# Unveiling the mechanisms of feeding and feedback in galaxy formation

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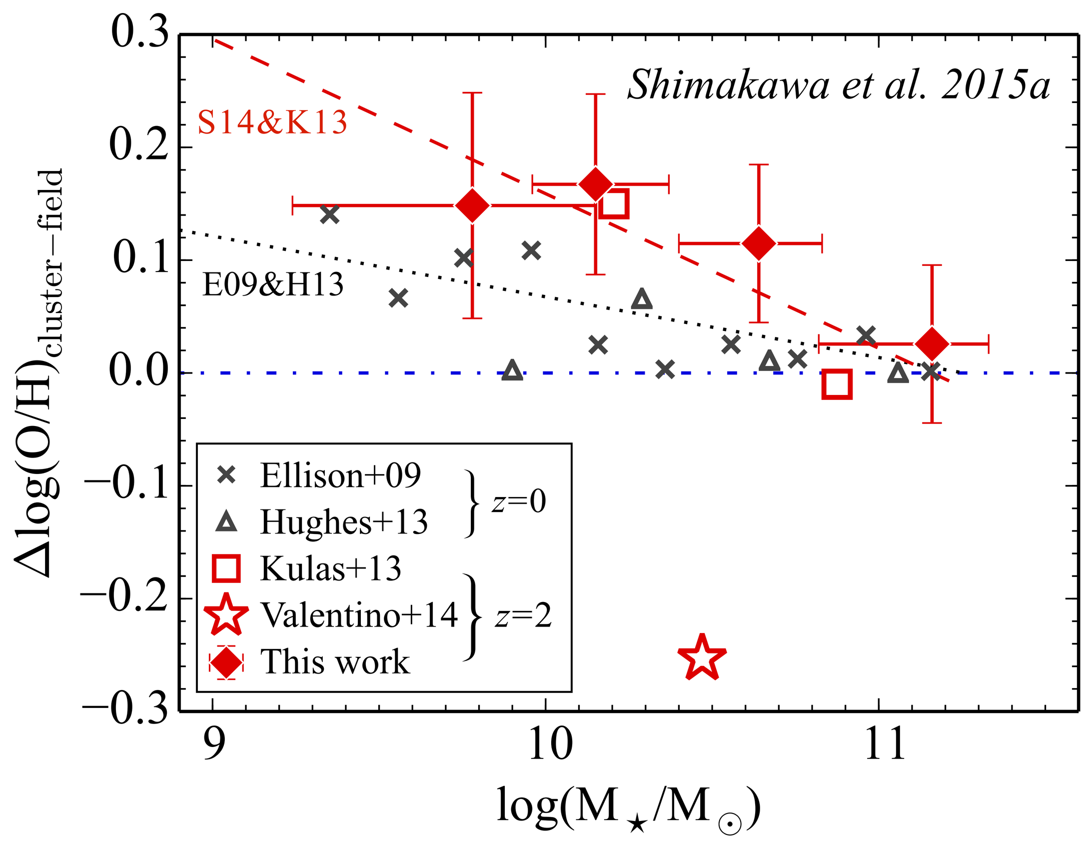
**Abstract** Feeding/feedback mechanisms are the most important keys driving the process of galaxy formation. Gas outflow ejects metals, kicks surrounding gas, and suppresses star formation. Then, recent models predict that the "cold gas accretion" is the dominant gas supply mechanism in high redshift galaxies. Those phenomena depend strongly on halo masses, redshifts and environments (Dekel et al. 2009). However, current observational challenges have not reached yet on constraining such mechanisms at all.
With such motivation, I propose the wide and ultra-deep spectroscopy to unveil inflow/outflow processes based on > a few thousand UV-bright galaxies at z=0.5-2.3 by using [OII], [NeIII] and FeII, MgII. This will provide us with enormous amount of the galaxies with outflow signatures and also some with inflow features. Those should be the best targets for the future AO-assisted IFU spectroscopy with TMT.

