Emission Line Classification of BAL and Non-BAL Quasars

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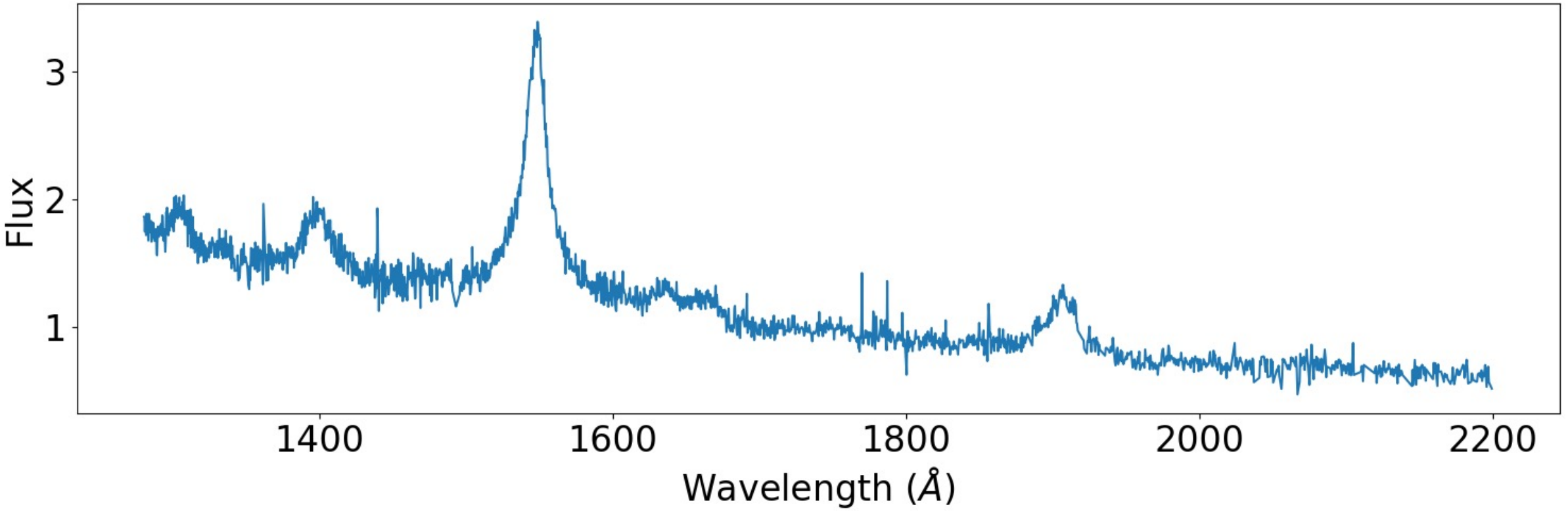
What is a Quasar?

- Highly luminous galactic core that radiates across the electromagnetic spectrum
- Incredibly distant : 10 million light years to billions of light years away
- Caused by friction between inflowing gases in the accretion disk

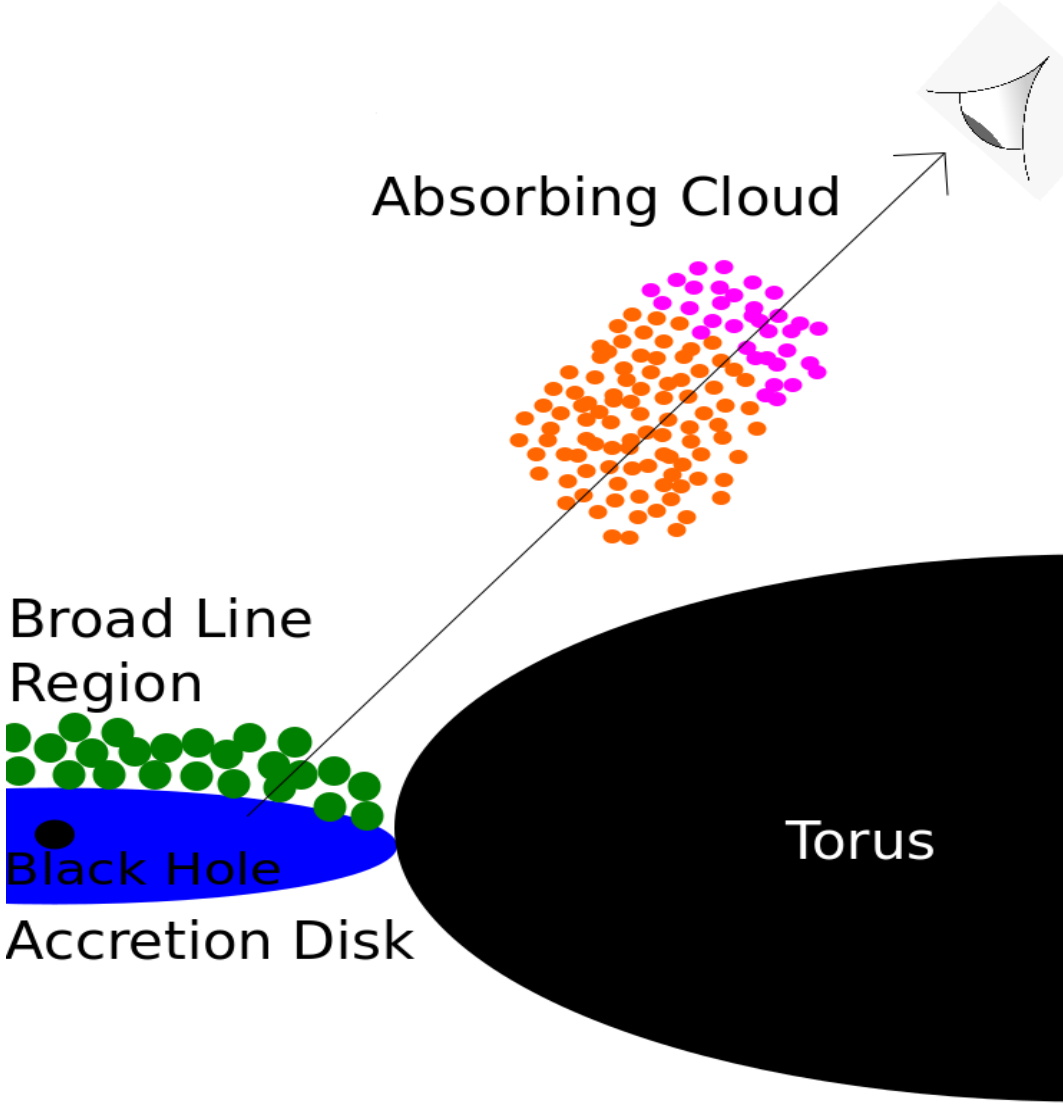
Image Source: https://cdn.britannica.com/63/21263-004-F9F98378/quasar-host-galaxies-Hubble-Space-Telescope.jpg

