D extracted spectra from summed (REPEATOBS) or cosmic ray rejected (CRSPLIT) images.
_sx2	image	2-D rectified direct or spectral images from summed (REPEATOBS) or cosmic ray rejected (CRSPLIT) images.

How should I extract the spectra?
COS:

- For each *xd1sum.fits file, create a 3-column (wave, flux, err) data file (.dat) and corresponding header (.hdr).

COS spectra have been recalibrated recently:

- Begin forwarded message:
  From: Paule Sonnentrucker <sonnentr@stsci.edu>

  Subject: Your COS/NUV program 12299
  Date: June 17, 2016 11:33:34 AM EDT
  To: "mxe17@psu.edu" <mxe17@psu.edu>
  Dear Dr Eracleous,

  The COS Team has recently determined that a calibration issue had the effect of applying erroneous wavelength zero-points for some of the COS/NUV data taken with the G185M, G225M, G285M and G230L gratings. We wanted to alert you to the fact that some datasets in your COS/NUV program with ID 12299 are affected by this calibration short-coming. While the full description of this issue can be found in the June 2016 edition of the COS STAN (http://www.stsci.edu/hst/cos/documents/newsletters/cos_stis_newsletters/stan1606.html), a brief explanation is provided to you in this correspondence.

  Due to the lack of suitable calibration or science data, the zero-point of the dispersion solutions for all G185M settings, and for select cenwave/stripe combinations of the G225M, G285M and G230L gratings had not been updated with on-orbit values after the Science Mission Orbital Verification phase in 2009 (see June 2016 COS STAN for list of affected configurations). This lack of proper calibration can result in a significant (up to 1 Angstrom) mis-registering of the wavelength for spectral features detected in the affected configurations. The COS Team delivered a new DISPTAB reference file in May 2016, which contains preliminary updates to the zero-points for the affected G225M, G285M, and G230L combinations. This reference file does not include updates for the G185M modes at this point. New data will be acquired during summer 2016 to determine accurate dispersion zero-points for all affected settings. The COS Team will deliver a new DISPTAB containing updated zero-points accurate to mission specifications for all affected NUV modes once the calibration data are analyzed.

  We encourage you to re-retrieve the COS/NUV datasets associated with program 12299 to ensure that you are using the current up to-date calibration products. You will be notified once again when the new DISPTAB reference file is available. Do not hesitate to contact us via the helpdesk (help@stsci.edu) if you have additional questions or concerns.

  Sincerely,
  The COS Team

Mike suggested that I could use the 2600 A interstellar Fe absorption feature to determine whether the wavelength calibration is good in the new spectra that I downloaded. As it turns out, we never have coverage of 2600 A in the COS spectra (it's always either off the red end of the spectrum, or in a gap).

Tuesday, July 26, 2016

The STIS spectra are not combined. There were 8 targets, each with 3 dither position and 2 CRSPLITs. The CRSPLITs have been combined in the *s1x.fits files, but the result of the different dither positions are not combined.

The exposure times are the same for all spectra for each target:

```
dat1 = mrdfits(raw_stis_files[i],1,header1,/silent)
dat2 = mrdfits(raw_stis_files[i+1],1,header2,/silent)
dat3 = mrdfits(raw_stis_files[i+2],1,header3,/silent)
regex = 'EXPTIME'
expt1 = header1(where(stregex(header1,regex) eq 0.))
expt2 = header2(where(stregex(header2,regex) eq 0.))
expt3 = header3(where(stregex(header3,regex) eq 0.))
print, expt1,expt2,expt3
```

The dithered exposures are not on a common wavelength scale. They do have all about the same resolution, however.

Combination procedure:

- Make a master wavelength scale of the first spectrum. It will have 1024 pixels.
- For each spectrum, throw out pixels where the DQ flag is 16 (i.e. the pixel value is >5σ times the median dark - these are huge noise spikes).
- Rebin each spectrum to the common wavelength scale.
- At each pixel, adopt an average of all the fluxes that don't have DQ=16.

It appears that the DQ=16 flag identifies the noise spikes really well, but also the [O III] emission lines sometimes. I shouldn't use it.
Do these hot points have huge errors? No.

