Searching for z>6 Quasars with Subaru / Hyper Suprime-Cam Survey

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Why we care high-z \((z>6)\) quasar?

- SMBH evolution/formation scenario
- IGM opacity during EoR
- Co-evolution with host galaxy
- Proto-cluster search

Unique probe of the early Universe!!
IGM Opacity

- Redshift evolution of IGM neutral fraction during EoR
- Spatially patchy reionization process suggested

Robertson+15

Near-zone

GP trough

Dark pixel
Published 100 $z>6$ QSOs

Past High-z QSO Survey
Published 100 $z>6$ qso's

Now, we should go deeper & higher-$z$ ($z>7$)

2016/03/07 The Reionization Epoch: New Insights and Future Prospects
Hyper Suprime-Cam Subaru Strategic Program (HSC-SSP) Survey
Hyper Suprime-Cam (HSC)

- Mounted on Subaru's prime focus
- Field of view: 1.5 deg diameter - ×7 Suprime-Cam!
- Sensitive at 1 μm (y-band) ➔ essential for z>6 science
M31 in one shot!

The Andromeda Galaxy (M31)

Suprime-Cam: 34' × 27'

HSC: 1.5° diameter
Optical multi-band survey with Subaru/HSC (5 years, 300 nights)
- **Wide**: 1400 deg$^2$, $r_{\text{lim}, 5\sigma} \sim 26$
- **Deep**: 27 deg$^2$, $r_{\text{lim}, 5\sigma} \sim 27$
- **UD**: 3.5 deg$^2$, $r_{\text{lim}, 5\sigma} \sim 28$

Most powerful optical survey before LSST
(~300@z~6 & ~50@z~7 QSOs) are expected to be found by HSC survey➡Powered by more general SMBH population!

We can address general SMBH evolutionary states at z>6

Table 7: Quasar Samples

<table>
<thead>
<tr>
<th></th>
<th>Wide (1400 deg²)</th>
<th>Deep (27 deg²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>redshift</td>
<td>3.7–4.6</td>
<td>&lt; 1</td>
</tr>
<tr>
<td>mag. range</td>
<td>4.6–5.7</td>
<td>3.7–4.6</td>
</tr>
<tr>
<td>number</td>
<td>6000</td>
<td>2000</td>
</tr>
</tbody>
</table>

Galactic Extinction E(B-V) #500 deg² overlapped with VIKING
Multi-color Candidate Selection

1. Bayesian ($P_{Q^B}$)
   - efficient
   - but less complete
     ‣ Based on Mortlock+12
     ‣ Surface density of quasar/star included as a prior

2. SED-fitting ($P_{Q^S}$)
   - complete
   - but less efficient
     ‣ various SED templates
     ‣ covering the bias in Bayesian selection

3. Two-color ($P_{Q^C}$)

We apply several probabilistic approaches for our $z>6$ quasar candidate selection.
Current Status

- We have started our unprecedented high-z quasar search with the first internal data release (~80 deg$^2$, $z_{\text{lim,5}\sigma}$~25.5)

- Subaru & GTC have spectroscopically followed-up 19/38 Main candidates so far

  - The faint-end of $z$~6 QLF will be discussed when the first follow-up is completed (next paper)
9 QSOs Discovered

- $5.9 < z < 6.9$
- $M_{1450}$ down to -22
  - ~3 mag deeper than SDSS
- Their multi-wavelength (opt/NIR/sub-mm) follow-up observation is ready to start
  - BH mass, accretion rate, BLR metallicity, IGM neutral fraction, host galaxy properties, etc…
Success Rate Quite High

- We have identified **15 (/19)** extra-galactic objects in Main candidates
- ~100% success rate at $z_{AB}<23.5$
- All known $z\sim6$ QSOs are successfully recovered by our Main selection
- 6 LBGs found from faint candidates

### z~6 QSO & LBG LF

- **New QSOs**
- **Known QSOs**
- **Galaxy**
- **Star**
- **ND**
Beyond the Tip of the Iceberg

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Summary

- Faint $z>6$ quasars contain valuable information on EoR
- HSC-SSP survey is able to reveal this unexplored realm by providing massive numbers of $z>6$ quasars, powered by more general SMBH population
- 9 $z>6$ quasars (+6 galaxies) have been discovered through the first follow-up observation. Our probabilistic candidate selection has worked quite successfully.
- Please check further details in Matsuoka et al. (2016)
Back-up Slides
Two-color diagram (i-z vs z-y)

$z_{AB} = 24$

$P_{Q}^B = 0$

$P_{Q}^B = 1$
Stellarity of new $z \geq 6$ QSO/LBGs
QSOs

Galaxies
QLF vs LBG LF