Quenching Quandaries in the MgII Circumgalactic Medium

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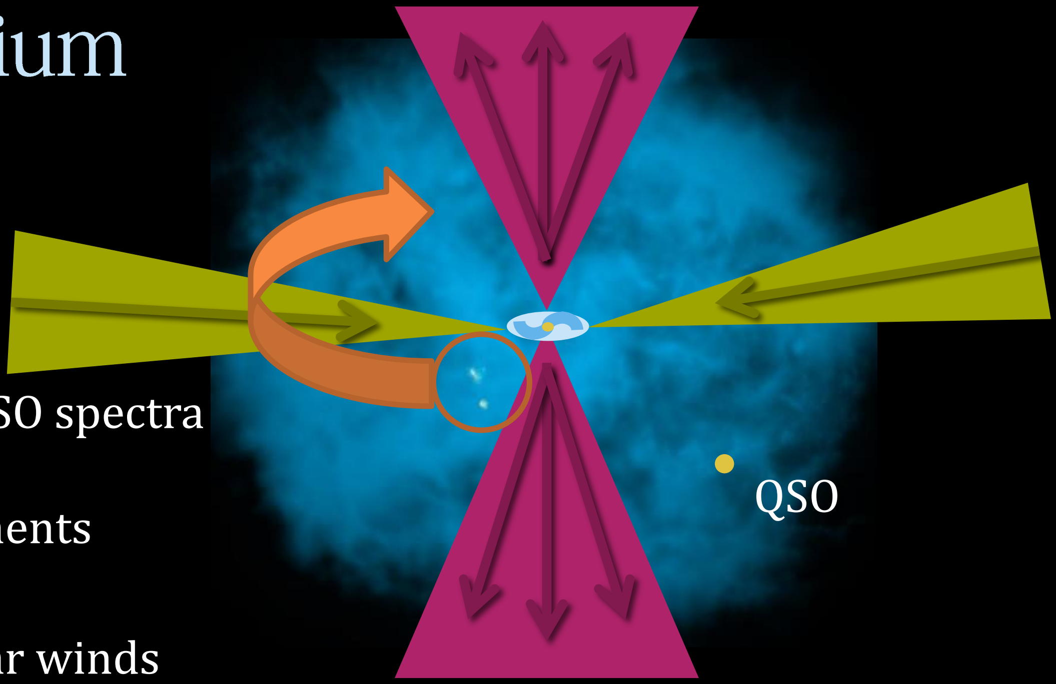
Circumgalactic Medium



- Large reservoir of multiphase gas
- Fuel for star formation
- Massive (e.g., Werk 2013)

- MgII absorption in background QSO spectra

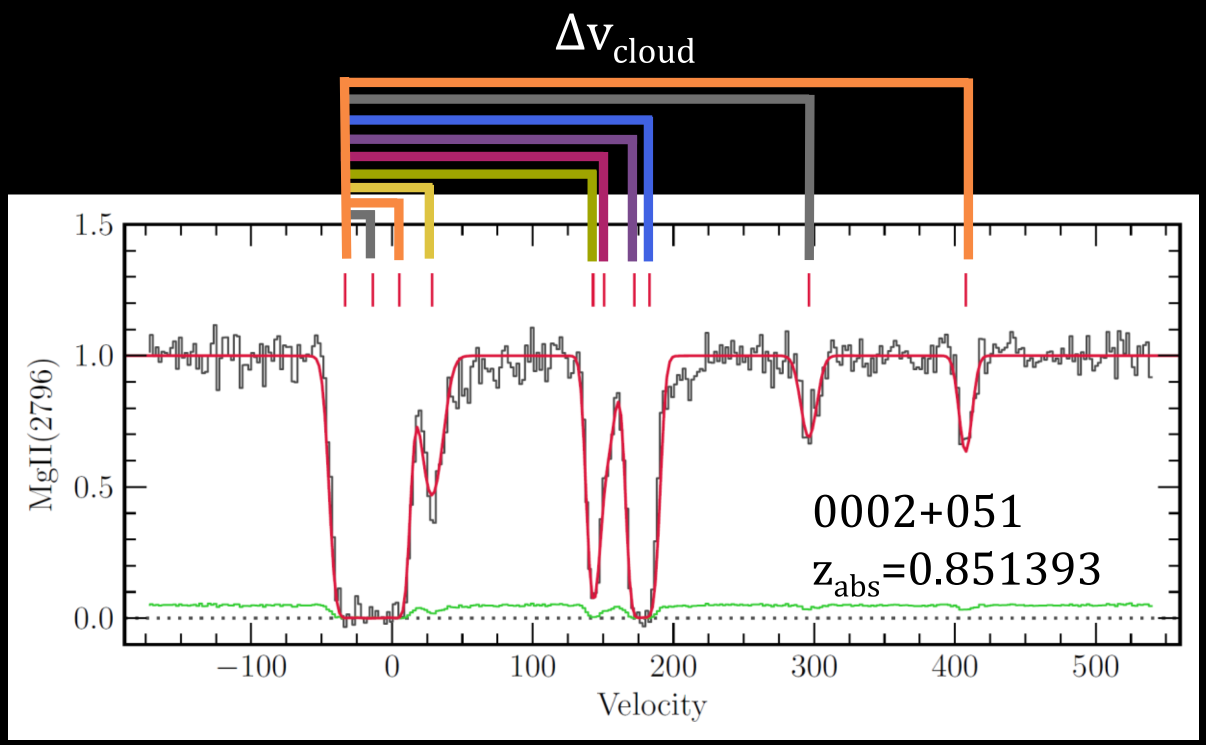
- Accretion along dark matter filaments
  - e.g., Rubin 2012
- Outflows from SN feedback/stellar winds
  - e.g., Bouche 2012
- Merging satellite galaxies