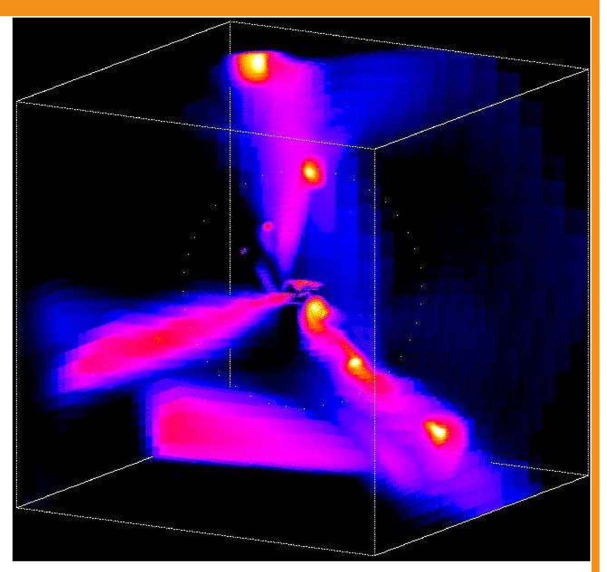
## Chemical evolution and its redshift & environmental dependences

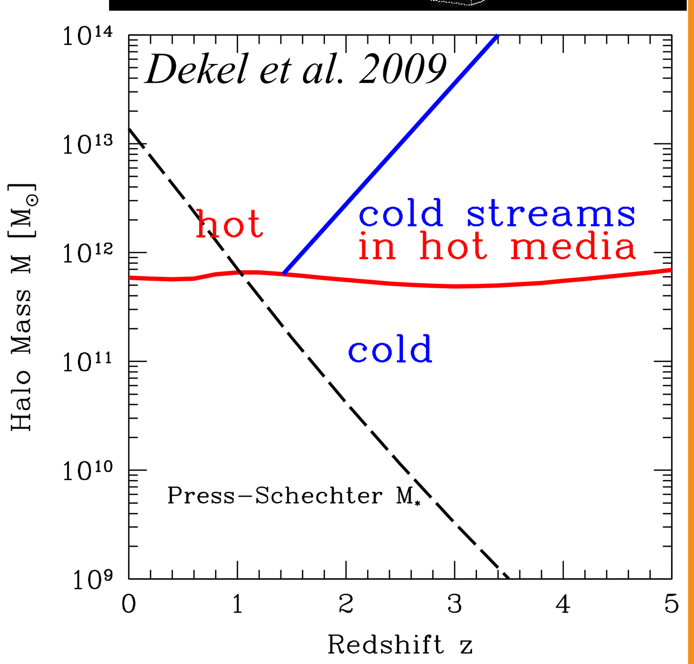
***Gaseous feeding & feedback processes play a significant role in chemical enrichment of galaxies.*** For example, gaseous metallicity is one of the crucial physical quantities to trace the chemical enrichment histories hence star formation histories of galaxies. There is a well-established relationship between stellar mass (or luminosity) and metallicity known as the M-Z relation (Tremonti et al. 2004). This reflects relationships among gas accretion, chemical nucleosynthesis and outflows of galaxies (Zahid et al. 2014). Based on such chemical cycles in galaxy evolution, redshift dependence of inflow & outflow process is analyzed (Yabe et al. 2015), which is comparable with the results from more direct approaches (Steidel et al. 2010, Boche et al. 2013). Those show that high-z galaxies should have higher inflow/outflow rates. Moreover, it may cause strong environmental dependence on chemical evolution as claimed by recent studies (Shimakawa et al. 2015a). It suggests the environmental dependence of “feeding & feedback” driven by surrounding gas pressure and/or gravitational forces.




## Cold mode accretion

***So far observations have not revealed in detail the mechanism of gas accretion, especially “cold mode” accretion.*** This dominates inflow process at high redshifts (Dekel et al. 2009), and depends also on halo mass and environments (Keres et al. 2005). Cold accretion often directly penetrates into centre of galaxies along filaments, allowing rapid mass growth compared to that from hot mode accretion. It can produce massive galaxies even at high redshift as ever found. In order to identify kinematics of stream-like inflows in high-z galaxies, (I) we need to find galaxies with clear inflow features, and (II) to conduct deep IFU spectroscopy to them.