Quasar Spectrum

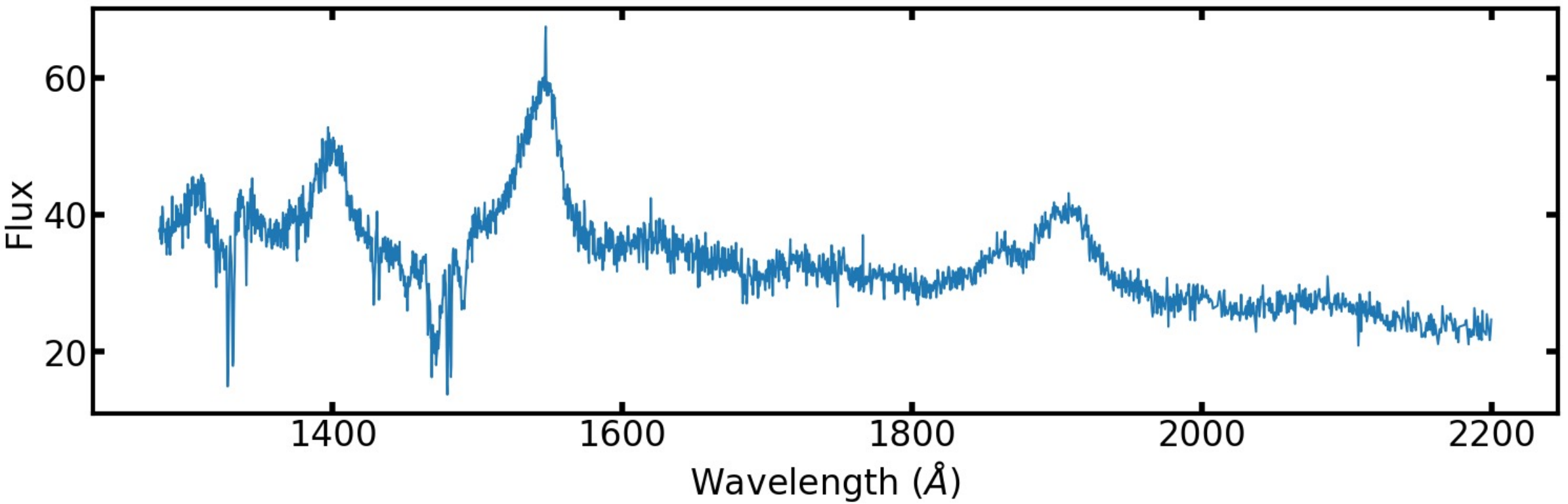


What is a BALQ?

- Stands for Broad Absorption Line Quasar
- Shows dips in luminosity across a broad range of wavelengths
- Caused by absorption from absorption ”clouds” far from the accretion disk