- Infalling and outflowing material preferentially found along major and minor axes, respectively (e.g., Bordoloi 2011, Kacprzak 2012, Lan 2014)

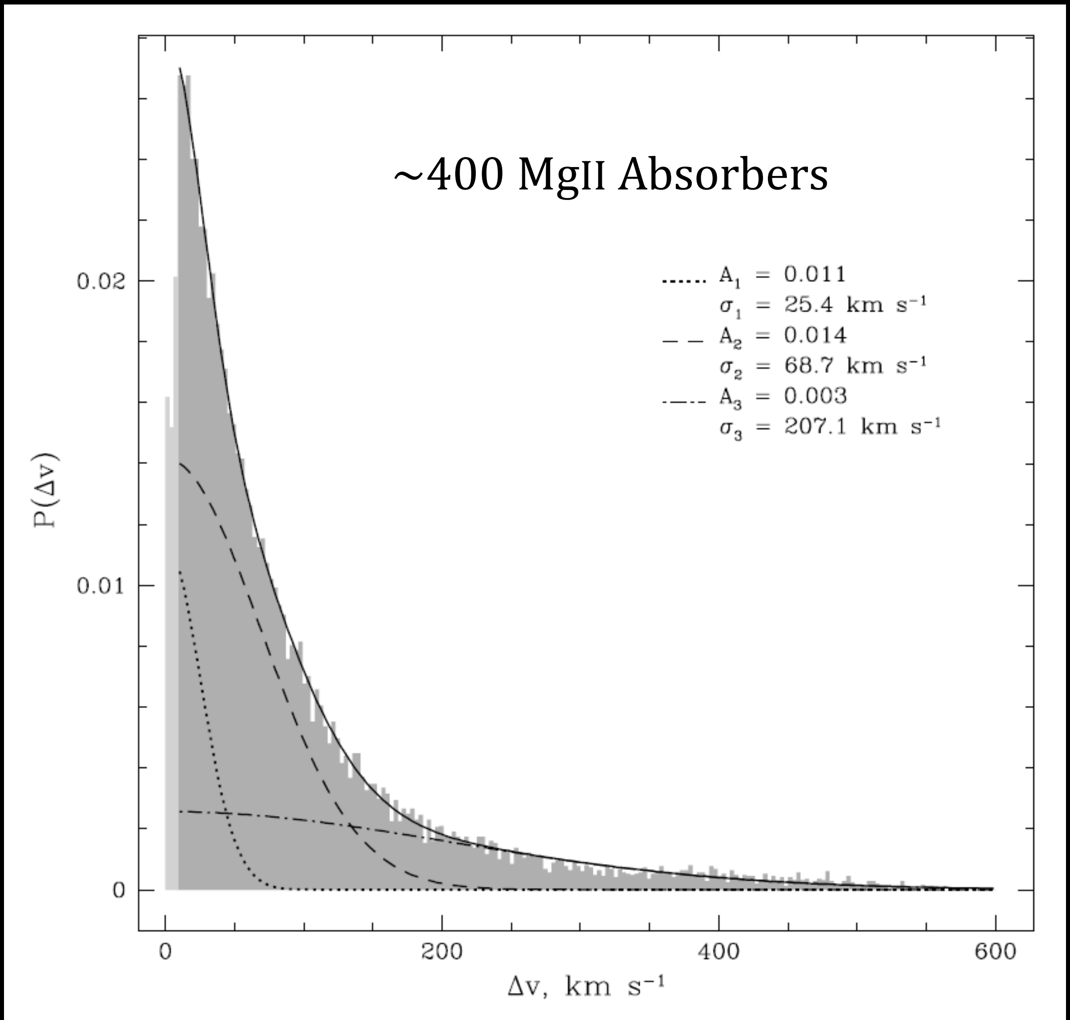
- What is the kinematic nature of material in the CGM as a function of galaxy type?

