HI Tomographic Survey in the SSA22 field (SSA22-HIT)

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The SSA22 field

200Mpc (comoving)

Density excess of LBG, DRG, SMG, LAB (Steidel+03, Matsuda+04, Kubo+13, Umehata+15, etc)

Highest density “proto-cluster”

LAE “group”

LAE “voids”

HI survey area of this work
Study of Gas LSS in the high-z Universe

(1) Gas in-/outflow between IGM and Galaxies are fundamental phenomena in the galaxy formation/evolution.

(2) Large Scale Structure (LSS) survey via galaxies and gas is a hot topic in the next surveys (e.g., Subaru/PFS).

Gas can be investigated via absorptions in the background objects’ spectra.
**HI Tomography (HIT) survey with Keck/DEIMOS**

**Panoramic survey of both HI and galaxies at z = 2.5 – 5.5**

5 nights in S15B, 2 nights in S16A, and 4 nights in S16B were awarded for **Subaru-Keck time exchange**.
We got additional 2 nights in S15B in UC time.

Targets are
~500 LBGs with $i' = 24$-25.5 mag.

Data was taken for the 6 masks so far.
- 600ZD (R~1500)
- $\lambda = 4000 – 9000\text{Å}$

6 masks in the **SSA22** field
(including the prominent proto-cluster at $z=3.1$)
Main Science (1) Galaxy-Gas spatial correlation

It’s not clear whether HI gas distribution align with galaxy distribution.

While some simulations predict positive correlation on ~ 10 Mpc scale (Cai+15, Stark+14), our recent observational work suggests no correlation.

Comparison between observations and simulations will be needed to understand HI-gal (no) correlation.

Higher resolution 3D map from HIT
Main Science (2) CGM HI & metal abs halo

CGM halo can be investigated by measuring HI/metal absorptions as a func of impact parameters.

Main Science (3) LSS survey with z > 4 galaxies

Previous photo-z analysis showed a redshift peak at z > 5. There may be another proto-cluster.
## Current data Summary

<table>
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<tr>
<th></th>
<th>Integration time [hour] in total</th>
<th>Integration time [hour] in 2015</th>
<th>2σ depth @5000Å per resolution [AB]</th>
<th>Goal depth: ETC 2σ per resolution in 4 h</th>
<th>Nspecz / Nobj</th>
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</table>

- Shallower than expected....
- 124 are newly determined

We show the results from data taken in 2015. Final products are not ready.
Redshift determination

- Redshift histogram for each category

Only objects with reliable specz (quality flag = A or B) are shown.
Redshift determination

Sky distribution of A and B objects

Surface density of $3.2 < z < 3.7$ gals

$= 0.17$ arcmin$^{-2}$

corresponding to

$\sim 1$ Mpc spatial resolution

for $z=3.1$ HI tomography
We need to smooth spectra or to stack of plural sight-line spectra, even after merging the 2\textsuperscript{nd} year data.
Summary

- IGM tomography in the SSA22 proto-cluster region is an unique survey.

- We spent 13 Keck/DEIMOS nights to survey a ~ 50 x 30 Mpc$^2$ area in the z ~ 3 Universe.

- Achieved depth is ~0.8 mag shallower than expected from ETC. This is not due to the weather condition.

- The data reduction is still on-going, but the first year data show that (1) the data quality is enough for specz confirmation of background galaxies (for tomography) but (2) their S/N in the DA range is too low.

- We plan to complete merging the all data (1st + 2nd year) and redshift determination this Jan ~ Mar.