BAL Spectrum



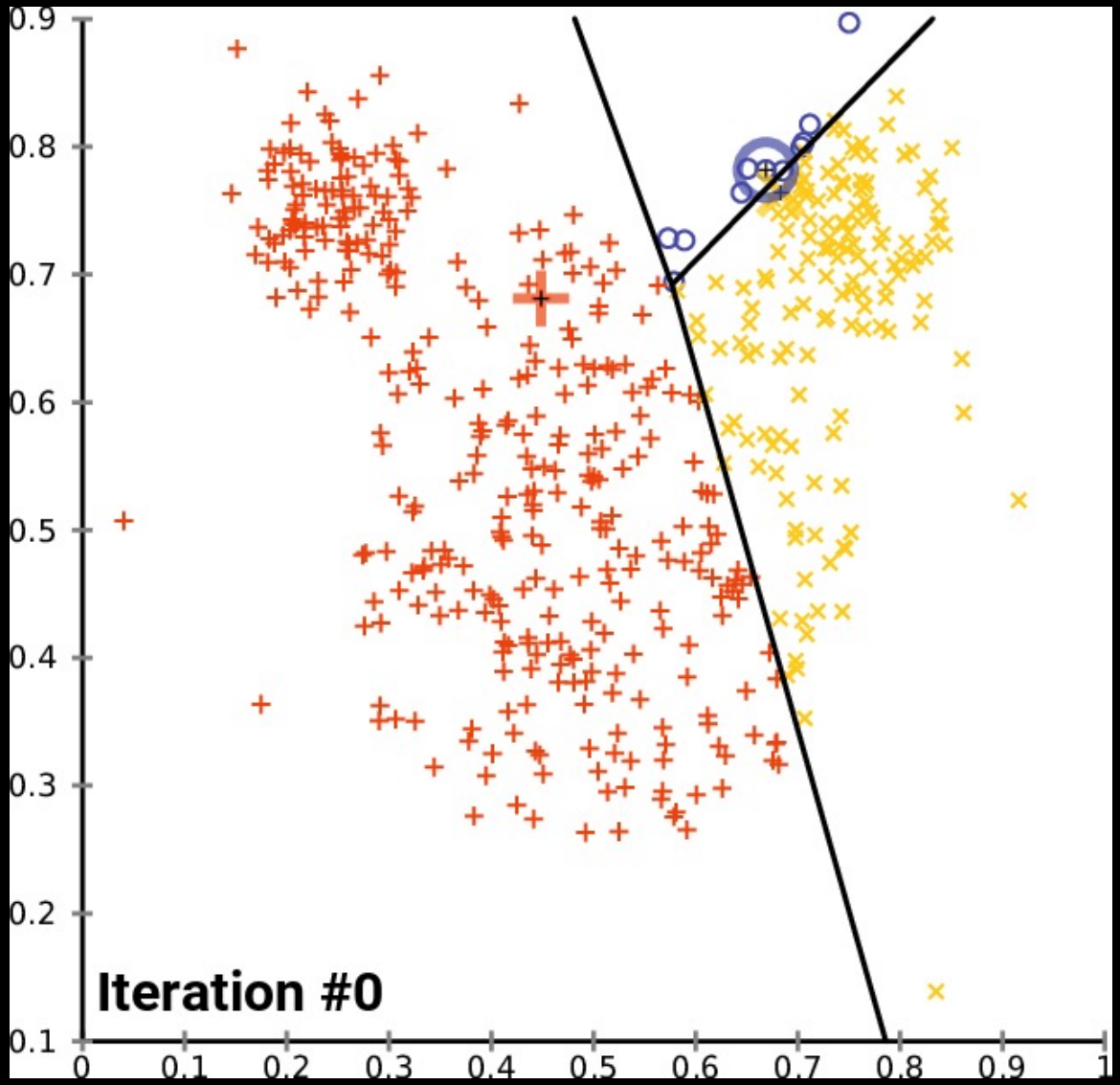
Motivations Behind Research

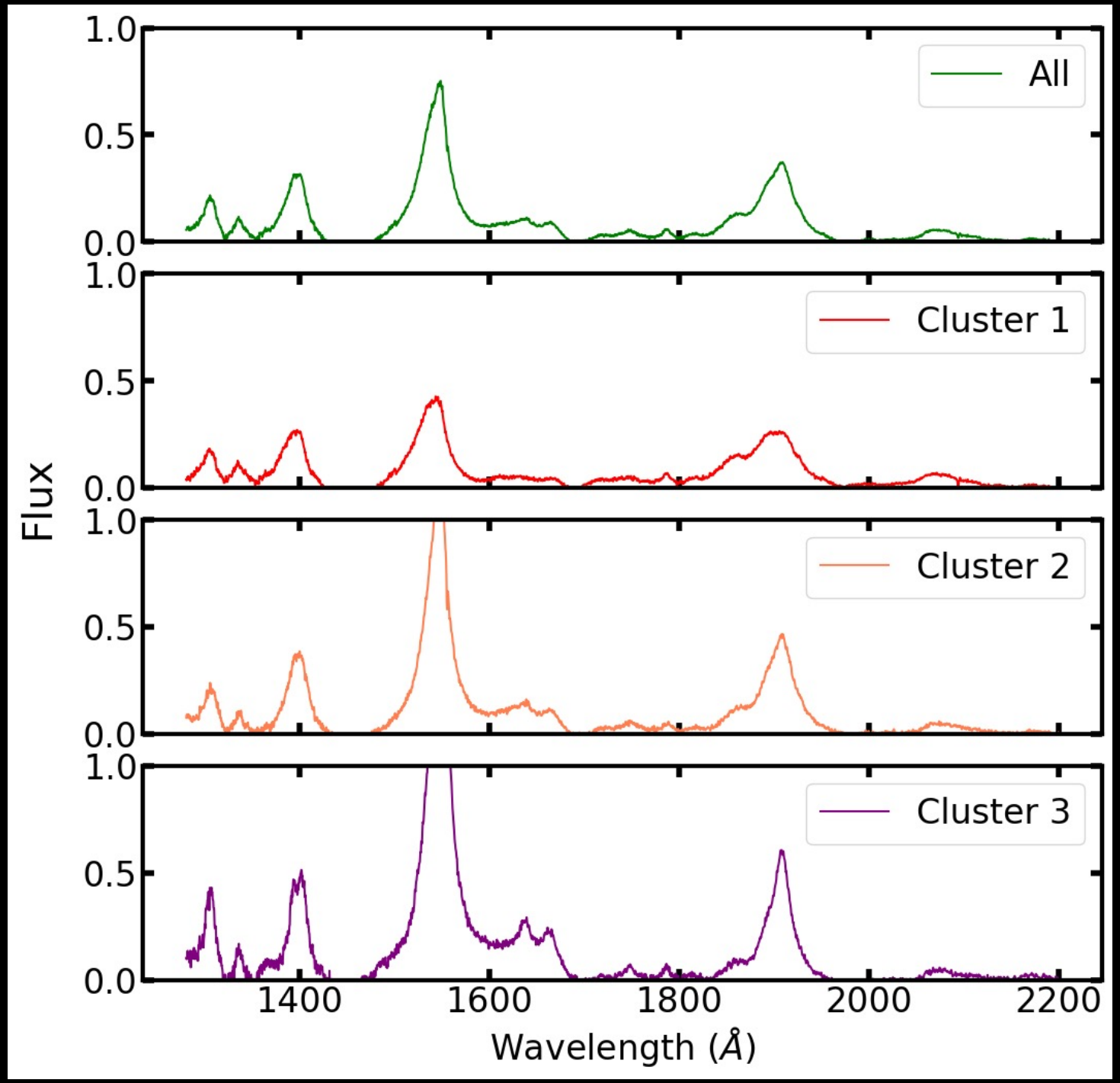
- NSF Proposal:
  - Funds SIMBAL work
  - Requires BAL spectra to be analyzed and non-BAL comparison sample
- 4MOST
  - New European survey facility added to the VISTA telescope
  - Used by SIMBAL to get better data on BALQs
  - BAL spectra need to be analyzed

Image Source:
https://www.eso.org/sci/facilities/paranal/telescopes/vista.html

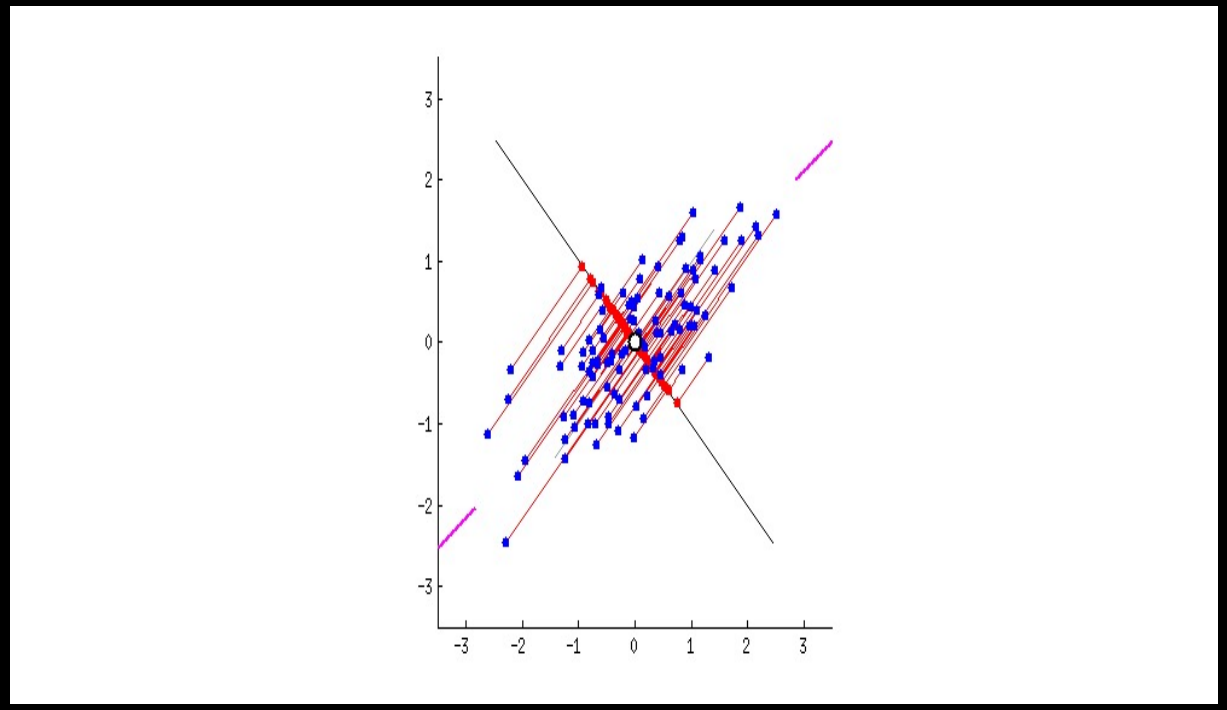
Research Process: Clusters

- K-Means Clustering program groups quasars into three clusters
- The quasars in each group have similar emission line properties
- Each cluster has a mean spectral shape
- Not all spectra look like the mean spectrum




All
Cluster 1
Cluster 2
Cluster 3
Flux
1.0
0.5
0.0
1400
1600
1800
2000
2200
Wavelength (Å)