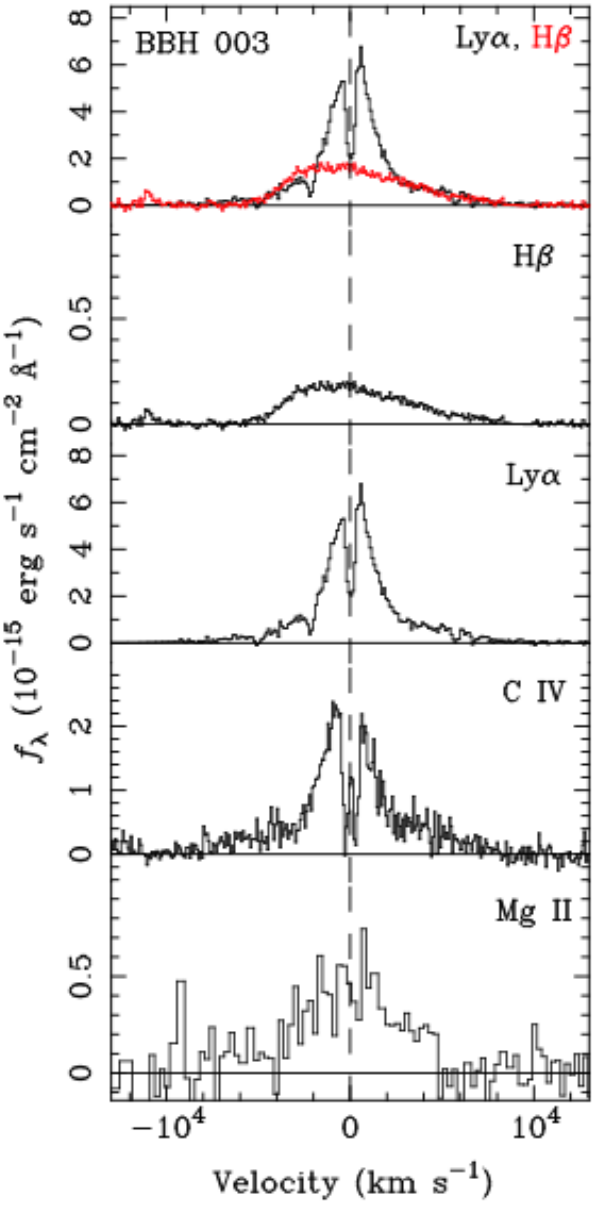
Okay. Here's the deal:

- STIS
  - Combine the 3 spectra from the dither pattern by:
    - Generating a common wavelength array. This is the wavelength array of the first spectrum, with the first and last element adjusted so that it is

available for all three spectra.
        - Rebinning the spectrum using my IDL version of Mike's rebin_linear_flam. I edited it to propagate the error array as it rebins (because all the new fluxes are linear combinations of old fluxes in neighboring pixels, this is easy).
        - Average the three spectra. Propagate the error array.
        - I didn't remove any hot/bad pixels.
    - The text header that I wrote out is for the first exposure. It will have 1/3 the exposure time. The .dat, .2ca, and .2cu spectra have the correct exposure times.
- COS
    - Don't throw out any bad data.

Wednesday, July 27, 2016

Okay, I need to make stacks of line profiles for each object. Like this:



I need the following steps:

- Identify and collect the spectra for each profile/object.
- Run specfit to produce continuum subtracted spectra.
- Generated stacked plots (Hα, Hβ, Lyα, CIV, MgII) in velocity space.
    - The COS spectra will need to be rebinned by 4-10.
- Overplot the broad Hβ model on the Hβ, Hα?, Lyα profiles.

Other data issues:
bbh000_20110720_HET has the wrong redshift so I didn't run specfit on it.
bbh080_20110526_HET doesn't cover all of the Hb line so I didn't (and won't be able) to run specfit on it.
bbh072_20140527_APOb needs the 2cu --> txt conversion.