Two-Point Velocity Correlation Function

- Cloud-cloud velocity probability distribution function
- Probability of finding any two clouds separated by line of sight Δv
- Velocity dispersion of clouds in absorber



Two-Point Velocity Correlation Function



Other works attribute Gaussians to:

Motions within galaxy and between galaxy pairs (Petitjean & Bergeron 1990)

Vertical dispersion in galaxy disks and rotational motion (Churchill+ 2003)

Different Gaussians due to the different processes occurring in different types of galaxies?

MAGIICAT

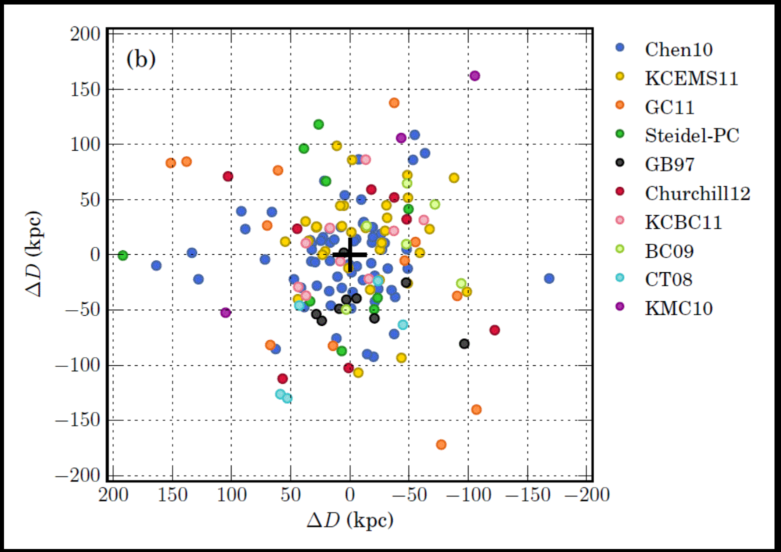
- MgII Absorber-Galaxy Catalog
- 182 Isolated galaxies have:
  - Detected MgII absorption or an upper limit on absorption
  - D < 200 kpc
  - Spectroscopic redshifts z < 1

Table 4
MAGIICAT Properties

Property	Min	Max	Median
$W_r(2796)$ (Å)	0.003	4.422	0.400
z_{gal}	0.072	1.120	0.359
D (kpc)	5.4	93.5	48.7
M_B	−16.1	23.1	−20.4
M_K	−17.0	25.3	−22.0
L_B/L_B^*	0.017	5.869	0.611
L_K/L_K^*	0.006	9.712	0.493
$B-K$	0.04	4.09	1.48

- Halo masses
  - Abundance matching
  - $10.7 < \log (M_h/M_{sun}) < 13.8$
  - Median $\log (M_h/M_{sun}) = 12$

- Kinematics Subsample:
  - 47 MAGIICAT pairs with HIRES/UVES spectra
  - Voigt profile fitted to obtain velocities of pixels involved in absorption
  - EW sensitivity cut of 0.07 Å



