Probing gas flows with spatially resolved metallicity
Gas flows are important in galaxy formation

- Accretion needed for continuous star formation
- Outflows remove gas and heavy elements, limiting the star formation rate and metallicity
  → Metallicity is sensitive to gas flows
  (metallicity = gas phase O/H)
Metallicity gradients

Radius

Metallicity (log O/H)

With outflows

No outflows
Metallicity gradients

- No outflows, no merging
- Merging

Graph showing metallicity (log O/H) vs. radius.
Line ratio offsets at high z!

→ Systematic error ~0.2 dex in metallicity (O/H)

Need direct measurements of O/H at high z to resolve this issue
Direct metalliclicity measurements at $z=0.8$

The DEEP2 Galaxy Redshift Survey:
Keck/DEIMOS spectra of $>50,000$ galaxies up to $z\sim1.5$
Strong lines of $\text{[O II]}$ and $\text{[O III]}$ covered for $z=0.72-0.87$

Spectrum of a $z=0.75$ galaxy from the DEEP2 survey

Image credit: the DEEP2 team
Direct metallicity measurements at $z=0.8$

The DEEP2 Galaxy Redshift Survey:
Keck/DEIMOS spectra of >50,000 galaxies up to $z\sim1.5$
Strong lines of [O II] and [O III]

Image credit: the DEEP2 team
α-element lines are reliable diagnostics!
(at least at $z\approx 1$, and likely at $z>2$)

$O$, $Ne$, $S$ line ratios show no offset from $z = 0\to 2.3$
Same relation between line ratios and metallicity
Can measure metallicity from $[O \ II] + [O \ III] + H\beta$
Spatially resolved diagnostics from HST grism spectra

Lensed galaxy at z=1.89
Lensed galaxy at $z=1.85$

Source-plane structure
~200 pc resolution

Jones et al. 2015a
Galaxies at $z \approx 2$ show a diversity of metallicity gradients

- Gradient slopes agree with the range found in cosmological simulations
- Merging / interacting galaxies have flatter gradients, as expected
- < 1 kpc resolution needed for accurate measurements (Yuan et al. 2013)
- Sample sizes increasing from ground-based AO and HST grism data

Jones et al. 2013, 2015a, Leethochawalit et al. 2015