Lya fits

- BBH000
  - 1212-1215,1250-1400
- BBH003
  - 1140-1150,1180-1190,1250-1350
- BBH004
  - 1140-1150,1177-1187,1250-1300
- BBH008
  - 1140-1160,1300-1350,1450-1500
- BBH013
  - 1140-1160,1300-1350,1450-1500, power law exponent lower limit dropped to -5
- BBH015
  - 1140-1160,1300-1350,1450-1500
- BBH023
  - 1100-1150,1275-1350, power law exponent lower limit dropped to -5
- BBH026
  - 1100-1150,1300-1350,1450-1500
- BBH027
  - 1130-1160,1300-1350
- BBH062
  - 1300-1350,1450-1500
- BBH072
  - 1170-1180,1275-1290,1350-1375
- BBH080
  - 1150-1160,1300-1400
- BBH085
  - 1090-1100,1275-1300

CIV fits

- BBH003
  - 1450-1500,1600-1650

- BBH004
  - 1450-1500,1600-1650
- BBH008
  - 1450-1500,1600-1650, power law exponent lower limit dropped to -5
- BBH013
  - 1450-1500,1600-1650
- BBH015
  - 1450-1500,1600-1650
- BBH023
  - 1450-1500,1600-1650
- BBH026
  - 1450-1500,1600-1650
- BBH027
  - 1450-1500,1600-1650

Mg II fits

- BBH000
  - 2650-2680,2900-3100, start Fe II strength at 1.0.
- BBH003
  - 2700-2750,2900-2950,3250-3400, power law only
- BBH004
  - 2630-2680,2850-3050
- BBH008
  - 2590-2680, 2880-2950, 2960-3300
- BBH013
  - 2600-2750,2900-3300, power law only
- BBH015
  - 2650-2750, 2905-32030
- BBH023
  - 2700-2750,2900-3000
- BBH026
  - 2600-2750,2900-3000,3200-3300
- BBH027
  - 2500-2750, 2900-3400, power law only
- BBH062
  - 2500-2750, 2850-3000, start power law at 400 and 40, start Fe II at 5.0 and 0.5.
- BBH080
  - 2500-2680, 2900-3050, set power law strength to 100 and step size to 10 before fitting
- BBH085
  - 2500-2750, 2900-3100

Ha fits

- BBH000
  - 5450-5750, 6000-6200, start power law at 4000 and 400.
- BBH003
  - 6000-6200, 7200-8000
- BBH004
  - 6000-6200, 7200-8000
- BBH008
  - 6000-6200,6900-8000
- BBH013
  - 5460-5620,6900-7050
- BBH015
  - 5460-5620,6900-7500
- BBH023
  - 6000-6150,7000-7500
- BBH026
  - 5750-5850,6000-6050,7000-8000
- BBH027
  - 5500-5600,6100-6150,7300-7400
- BBH062
  - 5500-5600,6050-6150
- BBH080
  - 5460-5620,6000-6150,6800-6900
- BBH085
  - t

Monday, August 1, 2016

Galactic extinction correction:

- I can correct all the spectra. But what about the spectral decompositions I've done?
  - I think that the fits will still be reasonably good, in the sense that if at some wavelength the model exactly went through the data, applying the same extinction correction at that wavelength will still yield a good fit.
  - However, I think if there was a discrepancy between the data and the model, it will be amplified:
    -

Tuesday, August 2, 2016

Hα spectral decomposition:

