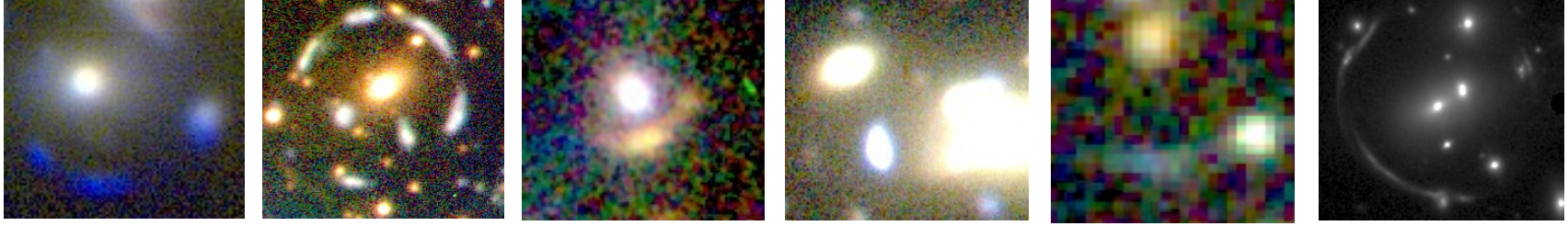

High Resolution Studies of Lensed Galaxies: Kinematics and Metal Gradients

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Motivation and Approach

Problem

Degree of gas cycling *via* feedback at high redshifts is not well constrained

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Approach

1) Metallicity gradients
   (simulations: Yang & Krumholz 2012, Gibson et al. 2013, etc.)
2) Kinematic properties

in star-forming galaxies at z≈2

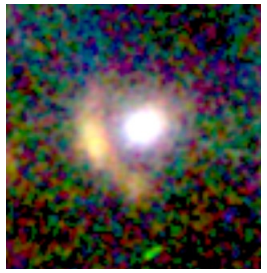
Targets were Selected using the Least Number of Criteria to Avoid Selection Bias

Select 15 gravitationally-lensed star-forming galaxies from the CASSOWARY catalog (Stark et al., 2013)

Selection criteria:

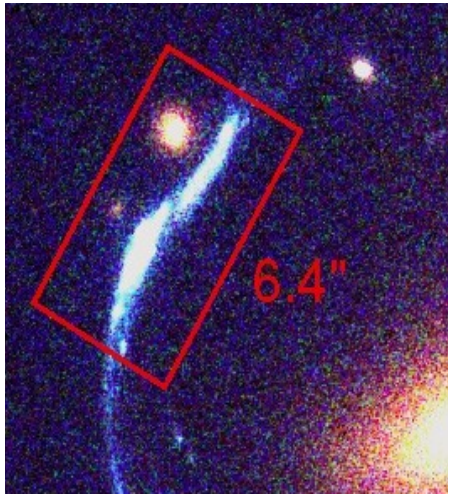
1) Availability during the scheduled observation period
2) Redshift z≈2
3) Presence of bright proximate tip-tilt guide stars

Observe with OSIRIS (IFU) on the Keck telescope to get spatially-resolved emission lines. Metallicities are measured from N2 and O3N2 method.

