# Search for High-z Quasars beyond z=6.5 with Subaru Telescope


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## Abstract

High-z QSO survey is extremely important to understand the early universe. The most distant QSO so far is found at z=6.43 (at 12.8 billion light-years away). Finding the QSOs beyond z=6.5, we can understand how much QSOs contribute to the reionization and how early Super Massive Black Holes(SMBHs) formed and evolved. We are on going deep imagings for 7 seqdeg in total on UKIDSS-DXS fields in order to detect high-z QSOs around z ～ 7 down to J < 23.5. This observation is a new search for the most distant QSOs at z ～ 7 utilizing unique capabilities of wide-field imaging of Subaru/Suprime-Cam, its high-sensitivity CCDs at ～1 um, and special filters to effectively isolate high-z QSOs from L/T dwarfs. We have carefully selected 15 promising QSO candidates that meet our color selection criteria, which is reliably far away from dwarf star region. We'd like to show our preliminary result in the poster.


## 1.Introduction

○**Constraint of SMBH evolution model in early universe**

- Extremely high luminosities ～ $10^{12} L_{\odot}$ of QSOs indicate the existence of SMBH at their centers.
- QSOs at z > 6 → $10^{8-9} M_{\odot}$ SMBHs have already existed at z > 6
- It is still unclear how SMBHs grew in less than 1Gyr
  → Formation and evolution models of early SMBH would be constrained by finding QSOs at z ～ 7.

○**How was the reionization process?**

- It is not clear how much QSOs have contributed to the reionization.
- The number density of QSOs in reionization epoch seems too low to dominantly contribute to the reionization.
  – But, the luminosity function(LF) of high-z QSO has been derived only at the bright end.
  → **Necessary to find higher-z and fainter QSOs in order to accurately constrain the photon budget of QSOs**

○**The main purpose of this study is to find QSOs at z ～ 7.**

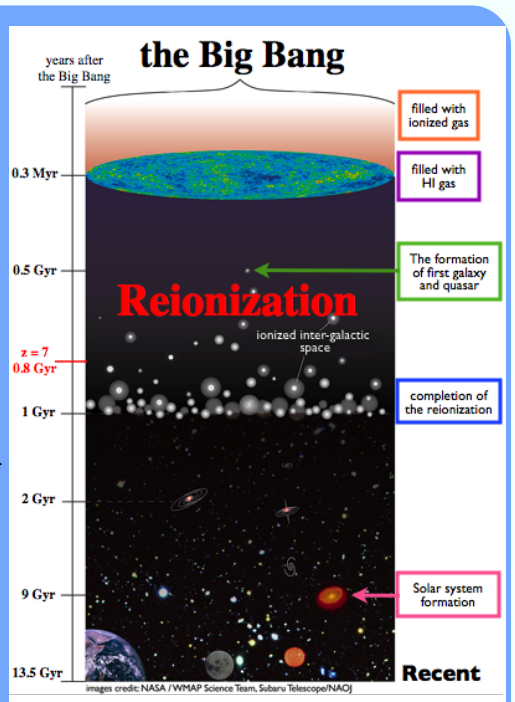


**Fig. 1.** A brief history of the universe

## 2.Method

■The special and unique zB and zR bandpass filters

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dividing the SDSS z band into two at the center (Fig.2)

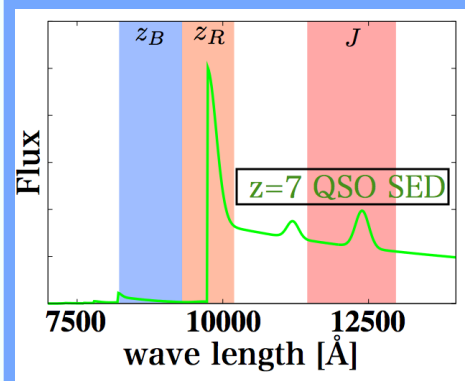


**Fig. 2.** spectra of QSO at z = 7 and transmission wavelength of zB, zR, J bandpass filters

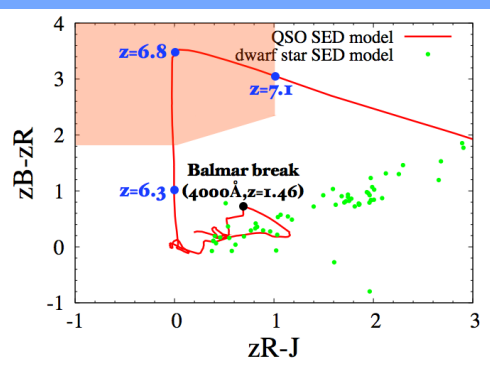


**Fig. 3.** 2-color diagram to select z ～ 7 QSO candidates. The objects in the orange shaded region are selected as z ～ 7 QSO candidates

■(zR-J) vs. (zB-zR) color selection makes it possible to effectively discriminate z ～ 7 QSOs from dwarf stars (Fig.2, Fig.3)

■The QSOs at z ～ 7 can appear in the zR and J-band images, while they would not be seen in zB-band images.