- BBH000
  - This object needs a special initial guess.
- BBH003
  - This one is going to need one of the [O I] Gaussians set to zero.
- BBH004
  - This will need the narrow Hα initial guesses bumped up to 1000.
  - Some components went negative, I fixed them to zero and refit.
- BBH008
  - This will need the narrow Hα initial guesses bumped up to 1000.
  - I tweaked the widths on the blue [N II] line.
- BBH013
  - Super shifted. I moved the centroids for Gaussians 15, 16, 17 to 6600 (these are broad Ha).
- BBH015
  - Excellent.
- BBH023
  - Started Gaussians 16 and 17 with centroids of 6600.
  - The narrow lines are so weak, they're hard to fit. Set the second set of Gaussians for the narrow lines to zero and fix them.
  - Make Gaussian 17 allowed to be super narrow.
  - It really needed another broad Ha Gaussian, so I gave it Gaussian 2 (which is usually [O I]).
- BBH026
  - Gave the broad Ha Gaussians larger starting guesses (5000+).
  - I had to release the asymmetry on Gaussian 15.
- BBH027
  - Started Gaussians 15 and 16 with centroids of 6600.
  - The narrow lines are so weak, they're hard to fit. Set the second set of Gaussians for the narrow lines to zero and fix them.
  - It really needed another broad Ha Gaussian, so I gave it Gaussian 2 (which is usually [O I]).
  - Make the [S II] flux step size 1.0.
- BBH062
  - The line isn't completely covered, so fit 6200-6593 A.
  - The narrow lines are so weak, they're hard to fit. Set the second set of Gaussians for the narrow lines to zero and fix them.
  - Fix all the lines with λ>6593 A to 0.
- BBH072
  - The narrow lines are so weak, they're hard to fit. Set the second set of Gaussians for the narrow lines to zero and fix them.

When I get back:
spfitpkg> pwd
/Volumes/ilarion1/runnoejc/Research/projects/smbbh/BBH/uvspec/specfit/Ha
spfitpkg> cl < tmp.cl

First, check that no specfit products exist for the objects in tmp.cl

Then I need to measure fluxes. Do it from the data for the broad lines. For UV lines with absorption, don't try to make any corrections and the measurement will be a lower limit.

Monday, August 8, 2016

Measuring flux ratios:

- I have to measure the fluxes from the data, not a specfit model (because I don't have one for the UV lines).
- In light of this, I should just measure the flux within +/- 10,000 km/s. I can't go down to 7% of the peak flux (because the data are too noisy and in practice this doesn't work - sometimes for Lyα it never gets down to 7% of the peak).

Tuesday, May 30, 2017

Comments on some sections of Mike's DPE UV spectroscopy paper:

- Black hole mass estimates
  - Mike measures black hole mass from the [O III] emission-line width, which is correlated with stellar velocity dispersion.
  - Mike follows the Shields et al. (2003), and is under the impression that this will over-estimate the black hole mass.
  - Some thoughts:
    - Shields et al. (2003) assumes that the [O III] line is Gaussian and converts between FHWM and line dispersion with a factor of 2.35. This is not good. Nelson & Whittle (1996) also assume a Gaussian line shape for the stellar absorption lines.
    - The issue with the [O III] width overestimating the stellar line widths is not that they just overestimate, it's a question of profile shape.
    - Brotherton et al. (2015, http://adsabs.harvard.edu/abs/2015MNRAS.454.3864B) does an empirical calculation that doesn't make any assumption about the profile shape. The uncertainty is 0.12 dex, so smaller than what you've been getting. Could do this instead.

        - The Bian & Zhao (2004) argue that the line width may be overestimated because the spectral resolution is too low. Brotherton at least made a correction for instrumental resolution.
- What does the community think about α_ox right now?
    - Well, it does correlate with luminosity, but also L/Ledd. So the fact that the DPEs don't fall on the α_ox - L_2500 relationship, but that may be because they're pretty extreme in L/Ledd.
    - Here are some papers:
        - Lusso et al. (2010): http://adsabs.harvard.edu/abs/2010A%26A...512A..34L
        - Brandt et al. (2000): http://adsabs.harvard.edu/abs/2000ApJ...528..637B

The plots:

- We don't need Hα. There aren't any spectra taken near the UV spectra (timewise), so we can't do a direct Lyα/Hα comparison. The only reason to do it is to easily compare to the DPE paper, and because it's a strong line. We could do a Lyα/Hβ comparison, and then in another spectrum do Hβ/Hα, but that is a little silly because it's not clear that we can compare even the line ratios between spectra.
- So for now, just totally skip the Hα, grab the Lyα/Hβ ratios (which can be derived from Mike's tables in the DPE paper), and point the reader to E12 for a comparison of the Hβ and Hα profiles.
- I don't think I necessarily even need the Mg II spectra, at this point. But I can check when they were taken, it might be relatively close in time to the other UV lines.
- I'm thinking I don't want to include the Hβ fits over the UV lines. The fits were really developed to get a smooth narrow-line subtraction, so I sometimes don't get all the bumps and wiggles of the Hβ line very accurately. That is, some of the fits look terrible. I could also just run specfit again on these particular ones and try to do better.