astronomy.nmsu.edu/cwc/Group/magiicat

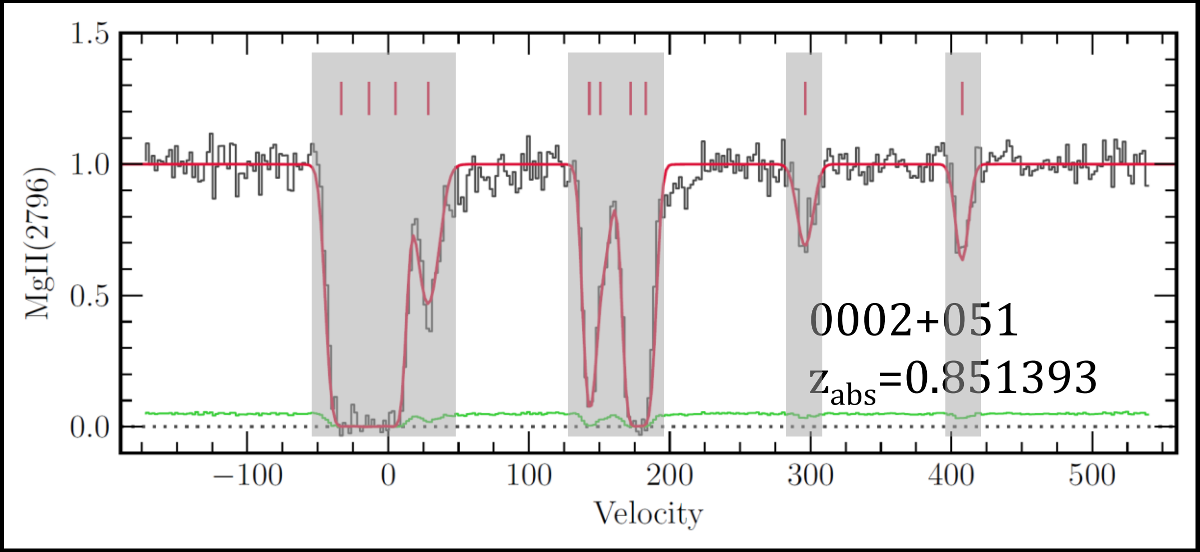
Gas Kinematics Expectations

- Blue Galaxies
  - Ongoing evolution from infalling material triggering star formation which causes outflowing material
  - Signatures: Larger internal velocity dispersions?
- Red Galaxies
  - Become quiescent over time due to lack of fuel for star formation
  - Merging satellites due to more massive and more dense environments
  - Signatures: Smaller internal velocity dispersions? Large dispersions of absorbers around the galaxy?

- Low and High Redshift
  - More star formation at larger redshift; depends on type
  - Merging rates decrease with decreasing redshift
  - Signatures: smaller internal velocity dispersions and dispersions of absorbers around galaxy at lower z compared to higher z?

Pixel TPCF

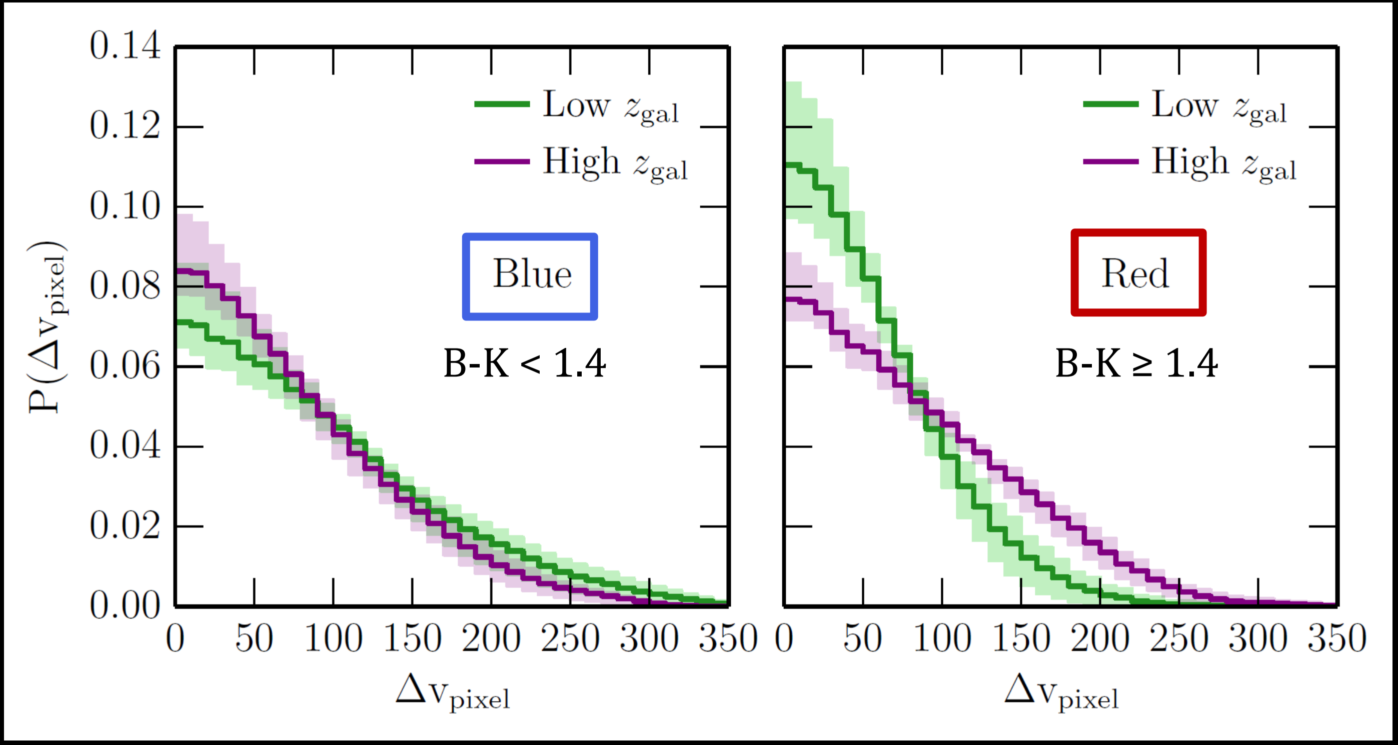
- Velocity differences of pixels associated with absorption
- Improved sensitivity to absorption – broad wings if present
- More data for better statistics