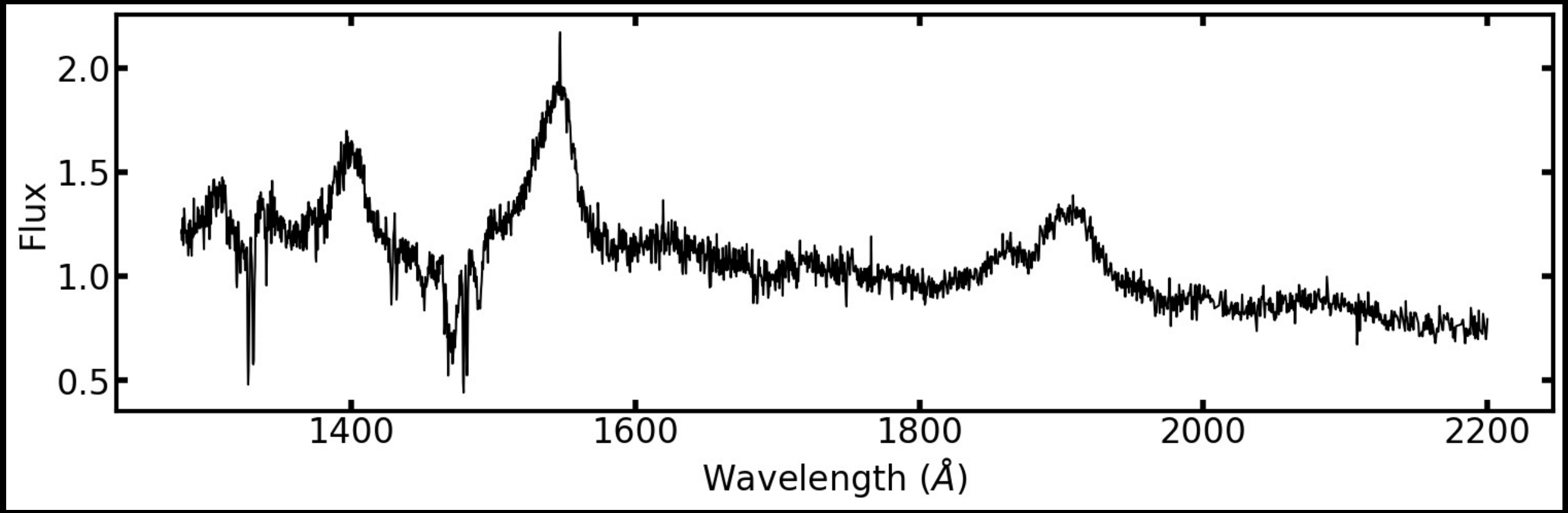
Research Process: Eigenvectors

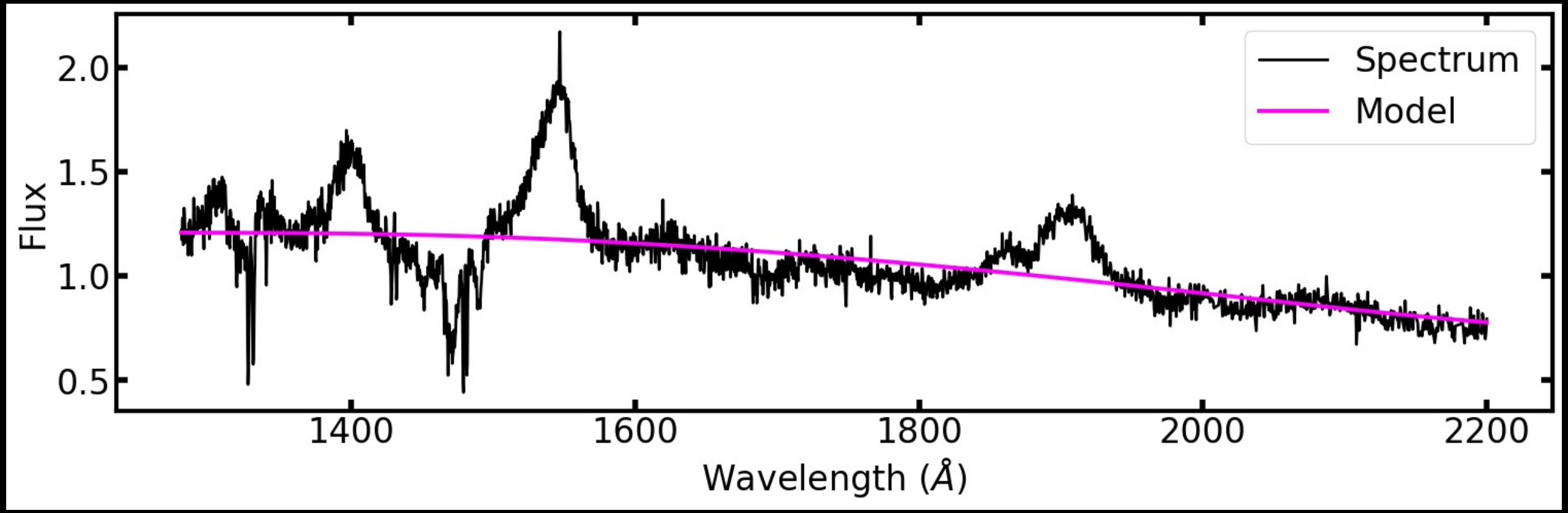


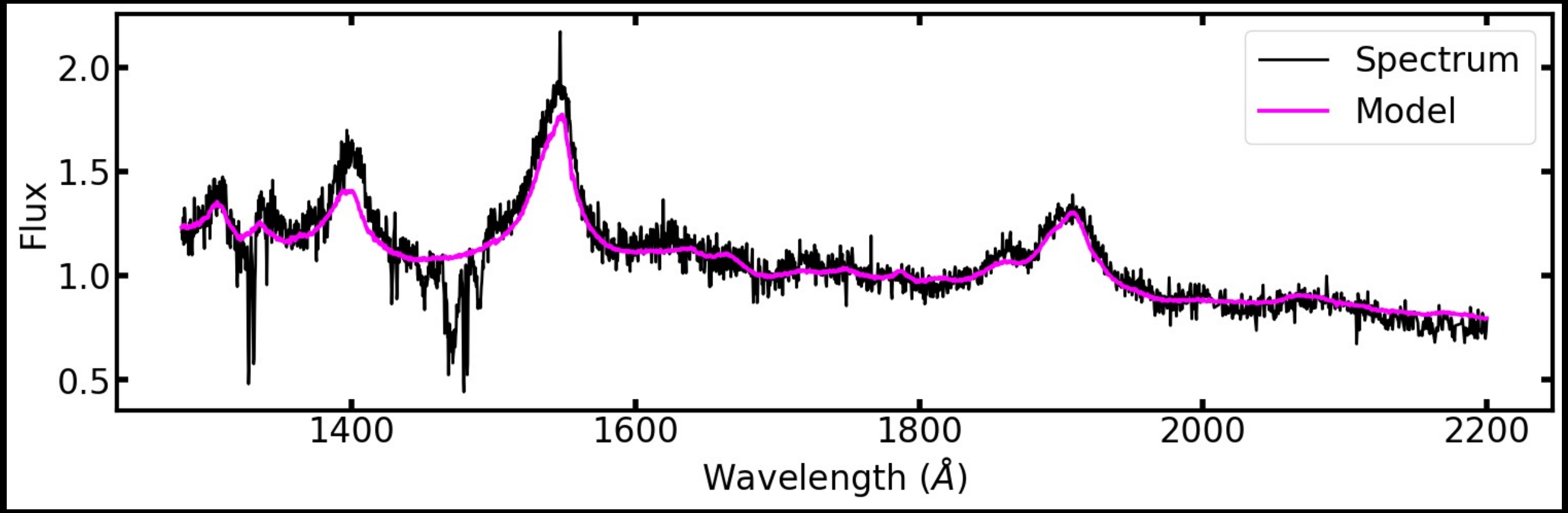
GIF Source: https://stats.stackexchange.com/questions/2691/making-sense-of-principal-component-analysis-eigenvectors-eigenvalues