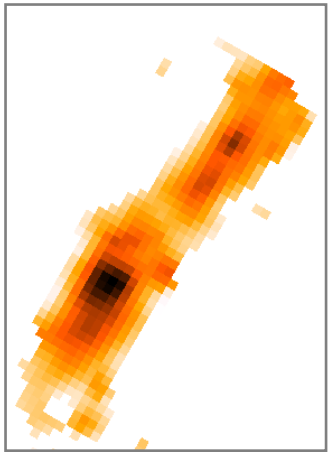


Lensing Leads to Better Spatial Resolution

HST image

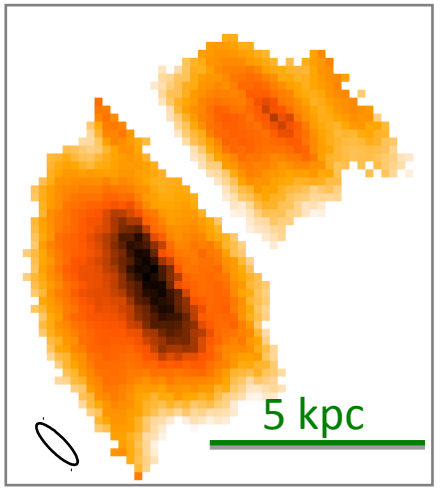


Hα map observed with OSIRIS



Re-lensing

Hα map in source plane



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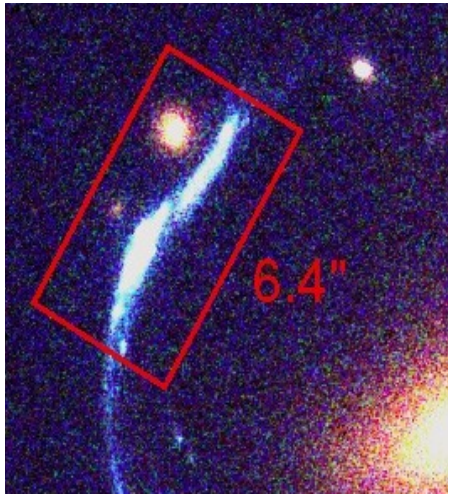

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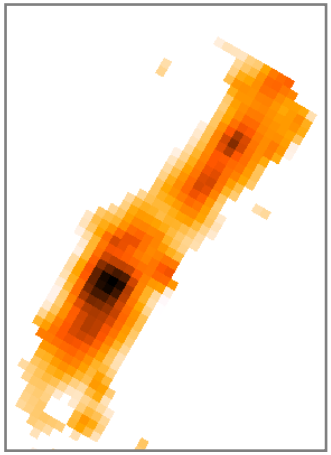

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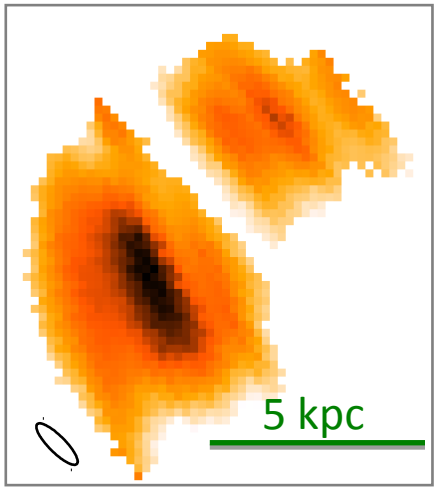

The typical resolution is sub-kpc.

Finding 1: Galaxies at z∼2 are Kinematically *Less Mature* than Expected

Previous studies

The majority of galaxies are rotation dominated e.g. 74% of galaxies in KMOS samples are rotation-dominated. (Wisnioski et al., 2015)

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Findings

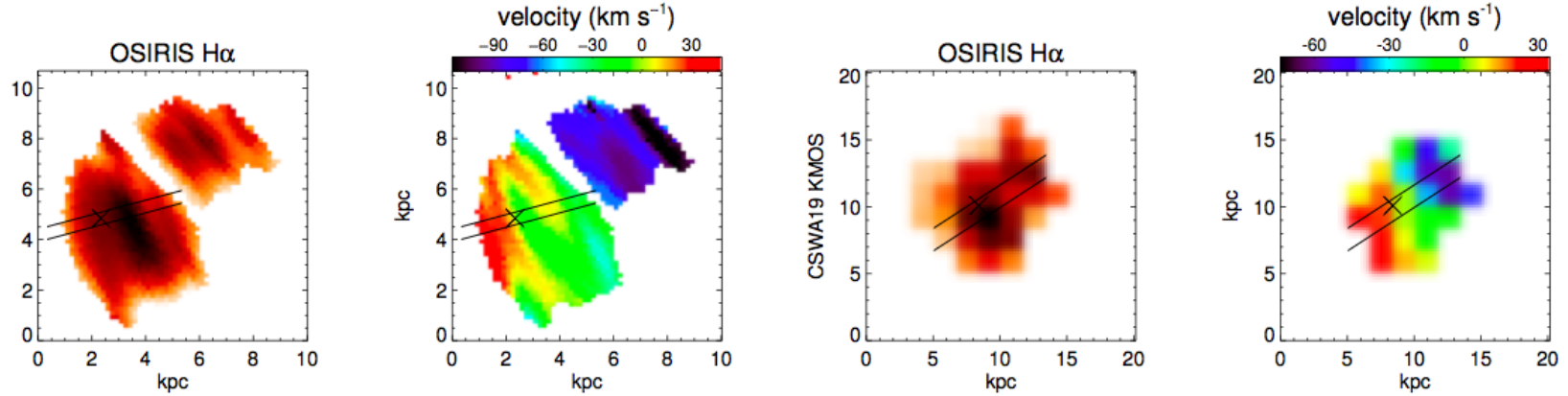
Half of our samples can be considered rotation-dominated based on a simple rotating disk fitting.

