Y-band Imaging of Extragalactic Fields and High red-shift Quasar

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Introduction
Observation
Data
Results
CEOU QSO survey
Discussion
Conclusion & Summary

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Introduction

- Early universe
- Re-ionization
- Evolution of galaxies

Moving to Early and Far objects

Quasar (Quasi-Stellar radio source)
Super Massive Black Holes

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Introduction
High redshift Quasars

1. Evolution of SMBH
2. Metal Enrichment History
3. Re-ionization epoch
4. Quasar Luminosity Function

Until now ~10 (z>6),
We need more high red-shift Quasars!
And more distant quasars!

In searching for the high redshift quasar, longer wavelength region like “Y-band” is critical.
What is Y-band?

- Centered at 1 μm between optical and NIR (z - Y - J)
Why Y?

- Not deeply explored wavelength region so far
  - Optical CCD and NIR detector have no good sensitivity
  - Recent technology allow us to observe with Y-band!

- Past work with Y-band:
  - Good for identification of low mass and cool stars and brown dwarf. (Hillenbrand et al. 2002)
Extragalactic study with Y-band: important tool for high-redshift objects

- High red-shift objects: Galaxies and Quasars
- High red-shift QSOs (z > 6) photometric selection method (Fan et al. 2000, 2001; Warren & Hewett et al. 2002)
- Adopted to large projects (UKIDSS, Pan-STARRS)

United Kingdom Infra Red Telescope (UKIRT),
Pan-Starrs 1 (PS1)
At Mauna Kea summit
Searching for high red-shift quasar

Difficulties for searching high redshift quasar

• Contaminations of Candidate
  • M/L/T dwarfs
  • Low red-shift galaxies
  • Instrumental artifacts
Extragalactic study with Y-band: important tool for high-redshift objects

- High red-shift objects: Galaxies and Quasars
- High red-shift QSOs (z > 6) photometric selection method (Fan et al. 2000, 2001; Warren & Hewett et al. 2002)
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Goal of this study

- Deep Y-bang imaging of extragalactic fields with optical CCD at 1-m class telescope
  - 1 mag deeper than UKIDSS-LAS (the UKIRT Infrared Digital Sky Survey-Large Area Survey) (20.4 AB mag)
  - Ahead of Pan-STARRS (the Panoramic Survey Telescope & Rapid Response System)

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- Provide Photometric calibration data
- **Number count** of detected sources for first time in Y-band
- **Color-color diagram**: high-redshift QSO selection method \((i-z \text{ vs } z-Y)\)

Venemans et al. 2007
Observation : where?

- **LOAO**
  - 1m, Arizona
  - FLI 2K CCD
  - Seeing ~ 2.5"

- **Maidanak Observatory**
  - 1.5m AZT-22
  - Seeing ~ 0.7"
  - **SNUCAM**
Observation

Maidanak Observatory
66°56' E, 38°41' N

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**Observation**

- **LOAO 1m, Maidanak 1.5m telescope (#)**
- **Targets**: famous extragalactic fields, 5 brown dwarf, (*) 5 SDSS QSOs (z~6)

<table>
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<th>Target</th>
<th>Log (Exp.time)</th>
<th>Area (deg²)</th>
<th>Depth 5σ (AB mag)</th>
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<td>20.2</td>
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<td>NEP</td>
<td>2.95~4.2</td>
<td>0.96</td>
<td>18.4~20.5</td>
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<td>0.2</td>
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<td>0.1</td>
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<tr>
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<td>0.1</td>
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</table>
Pre-process and stacking: IRAF

Astrometry: SCAMP, SWARP, (USNO B-1 catalog)

Standard star: A0V stars (zero color)

$k = 0.05 \sim 0.1$ (atmospheric extinction coefficient)

Photometry: Source Extractor

Cross matching: SDSS DR7, CFHT LS, UKIDSS DR2 plus, CFHT-NEP matched catalog (optical, IR)
A0V star: color is zero by definition

- $M = m + k(X-1) + \xi$
- $m = -2.5\log(DN/\text{sec})$
- $\xi_0 = m + m_0$
- $kX_1 + a = \xi_1$
- $kX_2 + a = \xi_2$

- A0V star: color is zero by definition
- $M$: actual magnitude
- $m$: instrumental magnitude
- $k$: atmospheric coefficient
- $X = \sec(z)$
- $\xi = \text{zero-point magnitude}$
Result: Number count

- Bright end: stellar sources
- Faint end: extended sources (extragalactic)
- Intermediate feature between I (optical) and J (NIR)-band number count
Effective method for high $-z$ QSO ($z \sim 6$) Distinction from brown dwarfs

Difficulties for searching high red-shift quasar
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- M/L/T dwarfs
- Low red-shift galaxies
- Instrumental artifacts

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Detection limit: potential of 1-m class telescopes with unique equipments

Sensitivity limit: LOAO versus Maidanak
  - Good seeing In Maidanak

Other application of Y-band imaging
  - GRB afterglow observation
Infrared Medium-deep Survey (IMS) - CEOU

- $z \sim 7$ Quasar survey
  - The most distant known quasar at $z = 6.43$
  - Intermediate-wide, Medium-deep Survey
  - UKIRT J-band observation + SPITZER + CFHT + Subaru
  - $200 \text{deg}^2$, $J \sim 23 \text{ mag}$
**z ~ 5.5 Quasar survey**

- **SDSS + UKIDSS + Mcdonald observation**
- **3000 candidates**
- **CQUEAN (Camera for QUasars in EArly uNiverse)**
- **(McDonald 2.1m ) + SDSS g, r, i + LSST z, Y, + Is, Iz filters**

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We carried out deep Y-band imaging observation at LOAO & Maidanak Observatory.

We performed Y-band source number count.

We found $i-z$ VS $z-Y$ color-color diagram is effective method of high-z QSO photometric selection.

There are another potentialities of 1m class telescope and Y-band observation.

CEOU is undergoing various survey to search high redshift quasars.

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Thank You

For more information
Please visit http://ceou.snu.ac.kr

감사합니다
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