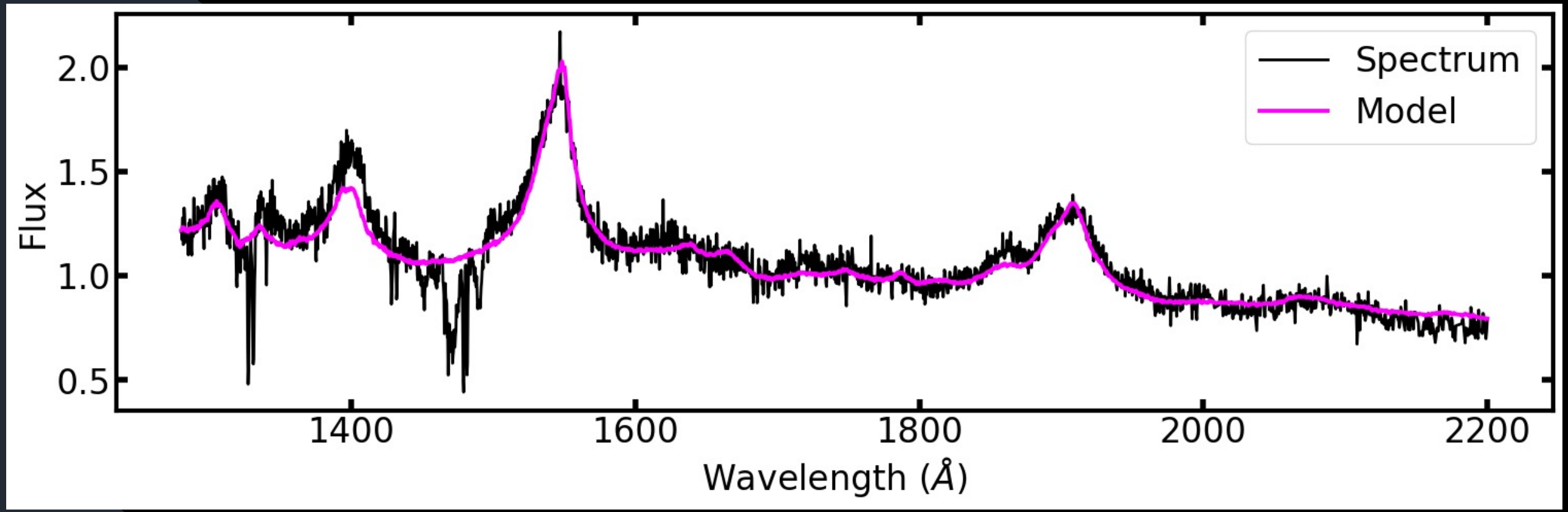
- Generated using Principal Component Analysis (PCA)
- Set of basis vectors used to alter mean spectra to account for variations in shape
- Each cluster has a set of four eigenvectors
- Coefficients are recalculated after every fit

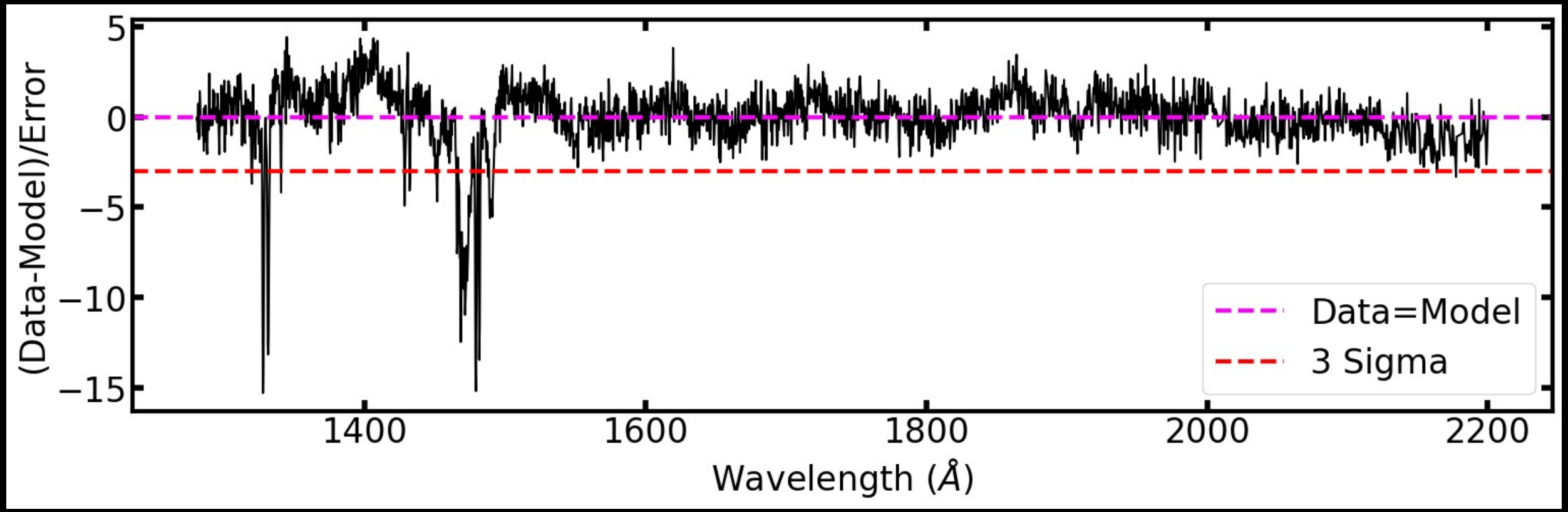
Research Process: Analyzing a BAL Quasar Spectrum