Flux measurements:

- Right now, I'm just integrating the continuum subtracted spectra to get emission-line fluxes, and then calling them limits when there's absorption.
- This is generally okay, except that sometimes the absorption makes the fluxes negative. **I need to do something about that.**

Friday, May 21, 2021

Finally coming back around to finish this project. Let's do a census of work so far:

- Sample:

    - There are 13 objects: BBH000, 003, 004, 008, 013, 015, 023, 026, 027, 062, 072, 080, and 085.
- Spectra:
    - I collected the COS and STIS spectra from HST.
    - I ran specfit on all the emission lines.
    - Some may need to be redone.

Mike on the ILR:

- He thinks it's a dome-like scattering region. Continuum photons are produced by the disk and encounter gas in this region. They are scattered to line wavelengths and velocities taking on some properties of the gas in the scattering region. But they weren't originally produced as line photons by collisional excitation.
- The dispersion of the line profile is a key prediction of this method, but not the centroid, so it may be consistent with Gordon's picture.
- Root is from Elitzur, Netzer, Collin-Souffrin.

Tuesday, June 1, 2021

What about the [N V] emission line?

BBH072 (i=10) may have some [N V] emission that's ruining the Lyα scaling.
BBH085 (i=12) may have some [N V] emission that's ruining the Lyα scaling. Harder to say because of absorption.

Thursday, June 3, 2021

Chat w/ Mike:
SDSS V spectral decompositions:

- Start time
- Data batch
- VAC?
- Be ready:
- Wouldn't it be nice if…
- Why don't you do…
- Enlist a small number of people to advise
- Declare a project
- Totally practical project to make measurements and produce VAC
- Declare the AE project for SDSS V later

How well should the Hβ and UV profiles match?

- Wills series from FOS series.
- Balmer lines and Lyman lines don't have the same profiles.
- Consult that and see how much I should insist that they have the same profiles.
- Or there should be no overshooting emission.

What can we say?

- Can we say that the Lyman lines are not shifted like the Balmer lines?
- UV lines shifts may be complicated by absorption.
- Systematic difference between blue and redshifted cases?
- Blue/redshifts should have the same outcome. Pattern shouldn't break when you look at each of these.
- Lya can't be shifted more than the Balmer lines, but less is okay (it's like pinching the line profile).

Conclusions:
1. All objects fail, therefore none are binaries.
2. Some fail, some could be binaries.
3. None fail, so there's a good chance they're all binaries.

Binary
DPE — call it a disk emitter
Outflow? Blueshifts and redshifts should have different behaviors. Compare to radio.
Preference to match in blue shifted cases but not red?
Lya is the cleanest test because it's the same ion.
- [x] Put a dashed line at zero velocity.
- [x] Start stacks at neg and add dashed line

Friday, June 4, 2021

How well do I expect the Lyα and Hβ profiles to match?

- A lot of the wisdom on this seems to be in the SED sample, actually.
- I took the SED objects and ran them through my code to find the best scaling to the continuum-subtracted line profiles.
    - Shang's fits aren't as good as mine, so sometimes this doesn't work super well because of [O III] residuals and other issues.
    - But generally, I don't find any better or worse agreement between the line profiles than I see in the BBH objects.

Wills et al. (1995): https://ui.adsabs.harvard.edu/abs/1995ApJ...447..139W/abstract

What if I compare to the 1400 A blend? It's supposed to have a profile more like the Balmer lines?

- I tried this. My code will do it if I just switch the w0_lya to 1400 A.
- The issue is that the 1400 A feature is a blend of two lines and it's already low S/N. I don't really have the data power to separate two line profiles in there and still tell if their shape matches Hβ.
- Although it occasionally works. BBH026 looks like the 1400 A feature is blue shifted.

