

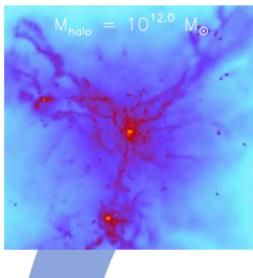
# Characterizing Gas Flow Using Multiply-lensed Quasars Carlos Carrillo-Gallegos Dr. Hsiao-Wen Chen

The University of Chicago



## **Gas Flow and Galaxy Evolution**

Gas falls into galaxies from the CGM/IGM

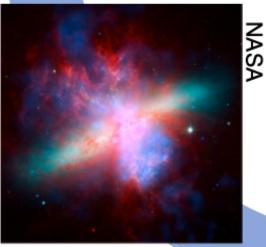


+ 100

201

NASA/ESA

### The Baryon Cycle



Stars & BHs inject energy, momentum, and metals into the ISM

Gas flow out of galaxies into the CGM/IGM

Figure: Newman/Carnegie Institute of Science, 2020

Stars & black holes form

Galactic structures emerge: disks, clumps, and bulges



AURA/STScl/NASA

## Galaxy Evolution

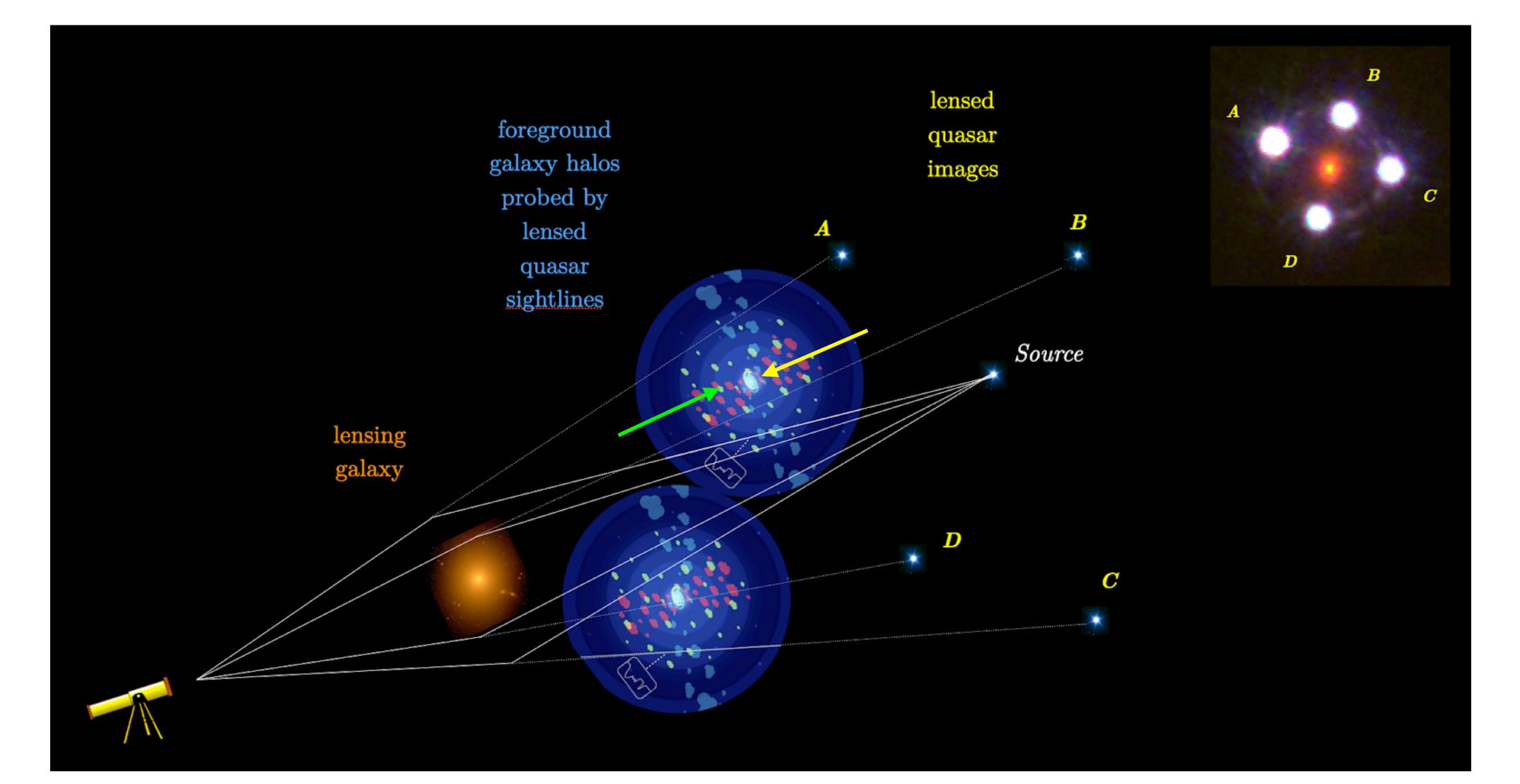
NASA

ESA

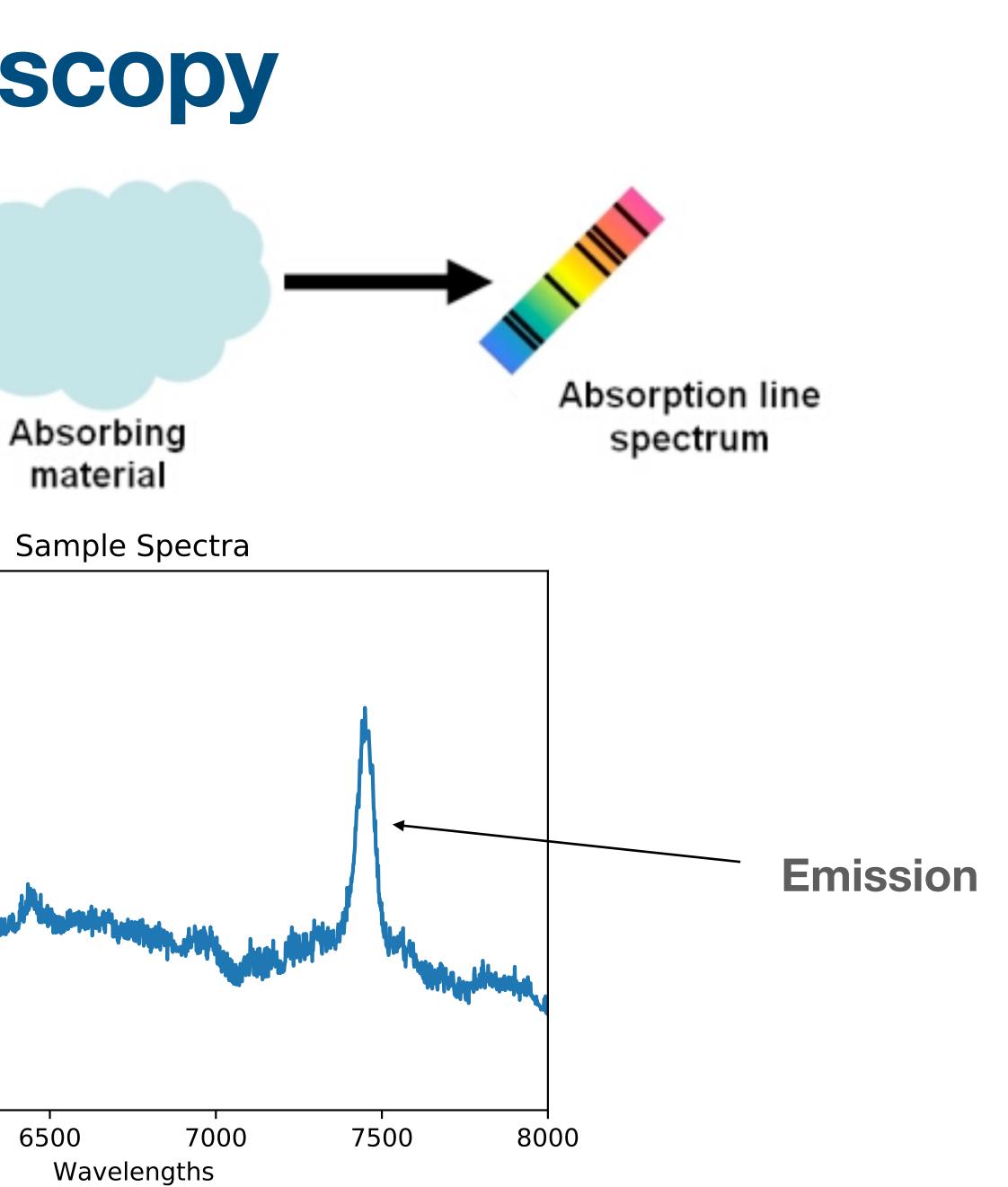


Feedback and dynamical evolution change the internal distribution of metals, dust, and stars