Internal Absorber Velocity Dispersion

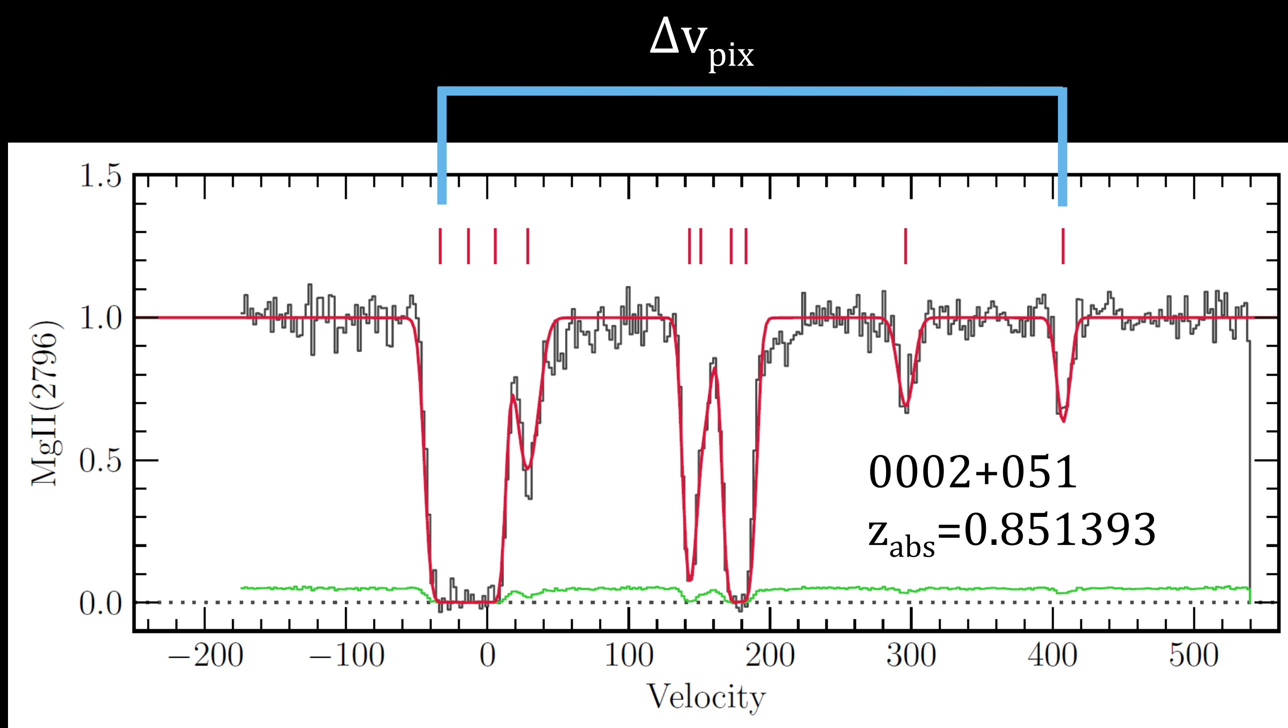
- Blue galaxies – velocity structure unchanged over 2 Gyrs (0.2σ)
- Red galaxies – redshift evolution with gas more relaxed at low z; internal dispersion less turbulent (6.5σ)