What fraction, by eye, can plausibly be said to match the Hβ spectra?

- BBH000
  - No data.
- BBH003
  - Yes, assuming that Lyα has a very strong ILR component.
- BBH004
  - Yes, assuming that the profile is substantially absorbed.
  - This implies that the broad peak is absorbed by NV (in order to avoid having Lyα > Hβ on the blue wing).
  - This is plausible, because there is substantial NV absorption, and because there's strong Lyα absorption as evidenced by the redshifted peak.
- BBH008
  - Yes, maybe.
  - There's blueshifted absorption on the Hβ profile that makes this look weird. Also, because of the ILR there's a terrible mismatch in the broad peak.
- BBH013
  - Yes, assuming terrible absorption from NV including of the broad peak.
- BBH015
  - Yes, definitely. You see the blue shifted peak.
- BBH023
  - Yes, but hidden by the ILR.
- BBH026
  - Yes, but hidden by the ILR.
- BBH027
  - Yes, but implies terrible absorption by NV.
  - Plausible, because the profile is terribly absorbed.
- BBH062
  - Yes, but crappy data.
- BBH072
  - Yes, but implies systematic NV absorption when I see only NV emission and no absorption profiles.

- BBH080
    - No data.
- BBH085
    - Yes, but implies terrible absorption.

Objects where the broad line shift is unambiguous: 003, 015
Objects that imply lots of absorption: 004, 013, 027, 072, 085
Objects with a strong ILR: 008, 023, 026

Are there any differences in red and blueshifted Balmer profiles?

- Both cases where you can see the shifted broad Lya peak they are blueshift, but that may be complicated by the fact that the NV line is on the red side.

For CIV, we get some compelling cases, but they're all blueshifts. Blueshifted CIV isn't really a revolution.

Redshifted objects:
004, 008, 013, 023, 027, 072

Blueshifted objects:
000, 003, 015, 026, 062, 080, 085

To Do:
I need to redo the scaling on BBH072. It's scaling up to the NV emission line, which mismatches the Lya peak.
Redo the scaling on BBH023, too, just so it doesn't overshoot the Hb peak.
Mark He II on BBH013 in red?
Figure out that BBH008 Hb absorption at ~4750 A.
Do CIV. It has CIV absorption where there's Lya absorption (in velocity space), but it doesn't have NV. This means that e.g., for BBH004, we might get a good handle on the redshifted peak.
Is the CIV line tricky because it's a doublet, whereas Lya is not? Think on this.
How do you get redshifted CIV absorption?

Thursday, July 1, 2021

Where do I expect there to be absorption?

- Lyα
    - C III* λ1175 (v=-10108)
    - Lyα λ1216 (v=0)
    - NV λλ1238,1242 (v=5917)

- CIV
    - CIV λλ1548,1550 (v=0)
    - He II λ1640 (v=17612)
    - O III] λ1663 (v=22063)
- Mg II
    -
    - Fe II λ2383 (v=-44465)
    - Fe II λλ2586,2600 (v=-22715)
    - Mg II λλ2796, 2803 (v=0)
    - Fe II λ2964 (v=17786)
- Hβ
    - He II λ4686 (v=-10912)

Ganguly et al. (2013): https://ui.adsabs.harvard.edu/abs/2013MNRAS.435.1233G/abstract

- Has wavelengths and other information about resonant doublets and absorption in Lya and 1400 A blend regions.

Gangly er al. (2007): https://ui.adsabs.harvard.edu/abs/2007AJ....133..479G/abstract

- Has some Fe absorption line wavelengths in the vicinity of Mg II.

I need to remember that there can be intervening absorption, so there doesn't have to be a line right there to absorb it, it can be redshifted.

BBH003

- There's a v=0 absorption system, you see it in Lyα, NV, CIV, and Mg II.
- There's a v~4000 absorption system. You see it in Lyα (a single line) and CIV (the doublet).
- All UV lines match Hβ.