## **Gravitational Lensing Illuminates Otherwise Undetectable Gas**



## **Absorption Spectroscopy** 3000 2500 2000 Flux 1500 Absorption 1000 -500 + 6000 5500



## WFI-2033 and Galaxy of Interest

1.1676

0.6544

## Lens

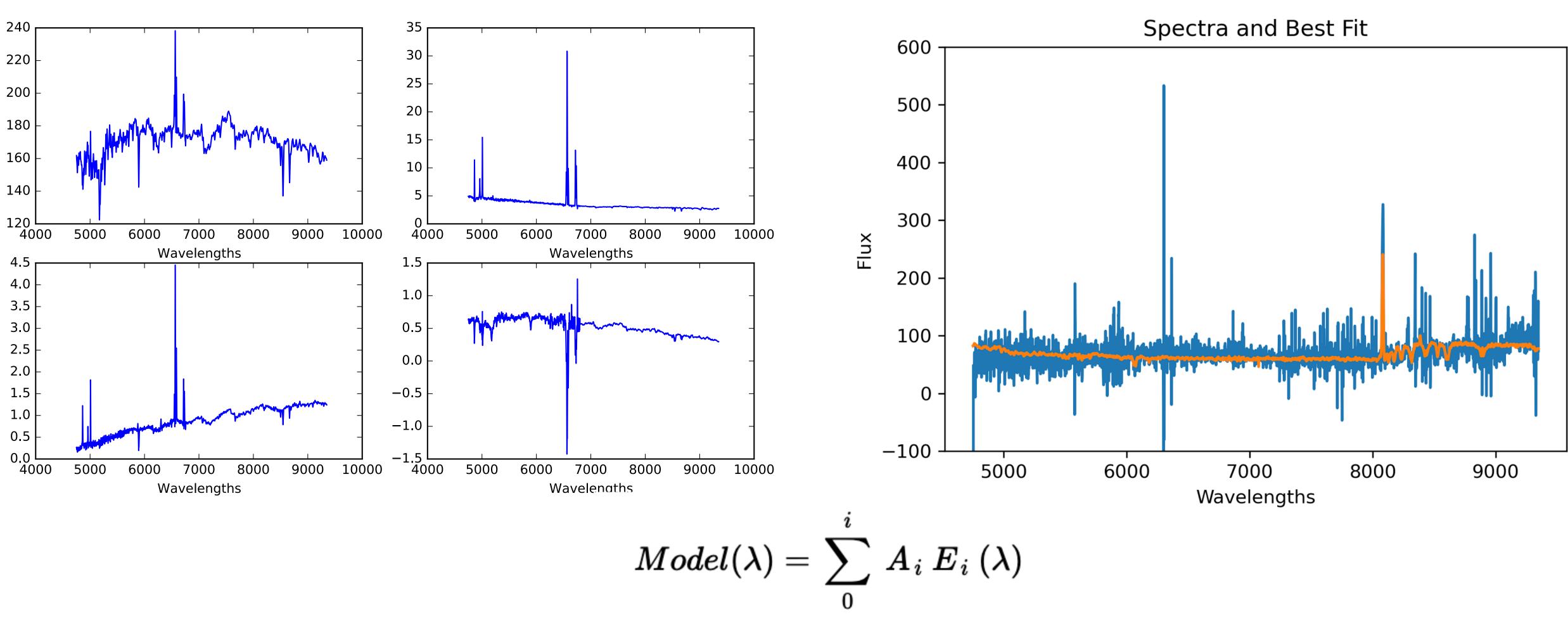
# Galaxy

0.6784





## **Chi-Squared Minimized Model** Systemic Redshift, z = 1.1676



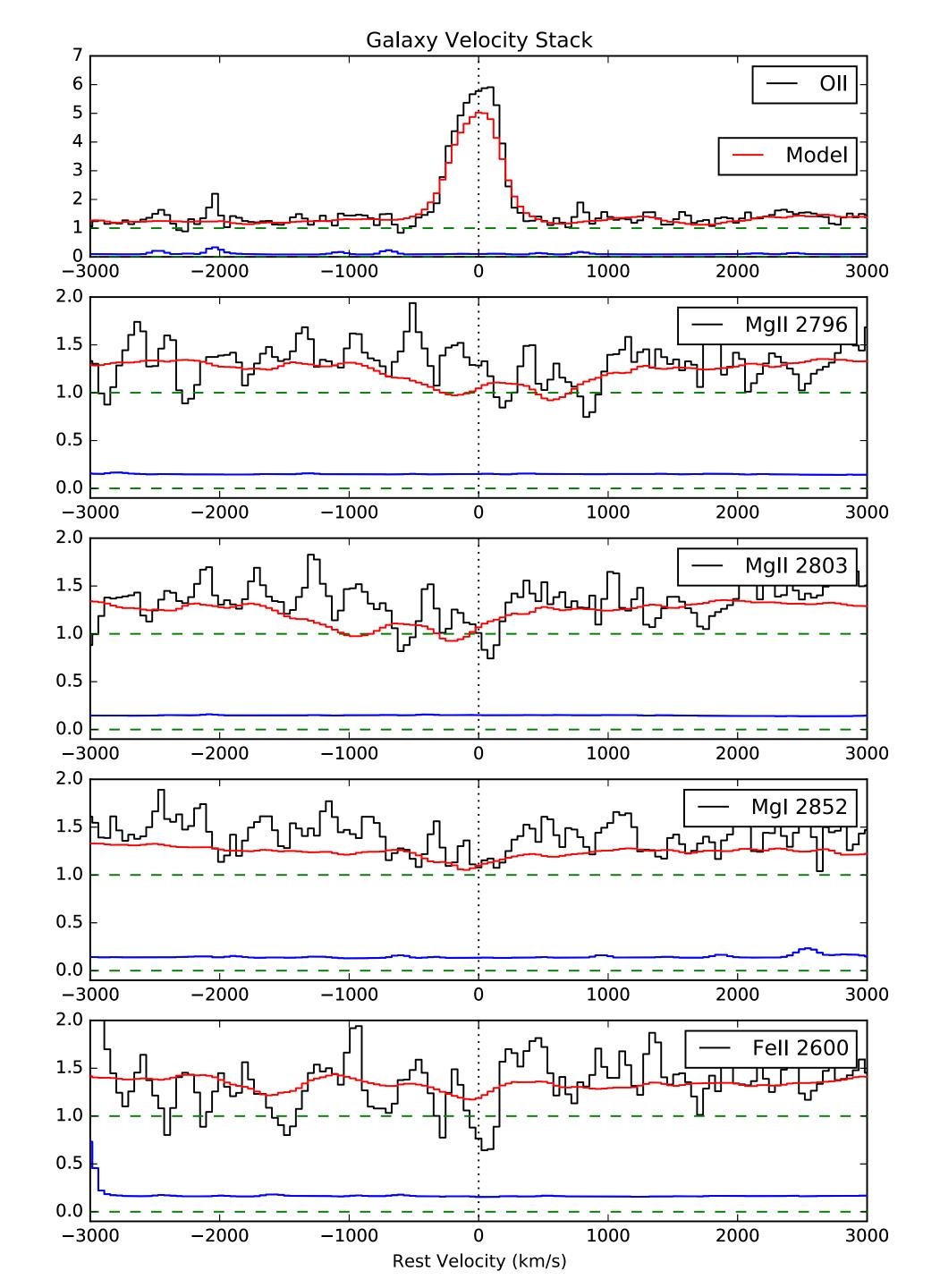
**Eigenspectra Templates** 

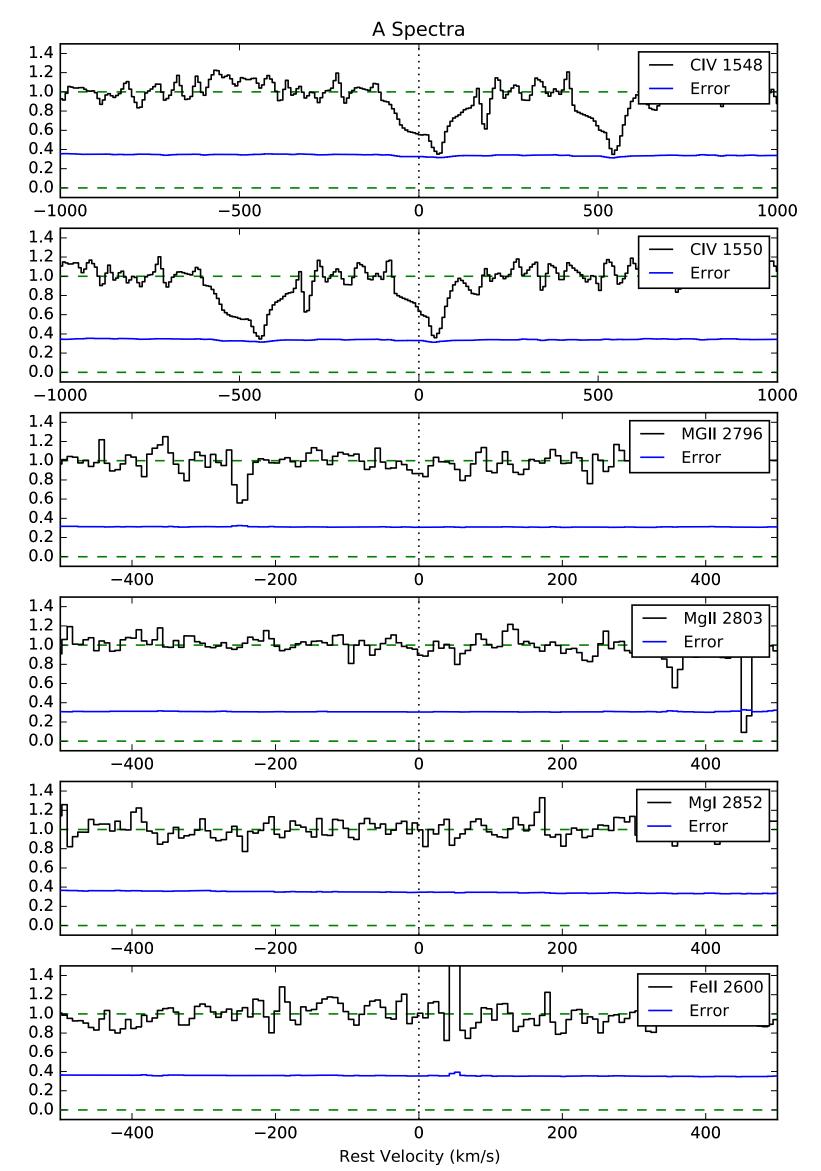
## Local Redshift of Key Gases in the Galaxy