■low-z galaxies having Balmar breaks (4000Å) at z ～ 1.5 can also be removed by our color selection.

## 3.Instrument

●**Subaru 8m telescope :**
feasible to catch higher-z and faint QSOs

●**Suprime-Cam (Fig.4):**

- Wide field of view (34' x 27')
  → Poweful to catch high-z QSOs with low number density
- Upgraded new red-sensitive CCDs
  → Twice higher sensitivity (～ 212%!!!) at 1um (zR-band) (Fig.5) than previous one

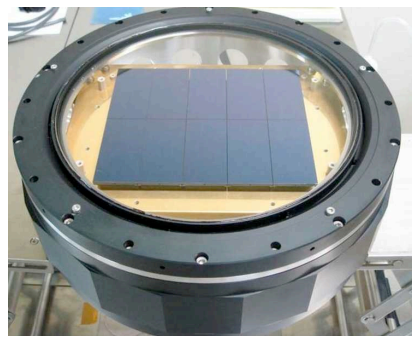

**Fig.4.** Suprime-Cam with new CCDs (images credit NAOJ)

## 4.Observation

- Date : 2009.6.22~24 (full time ×3 nights)
- **The zB and zR imaging for 7 seqdeg** in total on UKIDSS/DXS fields down to zB = 25.3, zR = 23.9 (3 σ , 2", AB).

**UKIDSS/DXS**

■Deep stacked J-band images are available at the UKIDSS archive
■depth : J = 23.4 (AB)

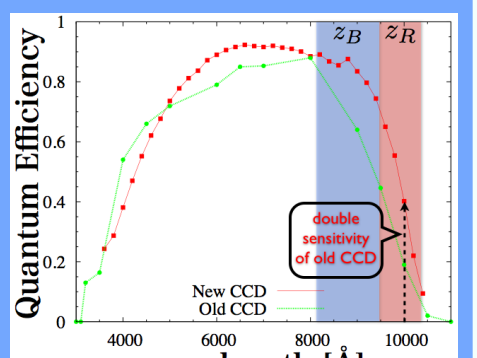


**Fig.5.**The quantum efficiency of old and new CCDs of Suprime-Cam

## 5.Result

●**2-color diagram (Fig.6)**

– green points : detected objects in our image data (400,000 objects)
– red triangle : 15 promising candidates of QSOs (6.5 < z < 7.1) have been found

●**They all look compact (Fig. 7)**

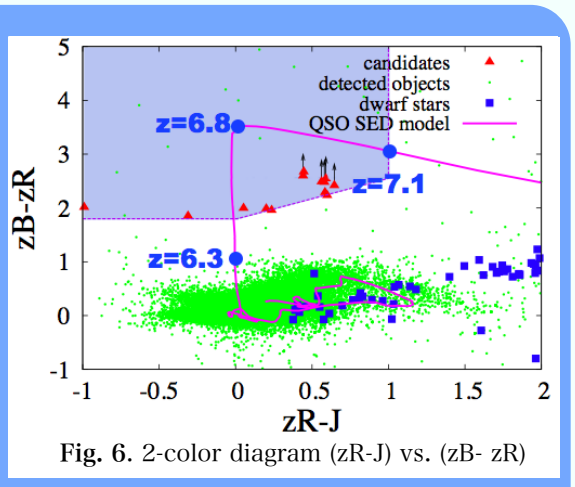


**Fig. 6.** 2-color diagram (zR-J) vs. (zB- zR)

## 6.In future

○**Spectroscopic follow-up for the QSOs candidates by Subaru/FOCAS is scheduled on next October / January**

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identify the real most distant QSOs

○**NIR spectroscopy**
→Metallicity of QSO and intergalactic medium(IGM)

○**Radio spectroscopy**
→Molecular gas in QSO host galaxy

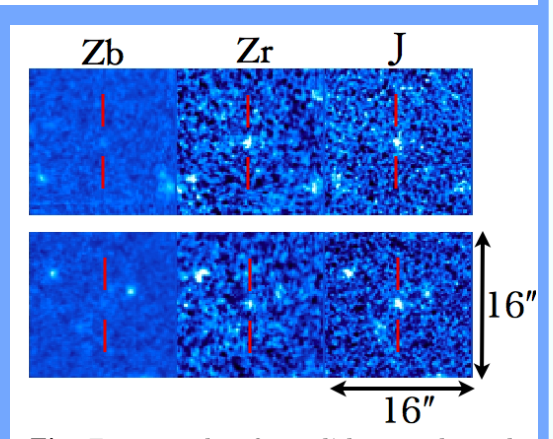


**Fig. 7.** example of candidates selected from the 2-color diagram


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