z_{gal} cut = 0.656



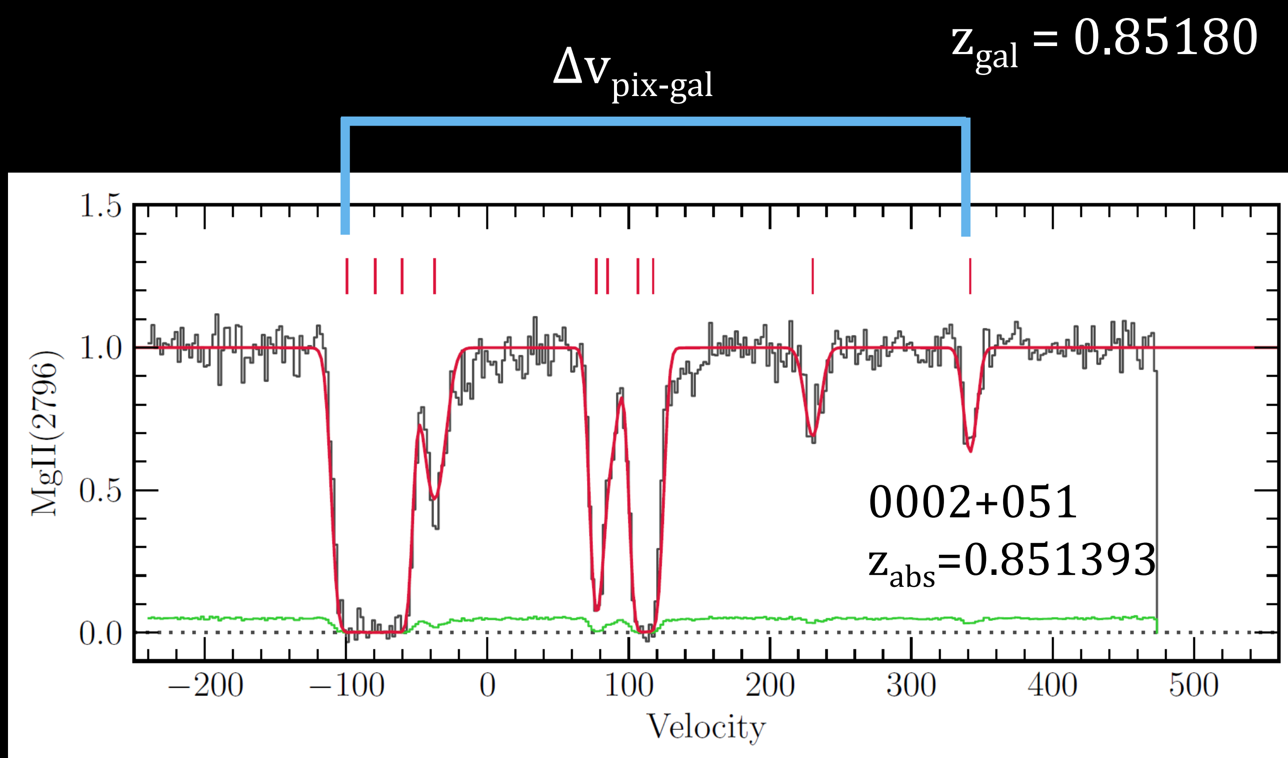
TPCF with respect to absorption

- Internal absorber velocity dispersion



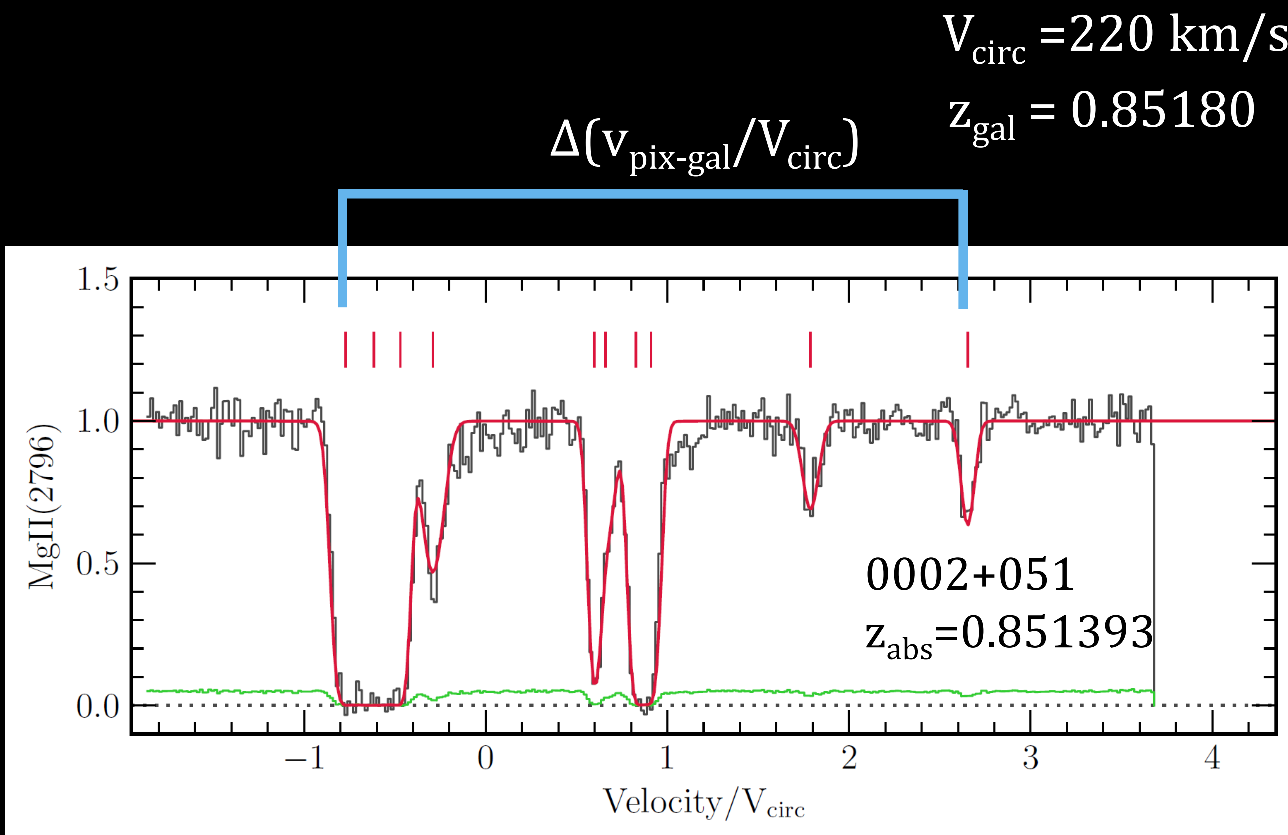