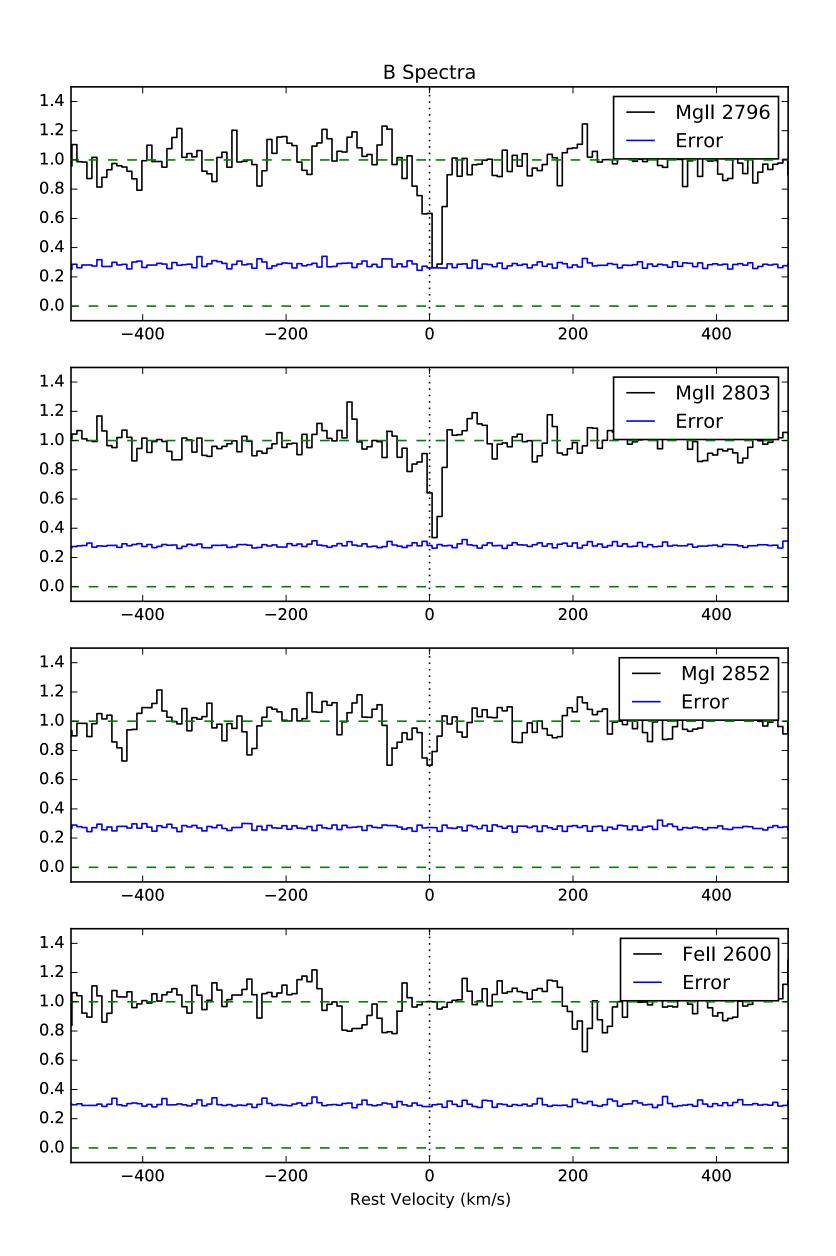
These plots show how far specific gases are redshifted from the systemic redshift of the galaxy.