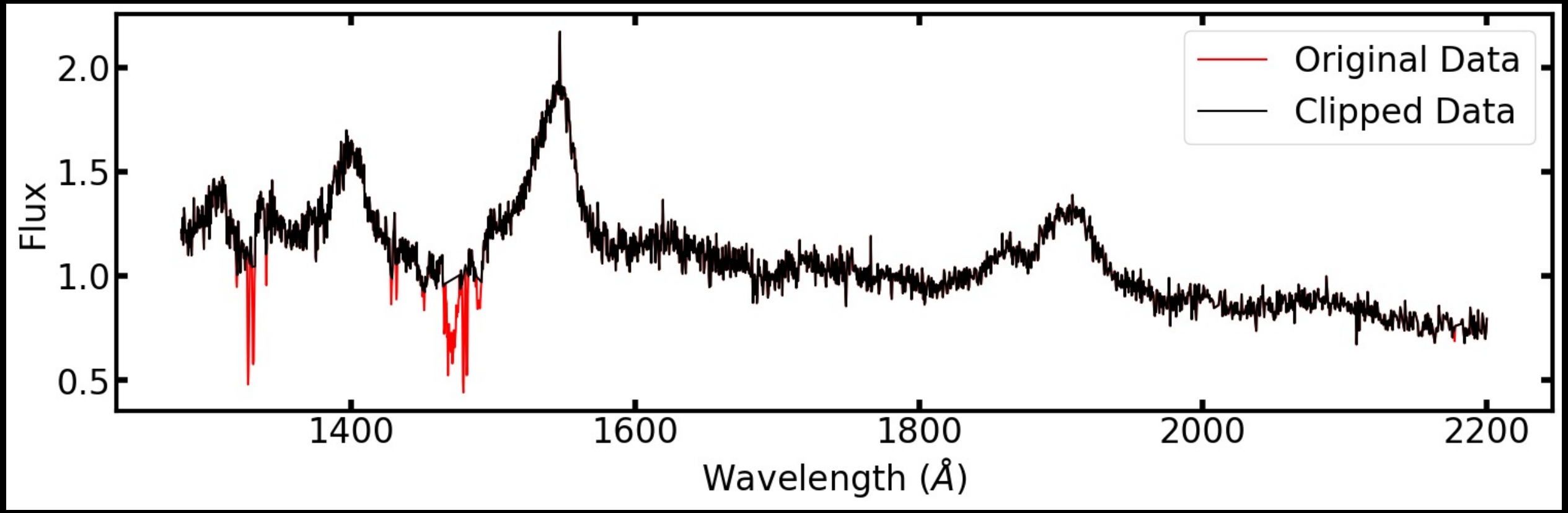

Flux
2.0
1.5
1.0
0.5
1400
1600
1800
2000
2200
Wavelength (Å)

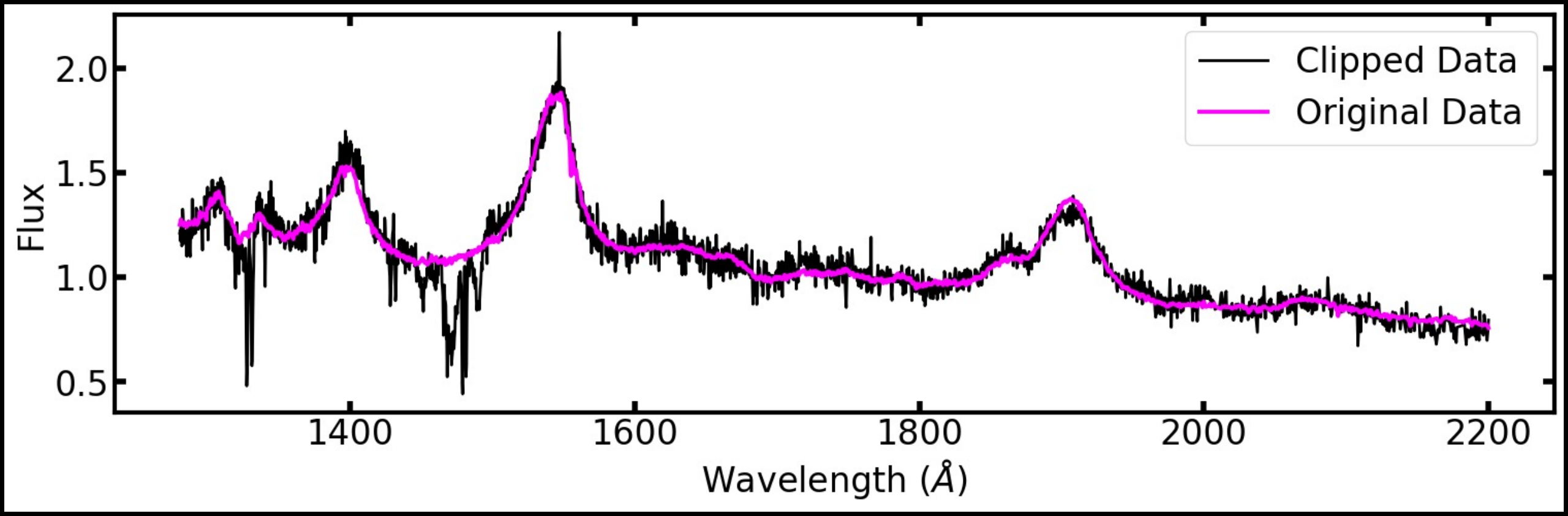

Spectrum
Model
Flux
2.0
1.5
1.0
0.5
1400
1600
1800
2000
2200
Wavelength (Å)


Spectrum
Model
Flux
2.0
1.5
1.0
0.5
1400
1600
1800
2000
2200
Wavelength (Å)