Low Spatial Resolution might be the Responsible for High Fraction of Rotation-dominated Galaxies

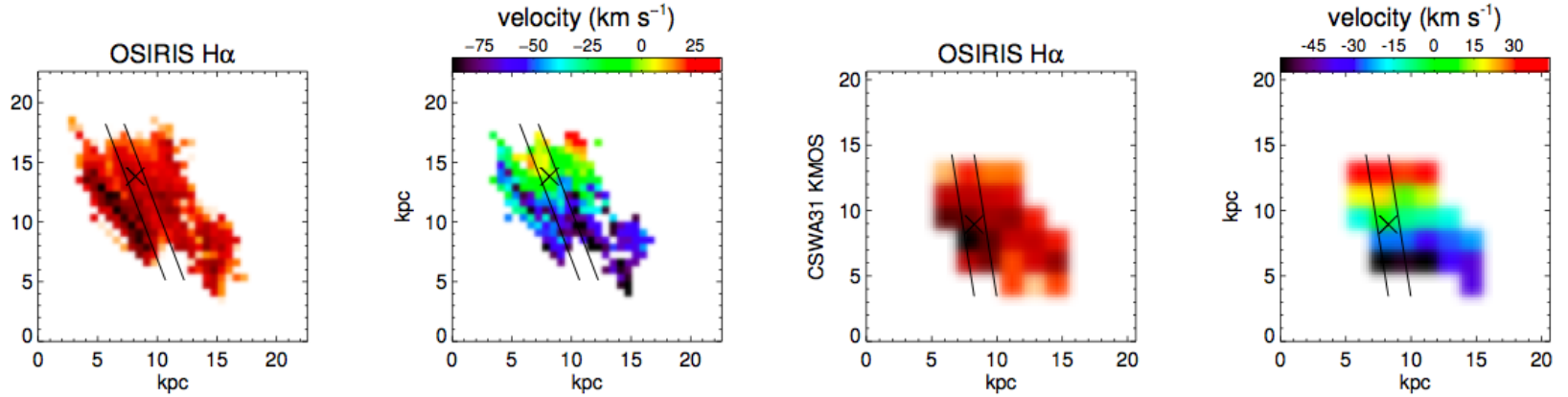
Observed with OSIRIS

Smoothed to non-AO & non-lensing

CSWA19

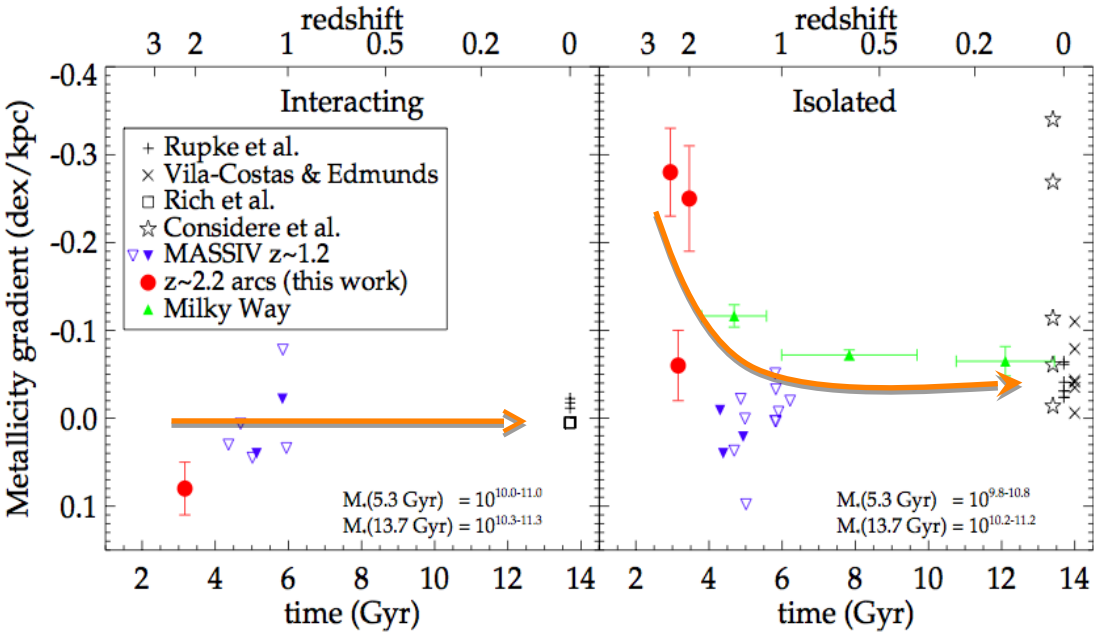


CSWA31



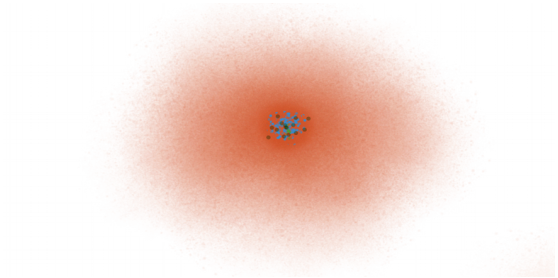
Some of the interacting galaxies might have been counted as rotating galaxies...