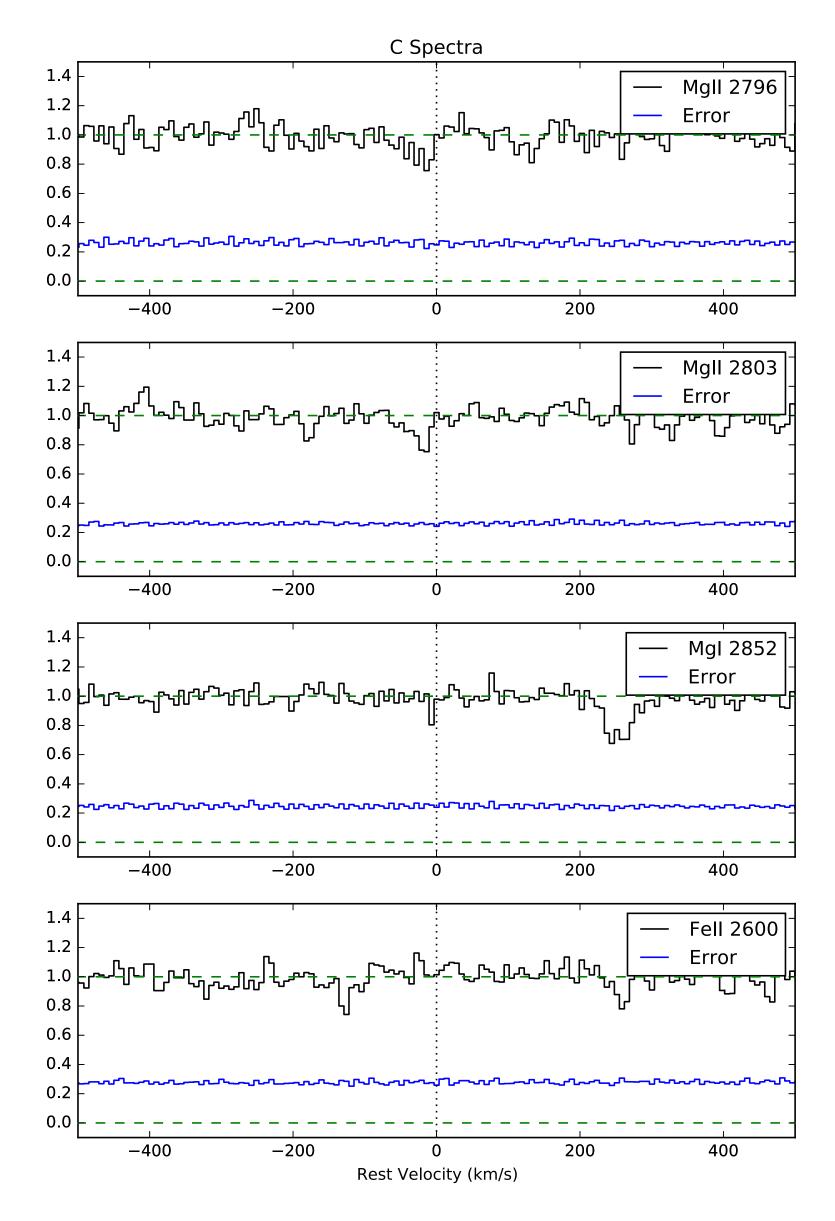
Peaks and valleys centered at 0 indicate no local redshift.

We find no significant redshifts of MgI, FeII, but slight redshifting at MgII 2796









## Summary

- There is ionized gas present in the halos surrounding the galaxy
- Majority of gas is not significantly redshifted from the systemic velocity of the galaxy

## Future Outlook

 Mapping the motion of gas between the galaxy and its surroundings

## Acknowledgements

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- The University of Chicago
- The Leadership Alliance