BBH004

- The Lyα line profile is extremely absorbed, both by Lyα and NV.
- Scaling the broad Hβ line to match the maximum emission on the blue side of Lyα implies that the blue wing of the profile is absorbed almost to v=0. The same happens in CIV and MgII, which shouldn't suffer from red-wing absorption (because there's no NV).
- These UV lines don't match Hβ.

BBH008

- The Lyα profile shape doesn't match Hβ, which has a dip on the blue wing at -8-10,000 km/s and a very cuspy peak. If you match the blue wing so that it appears to match, it implies a little bit of extra emission in Hβ that isn't matched by Lyα on the red wing. This is bourne out in CIV and MgII to a greater extent.
- However, the Hα profile doesn't seem to match Hβ, either.
- In all lines, it's not possible to match the dip at -8-10,000 km/s or the excess at 10,000 km/s.
- Lines look shifted, but don't match Hβ.

BBH013

- The continuum subtraction on Hβ for this one isn't perfect. As a result, the scale really needs a multiplication and addition. I'm not giving it the addition (I really should just redo the spectral fit so it's better at ~5200 A).
- Matching the Lyα and CIV lines on the blue wing implies a huge absorbed flux on the red side of the line.
- The Hβ line matches Hα pretty well, and Mg II okay (it's kind of an intermediate behavior between Hα and the UV lines).
- Hα matches Hβ. Mg II sort of looks shifted but not exactly like Hβ. The UV lines imply a huge absorbed flux on the red wing, which is where the Hβ peak is.

BBH015

- This one is perfect. All the lines show a blueshfited, asymmetric profile that matches very well.
- All lines match Hβ.

BBH023

- The profiles don't match perfectly, but they're pretty convincing.
- CIV looks like it has some absorption doublets right near the redshifted peak of Hβ. Can this produce absorption at the same velocity in the Lyα profile?
- Lines look shifted, but don't perfectly match Hβ but still pretty good.

BBH026

- The profiles are not completely perfectly matched, but they're all pretty compelling.
- It does look like CIV and Lyα have a decent ILR component, or the profile just isn't quite as cushy as Hβ, Hα, and even Mg II.
- All lines match Hβ.

BBH027

- Only has CIV and Lyα.

- Matching the blue wing of the line implies absorption where the redshifted Hβ peak falls. The Lyα line is totally eaten away. It seems like this may be plausible, because there's actually a distinct absorption line at that velocity in CIV.
- Lines look very absorbed, but the profile could plausibly still match Hβ in light of this.

BBH062

- Lyα is noisy and has narrow absorption lines, but appears to be a pretty good match for Hβ.
- Mg II appears to match the peak of Hβ and its blue wing, but the red wing of Mg II is much lower. There are some dips that may indicate absorption?
- Hα has only partial coverage, but it gets the blue shifted peak and it seems to match Hβ.
- Lines look shifted, but don't match Hβ.

BBH072

- The Lyα line profile doesn't match the Hβ redshift. There's no sign of absorption, although there is clear NV emission.
- The Hα line does seem to match Hβ pretty well, modulo the [N II] narrow lines.
- These Lyα line doesn't match Hβ.

BBH080

- The Hβ coverage is poor, half the line is missing. It does resolve the blue shifted broad line peak, however.
- Mg II matches Hβ pretty well, although the narrow line is broader.
- Lyα seems like it may have a blue shifted peak, but it's not as shifted nor as cuspy as Hβ.
- Lines look shifted, but Lyα doesn't match Hβ. Mg II does.

BBH085

- Lyα is absorbed at and blue of the peak, which is where Hβ peaks. There's also absorption that's at and blue of NV.
- This is plausibly absorbed, Mg II seems to match Hβ but is heavily absorbed as well. You can even see line-locked doublets.
- Lines look very absorbed, but the profile could plausibly still match Hβ in light of this.

2 excellent matches
5 imperfect match, visible shift
2 absorbed, but plausibly matched
2 don't match

Monday, July 5, 2021

What's this C III* line?

- https://ui.adsabs.harvard.edu/abs/2010arXiv1012.2052L/abstract

Why doesn't BBH027 have Mg II or Ha scale plots?

Friday, September 17, 2021

What are resonance lines?