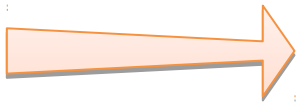
Previous Picture: Inside-out Growth
▭ Steep to Flat Unless Interacting



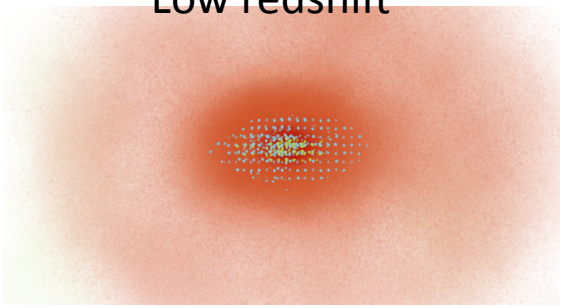
Jones et al., 2013

High redshift

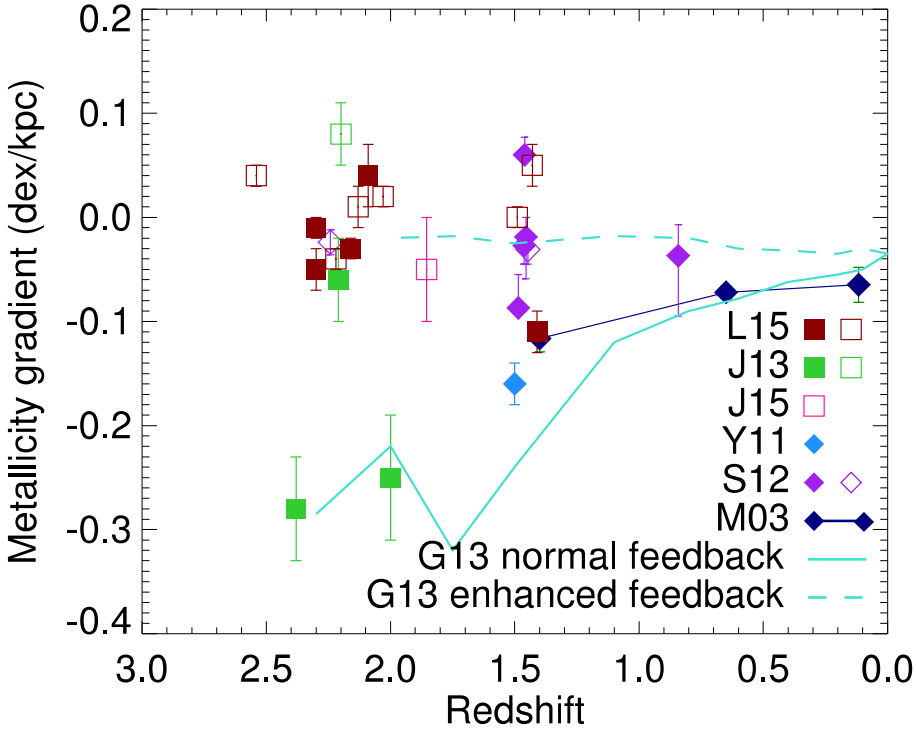


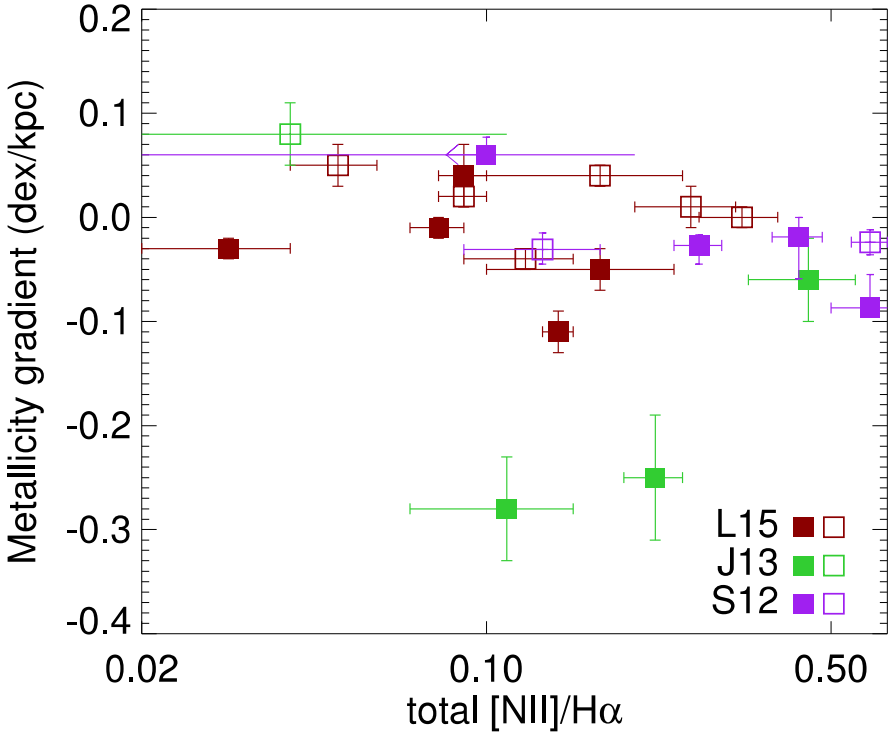


Low redshift



Finding 2: Many Galaxies at z∼2 have Flat Gradients



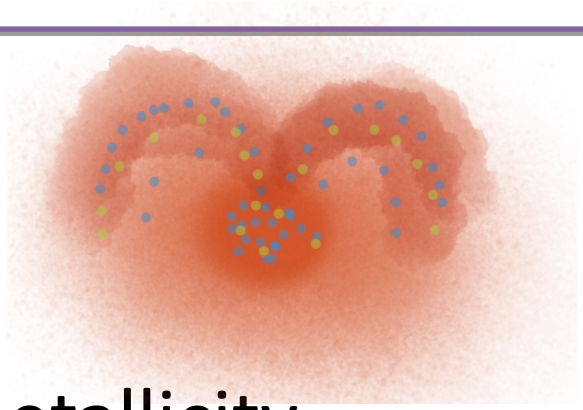


Solid points : isolated and rotation dominated galaxies

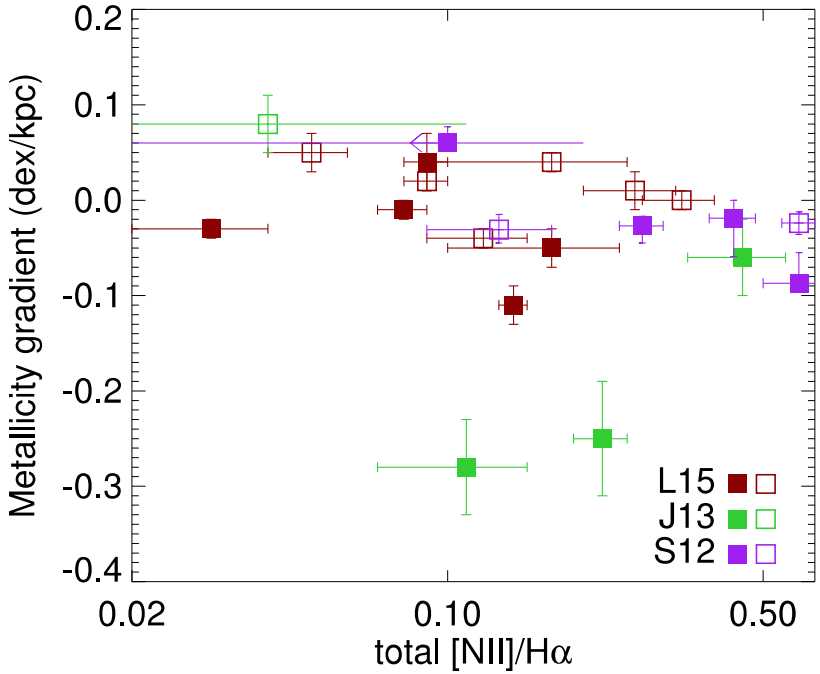
Blank points: interacting or dispersion dominated galaxies

Stronger Feedback is the key to flat gradients

- Feedback mixes the metals



- Feedback lowers the total metallicity



Takeaway Points

- Spatial resolution is important in galaxy classification. Galaxies at high redshift might not be as kinematically-mature as believed

- Galaxies at high redshift have diverse metallicity gradients. Feedback plays a key role in these diverse gradients

- The majority of galaxies have flat metallicity gradients
  - strong feedback scheme.

ApJ, 820, 84