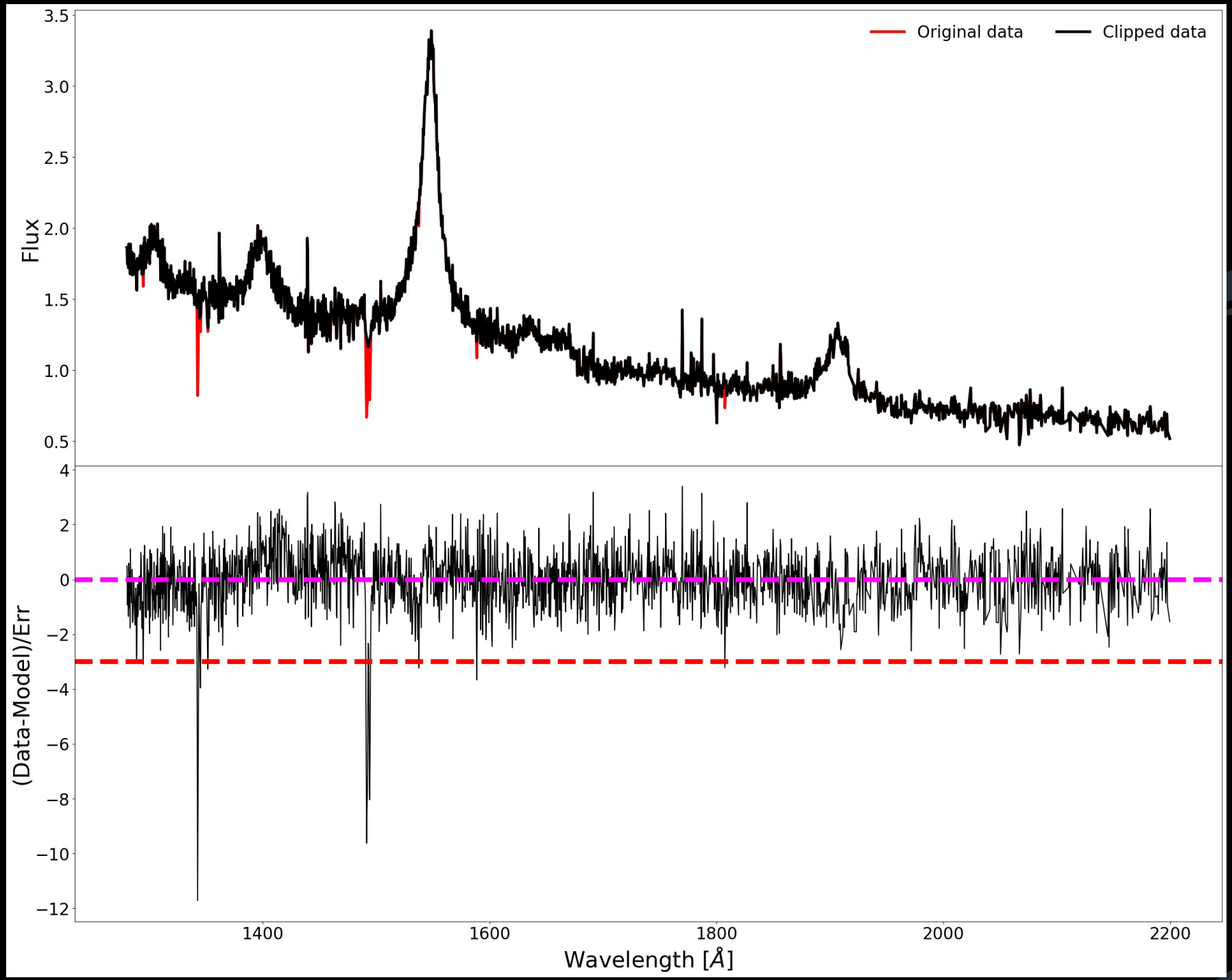

Spectrum
Model
Flux
2.0
1.5
1.0
0.5
1400
1600
1800
2000
2200
Wavelength (Å)


5
0
−5
−10
−15
(Data-Model)/Error
1400
1600
1800
2000
2200
Wavelength (Å)
Data=Model
3 Sigma

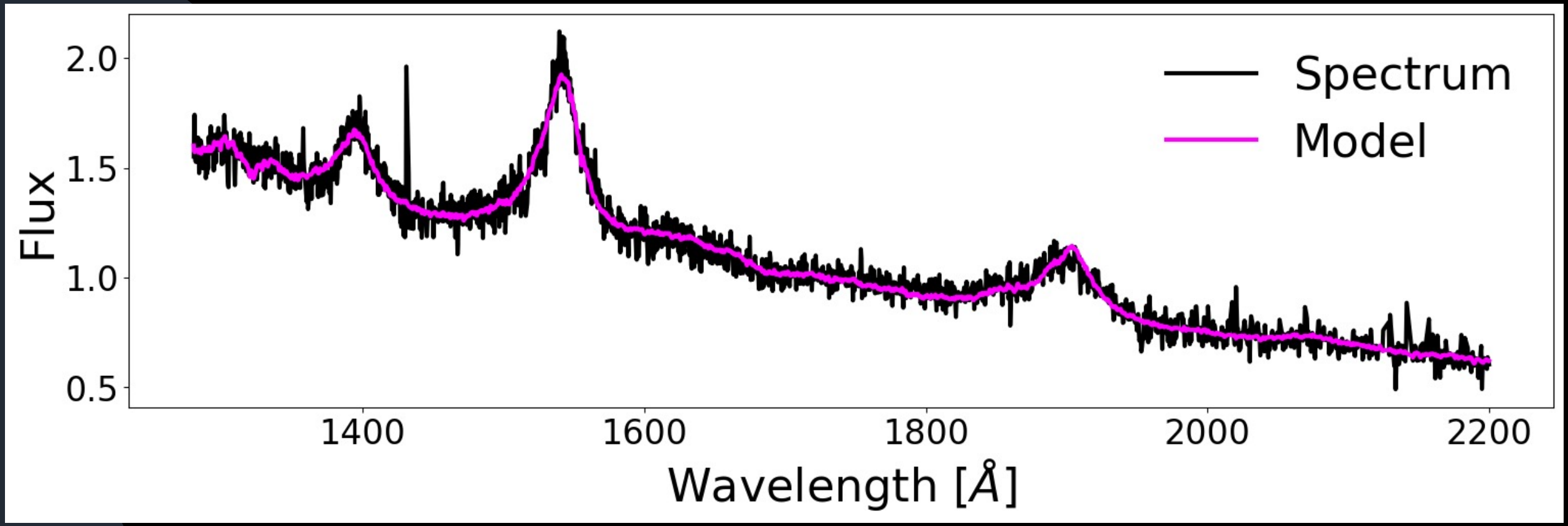

Original Data
Clipped Data
Flux
2.0
1.5
1.0
0.5
1400
1600
1800
2000
2200
Wavelength (Å)


Clipped Data
Original Data
Flux
2.0
1.5
1.0
0.5
1400
1600
1800
2000
2200
Wavelength (Å)

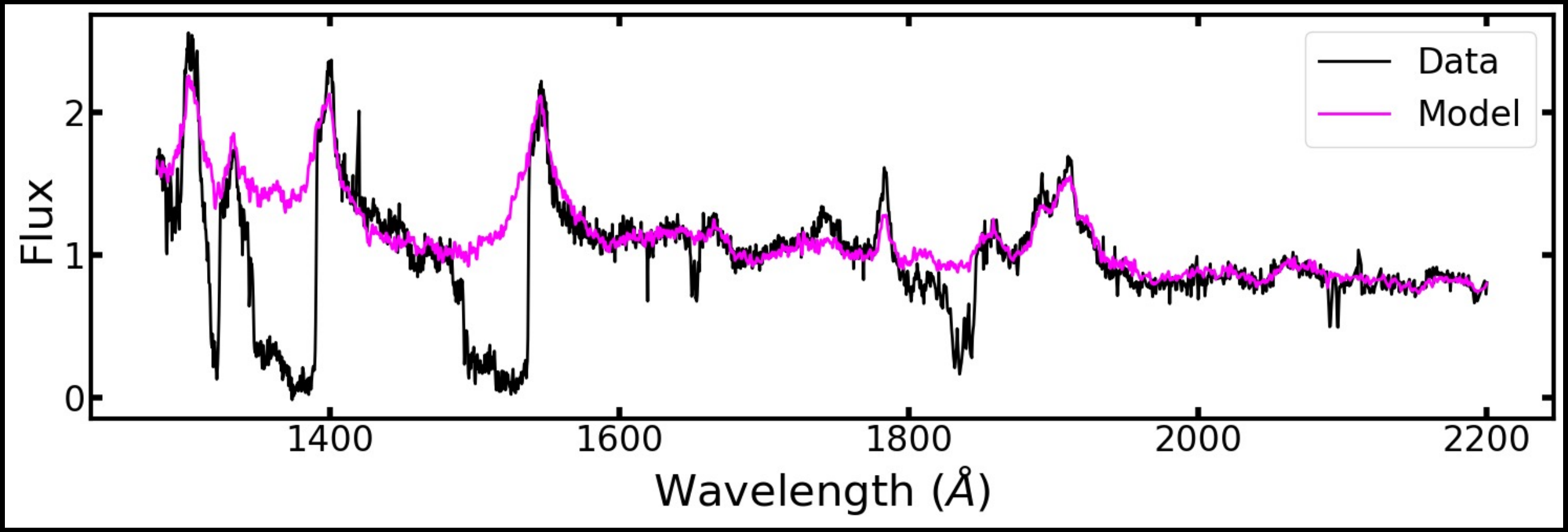
Research Process: Cleaning Non-BAL Quasar Spectra


Original data
Clipped data
Flux
3.5
3.0
2.5
2.0
1.5
1.0
0.5
(Data-Model)/Err
4
2
0
−2
−4
−6
−8
−10
−12
1400
1600
1800
2000
2200
Wavelength [Å]