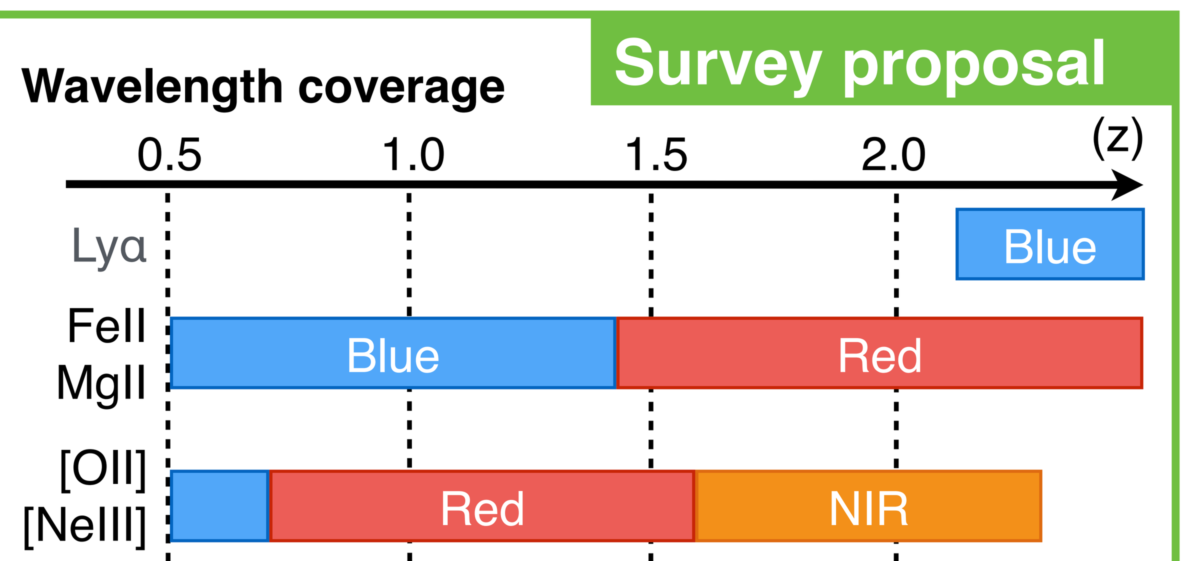



## IS vs nebular lines

***Combination of interstellar (IS) absorptions and nebular lines allows us to investigate inflow/outflow signitures of star-forming galaxies.*** FeII and MgII are well-investigated lines from the aspects of models (Prochaska et al. 2011) and obsevations (Erb et al. 2012). Those also can be observed in the galaxies at nearly-all redshift range. Past works (e.g. Erb et al. 2011, Steidel et al. 2010) have studied outflow velocities and physical properties for ~100 UV-selected galaxies at z=1-2. However, current datasets still need more statistic to reveal environmental dependence, redshift evolution, and so on. Then, they suffer from inhomogenious sample in the sense that they had to rely on different IS absorptions of the galaxeis at different redshifts. The capability of wide-coverage of the spectroscopic wavelength is needed to resolve these problems. In addition to that, the most of galaxies basically show only outflow signiture, whilst nobody constructs a sample that includes a large amount of galaxies with inflow features. A lot more numbers of spectroscopic sample would enable us with establishing such unique data.

## Survey proposal

***I propose the ambitious survey to study galaxy feeding/feedback mechanisms and those redshift/environmental dependences based on UV bright galaxies at the redshift between 0.5 and 2.3.*** In order to detect UV continuum, PFS-SSP should include "ultra-deep field" as HSC-SSP doing now. This must allow us to study feeding and feedback processes statistically founded on the most large amount of dataset for the first time.
For example, we can study the physical correlation between outflow velocities of the galaxies and other properties (SFRs from UV or [OII], redshifts, metallicities from [OII]/[NeIII]). We can test how large effects of gas transfers on galaxy evolution by combining with the rest-NUVur diagram (ugi/giY at z=0.5/2.3) which is sensitive to star-forming activities for a given stellar population (Schawinski et al. 2014). Especially, if we find the objects having inflow signitures, those should be the best data for the future follow-up IFU with TMT.




*PFS allows us to trace the rest 2600-3869Å of the galaxies at z=0.5-2.3. I do not know the accurate PFS sensitivity, but to detect UV continuum, >10h (ref: Yabe-san’s talk; additional ~10h in red may be needed) integration time would be favored.*

## Search for ISM pressure of high-z galaxies

***Line ratio of [OII]λλ3727,3730 doublet taken by R=4400 resolution of PFS (NIR) gives us with electron density ($n_e$) of star-forming galaxies at z=2.*** Electron density proportionally relates with total gas density and mean ISM pressure when we assume HII region is fully-ionized at the electron temperature of ~1E4 K which is typical value in galaxies (Dopita et al. 2006).
Shimakawa et al. (2015b) for the first time have found the tight relation between SFR surface density and electron density. Direct connection between Hα depth of HII regions and mean electron density could show that high SF intensity arise from high ISM pressure (see also Liu et al. 2008; Shirazi et al. 2014). PFS will allow us to study that in detail based on extremely large dataset.