Shows profiles of LyA: https://www.brown.edu/research/projects/scientific-computing/sites/brown.edu.research.projects.scientific-computing/files/uploads/Resonant%20scattering%20and%20Ly%CE%B1%20radiation%20emergent%20from%20neutral%20Hydrogen%20halos.pdf
Peter Laursen dissertation (has textbook level radiative transfer and scattering physics): https://arxiv.org/pdf/1012.3175.pdf
Netzer AGN emission lines: https://ned.ipac.caltech.edu/level5/March02/Netzer/Netzer_contents.html
Marziani et al. (2020): https://ui.adsabs.harvard.edu/abs/2020Atoms...8...94M/abstract

2. The UV Emission Lines

The spectral range between ≈1230 and 1950 Å can be subdivided into four regions, each of them associated with a prominent emission blend: (1) the Lyα + NV blend; (2) the 1400 blend, made by the SiIV doublet and the OIV]λ1402 multiplet; (3) the HIL blend CIV + HeIIλ1640; and (4) the blend at 1900 made predominantly by IILs. The main constituents of the four blends are listed below.

- The Lyα + NVλ1240 blend: The χ of the NVλ1240 parent ionic species ≈ 78 eV is the highest among the line considered here. The NVλ1240 is due to a resonant transition ($^2P^o_{\frac{3}{2},\frac{1}{2}} \rightarrow ^2 S_{\frac{1}{2}}$) in the lithium isoelectronic configuration;
- The 1400 Å blend [26]: The SiIV doublet is also a resonant doublet ($^2P^o_{\frac{3}{2},\frac{1}{2}} \rightarrow ^2 S_{\frac{1}{2}}$, from the sodium isoelectronic configuration, $1s^2 2s^2 2p^6 3s^1$). The creation ionization potential of Si^{3+} is much lower, ≈34 eV, than the one of N^{+4}. The OIV]λ1402 inter-combination multiplet is due to transitions between a ^4P term and $^2P^o$ term where the first term is at 0.04785 eV above ground level, with critical densities in the range $n_c \approx 2 \times 10^{10}$–$6 \times 10^{11}$ cm^{-3} [27,28];

- The CIV+ HeIIλ1640 blend: The CIV line is a resonant doublet ($^2P^o_{\frac{3}{2},\frac{1}{2}} \rightarrow {}^2S_{\frac{1}{2}}$) and is again emitted by a transition in the lithium isoelectronic configuration. The parent ionic species has an ionization potential of ≈50 eV. HeIIλ1640 is emitted via 3d ^{2}D → 2p ^{2} P ^{o}, which corresponds to a transition between two very high energy levels above the ground state (48 and 40 eV). The HeIIλ1640 line is blended with the red side of CIV, and the two lines are often measured together [29].
- The blend at λ1900 Å is due, in most part, to the AlIIIλ1860 doublet and to the SiIII]λ1892 and CIII]λ1909 lines. AlIII is a resonant doublet as CIV ($^2P^o_{\frac{3}{2},\frac{1}{2}} \rightarrow {}^2S_{\frac{1}{2}}$) in the sodium isoelectronic configuration, while SiIII] and CIII] are due to inter-combination transitions ($^3P^o_1 \rightarrow {}^1S_0$) with widely different critical densities (≈2×10^{12} cm^{-3} and ≈3.2×10^9 cm^{-3}, respectively; [18]). The parent ionic species imply ionization potentials $20 \lesssim \chi_i \lesssim 30$ eV, intermediate between the ones of the LILs and of the HILs; $\chi_i \gtrsim$ 40–50 eV.

Especially helpful sources:
Davidson & Netzer (1979): https://core.ac.uk/download/pdf/211333388.pdf

- Resonance lines are permitted transitions whose lower level is a ground state because it can produce a very high optical depth!

Tom Theuns grad lectures on IGM: http://icc.dur.ac.uk/~tt/IGM.pdf
Peter Laursen dissertation: https://arxiv.org/pdf/1012.3175.pdf
NED Level 5: https://ned.ipac.caltech.edu/level5/March02/Netzer/paper.pdf