TPCF with respect to the galaxy

- Velocity dispersion of absorbers around galaxy



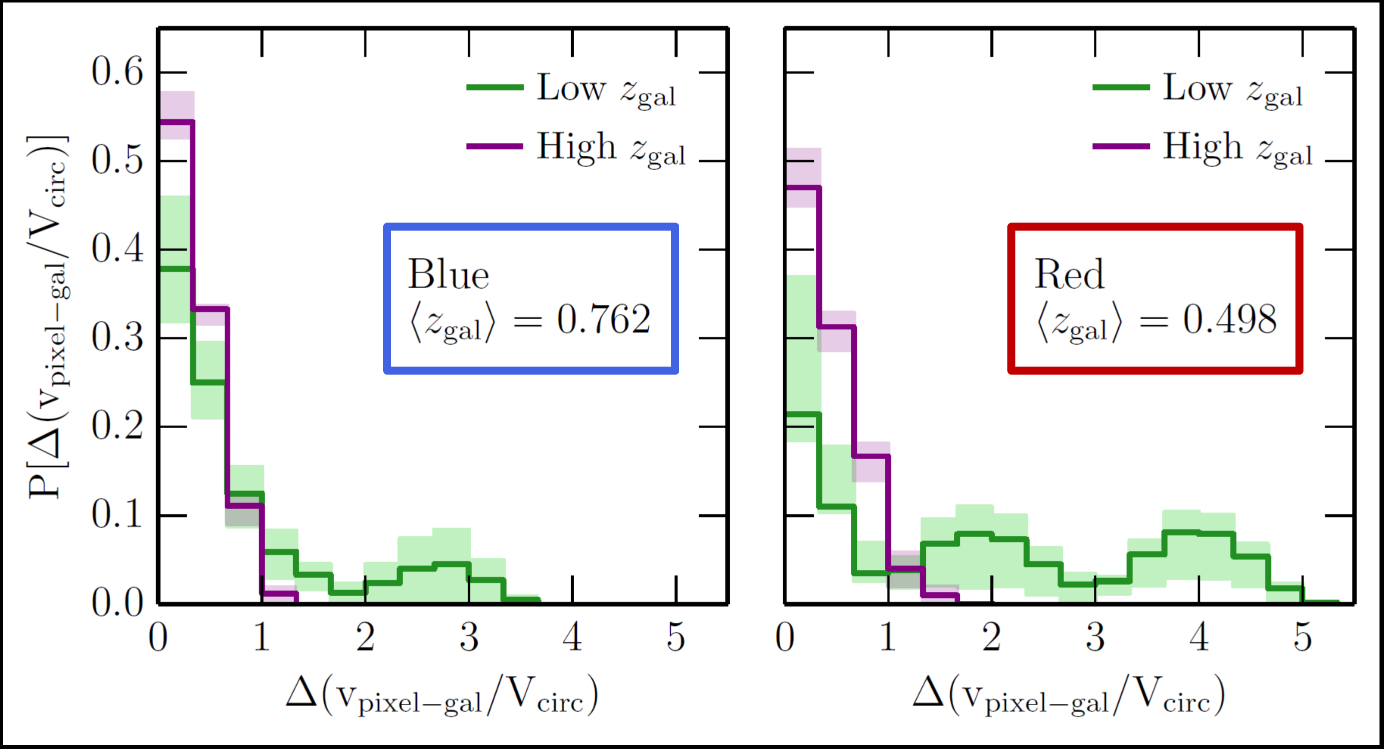
TPCF normalized with respect to the galaxy