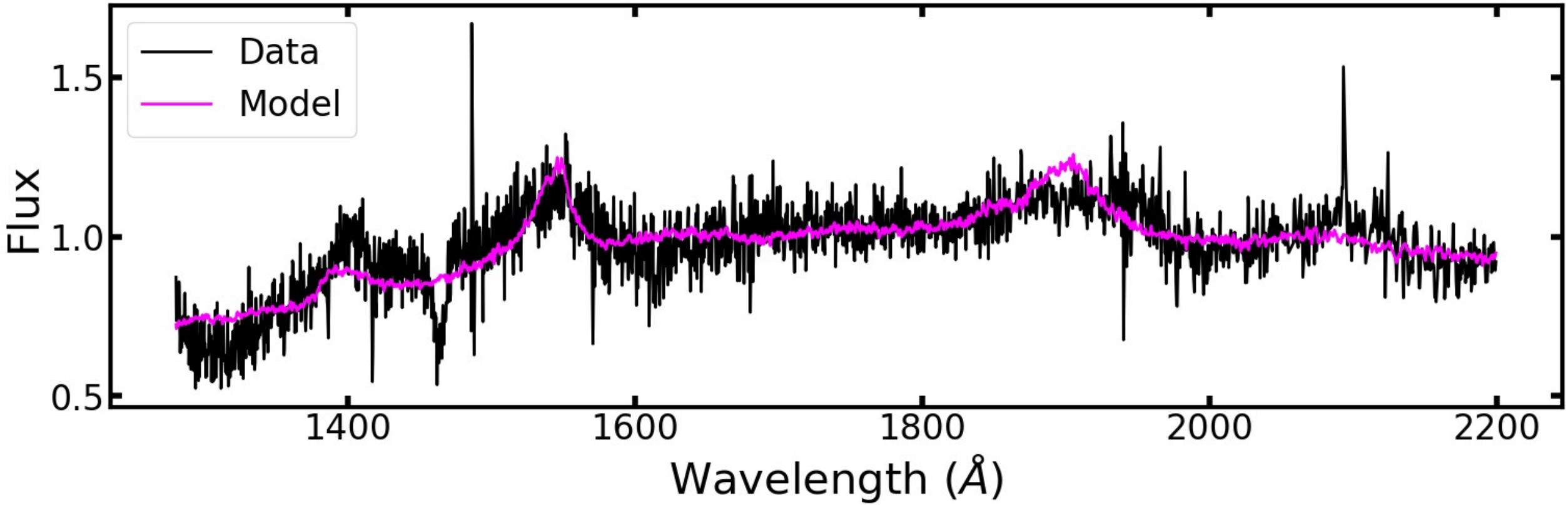
Results from Model Fitting: Successful non-BAL Model Fits


Spectrum
Model
Flux
2.0
1.5
1.0
0.5
1400
1600
1800
2000
2200
Wavelength [Å]

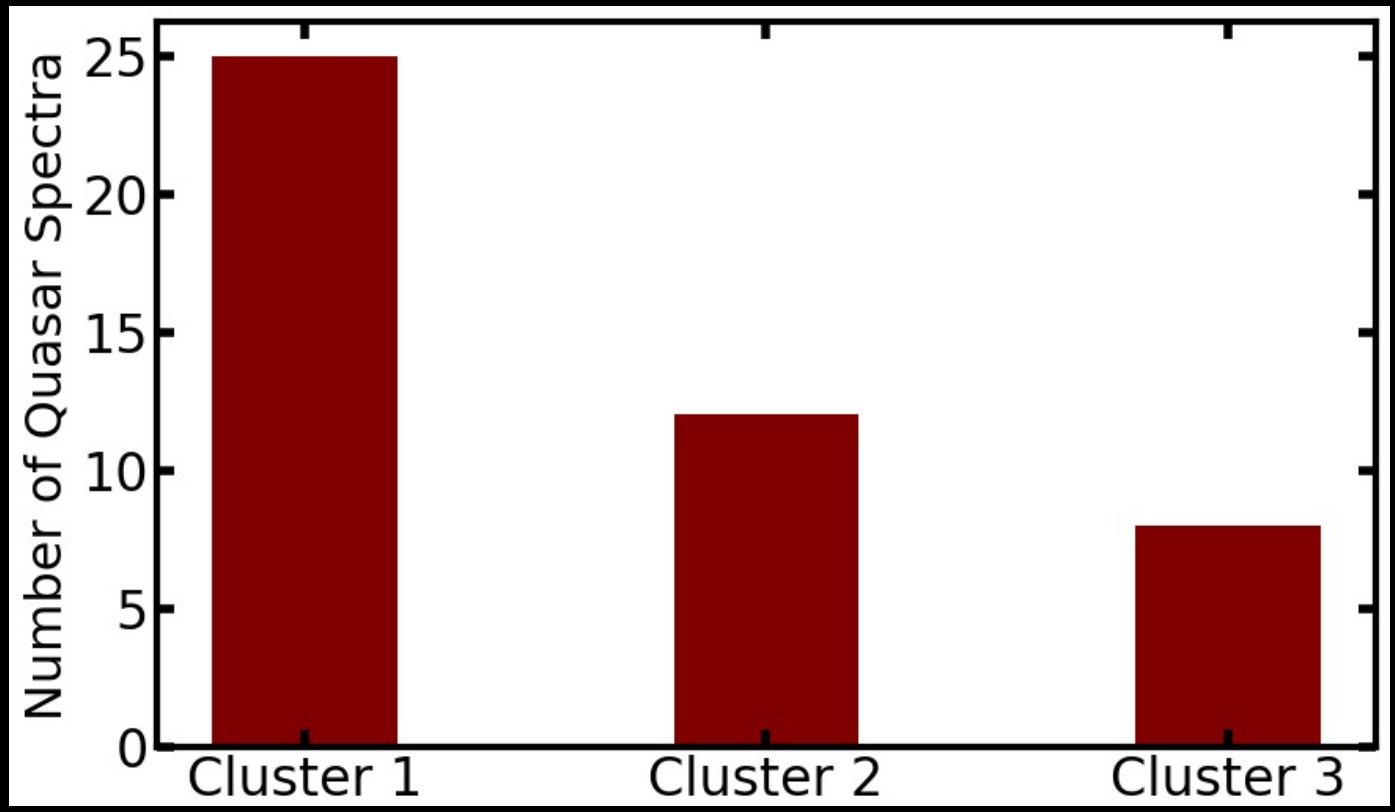
Results from Model Fitting: Successful BAL Model Fits


Data
Model
Flux
0
1
2
1400
1600
1800
2000
2200
Wavelength (Å)

Results from Model Fitting: Difficult BAL Model Fit


Data
Model
Flux
1.5
1.0
0.5
1400
1600
1800
2000
2200
Wavelength (Å)

Conclusion

- Research into BAL quasars will help broaden our understanding of galactic evolution
- My goals are to fit and characterize all BAL and non-BAL spectra in our data set
- Work for the near future:
  - Automate spectra-analyzing program
    - Automate “clipping” without cutting into “good” data points
    - Constrain requirements for the best fitting model

Cluster Plot for 45 Quasars