- Velocity dispersion of absorbers around galaxy



Velocity Dispersion Around Galaxy

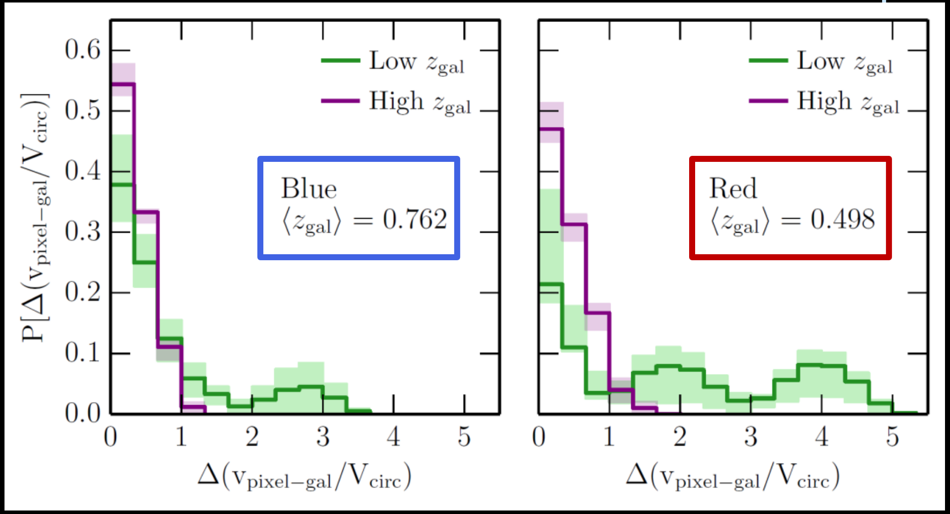
- Blue galaxies – narrow velocity range, large velocities at low z (2.2σ)
- Red galaxies – narrow velocity range at high z, large velocities at low z (7.0σ); low z more extended in velocity than blue gals (3.5σ)



Quandaries...

Expectations

- Blue galaxies currently forming stars, red galaxies are not. Outflows and infall therefore in blue, not red
- Red galaxies tend to be in more overdense environments



Questions

- What is the kinematic nature of higher velocity material around galaxies at lower z?
  - Explanation: Possibly outflows in blue galaxies
- Why is higher velocity material present and so dramatic in red galaxies?
  - Explanation: Material seen at high Δv might be gas in satellites instead of outflows

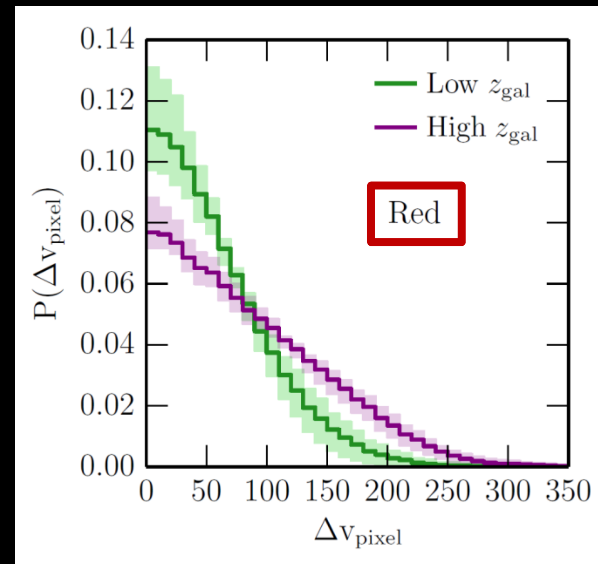
Quandaries…

Expectations

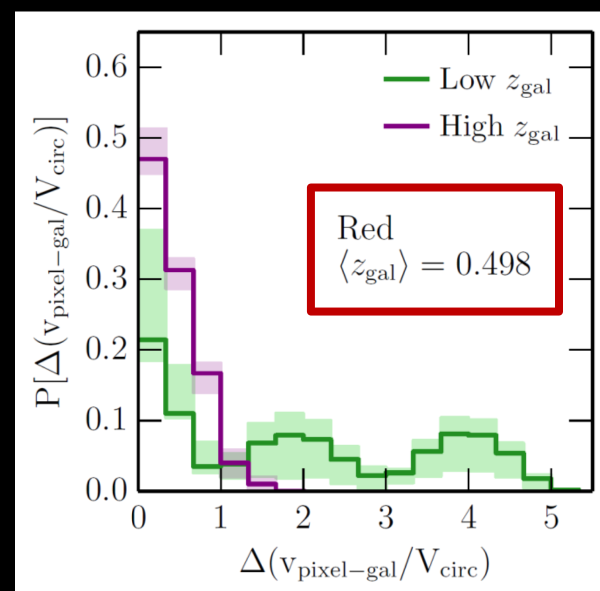
- Red galaxies to become more quiescent over time rather than more active

Questions

- Why does internal absorber dispersion become more quiescent over time but more stirred up with respect to the galaxy at lower redshift?
  - Explanation: Ancient outflows in red galaxies stirred up material around galaxies while absorbers themselves have since settled?



Internal absorber dispersion



Dispersion of absorbers around galaxy

Summary

- Internal dispersion of absorbers in red galaxies more quiescent over time while blue galaxy absorber structures do not change over 2 Gyr
  - Absorption in blue galaxies may reflect ongoing evolution
  - Settling of absorption in red galaxies may indicate passive evolution – no more stirring of the gas

- Dispersion of absorbers around galaxies at lower z larger than higher z
  - Possible outflows or satellites at lower z?

- Simulations would help untangle processes giving rise to velocity structure!