Study on the Environment of QSOs with Redshift 1~3 using the JVO System

Yuji Shirasaki National Astronomical Observatory of Japan and JVO collaboration

Objectives

QSO-Galaxy correlation:

- Formation and Fuelling mechanism of QSO
- History of the large scale structure formation
- Observations so far:
 - z < 1.0
 - Poor statistics (~tens of QSOs)
- Goal of our study:
 - Explore z > 1.0
 - High statistics (~hundreds or more)
 - QSO/AGN catalog (SDSS, 2dF, ...) 100,000 known QSOs/AGNs
 - Archived deep images by large telescopes (Subaru).
 - Opt ~ IR (SuprimeCam, MORICS)

Data Discovery through JVO

Two VO data services are constructed:

- QSO Catalog data service (Veron et al. 2006 from VizieR)
- Subaru SuprimeCam image data service
- Both services are developed by using the JVO SkyNode toolkit.
- <u>http://jvo.nao.ac.jp/download/skynode-toolkit</u>

SuprimeCam images containing cataloged QSOs are searched on JVO portal service.

Three kinds of data search methods

SQL Search mode

General interface for data access

	表示(V) 移動(G) ブックマーク(B) ツール(T) ヘルブ(H)	
<u>s Registry</u>	Data Search Search <u>Workflow Result Database QSO DataViewer Link MemoryMonitor Logout</u> ⇒ <u>All Simple</u> JVOQL <u>Subaru</u>	
SELECT	JVOQL qso.*, img.* ivo://jvo/vizier/VII/235:qso_veron_2003 qso, ivo://jvo/subaru/spcam:spcam_mos_view AS img	
WHERE	<pre>qso.id between 0 and 10000 AND img.format = 'image/fits' AND img.filter_id = 'W-C-RC' AND qso.v_mag < 20 AND img.region = Circle((qso.raj2000, qso.dej2000), 0.02)</pre>	

User I/F Dedicated for a specific purpose

🕘 QSO-Galaxies Search - M	ozilla Firefox	-OX
ファイル(E) 編集(E) 表示(<u>V</u>)	移動(④) ブックマーク(風) ツール(① ヘルブ(日)	Ó
QSO-Galaz	ties Search	<u> </u>
<u>Status Registry Search Wo</u>	orkflow Result Database QSO DataViewer Link MemoryMonitor Logout ⇒ Query Catalog PhotoZ	
Data Search		
Search Check SQL		
ID for your query	Observation Name	
Search Method	All Sky C Specify Region C By QSO Name	
Search Region	RA: 189.20625 [deg] Dec: 62.216111 [deg] Radius: 0.2 [deg]	
QSO ID	ID BETWEEN 0 AND 10000	
QSO name	not selected	
Brightness	V_mag[mag] between 10.0 and 20.0	
Redshift	z between 0.0 and 4.0	
Table of SuprimCam	spcam_exp_view (Table for SuprimCam Exposure) 💌	
Image Filter	W-C-RC	
Image Size	2.0 [arcmin]	
Search Check SQL		
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261		16

Workflow (Script) mode

Automate the procedure: data discovery, data retrieval, image analysis (source extraction), photo-Z estimation ...

Vorkflow – Mozilla Firefox	
(ル圧) 編集(圧) 表示(⊻) 移動(G) ブックマーク(B) ツール(T) ヘルプ(出)	
VOIABLE Catalog ArrayOfString listOfFileName	
ArrayOfString listOfObjectName	
ArrayOfString listOfCatalogName	
String wdir	
int numBands	
ArrayOfString listOfFileForObject	
ArrayofString fistoffffefofasjett ArrayOfDataHandler listOfDataHandler	
ArrayOfString listOfFilterName	
VOTABLE resultPhotoZ	
String resultFileName	
SEQUENCE	
jvoql = QSOStudy.createJVOQL(qsoTable, ra, dec, radi, imageTable, imageSize, magLimit)	
votableForImage = executeQuery(jvoql)	
storeVOTable(votableForImage[0], result file1)	
listOfURL = QSOStudy.getListOfURL(votableForImage[0])	
listOfFileName = QSOStudy.getListOfFileName(votableForImage[0])	
listOfObjectName = QSOStudy.getListOfObjectName(votableForImage[0])	
listOfCatalogName = QSOStudy.getListOfCatalogNameForObject(listOfObjectName)	
FOR listOfURL	
INVOKE ivo://jvo/tools/sextractor catalogDH = performForURL(listOfURL[count])	
storeVOTable(catalogDH, listOfFileName[count])	
END	
wdir = getCurrentWorkDir()	
FOR listOfObjectName	
numBands = QSOStudy.prepareForHyperZ(wdir, listOfObjectName[count], listOfFileName, listOfCatalogName[count])	
END	
PARFOR listOfObjectName	
executeHyperZ(listOfCatalogName[count], listOfObjectName[count])	
END	
END	

Procedure of QSO image search

1. Request QSO Coordinates (ADQL)

2. QSO Coordinates (VOTable)

QSO Catalog 108080 records

3. Request images of QSOs (ADQL+VOTable)

4. Metadata of Images (VOTable)

5. Request an image (HTTP Get)

6. A QSO image (FITS)

Subaru SuprimeCam Image Data 30444 exposures 291 mosaic images

🕲 QSO-Galaxies Search - Mozilla Firefox

ファイル(E) 編集(E) 表示(V) 移動(G) ブックマーク(B) ツール(T) ヘルブ(H)

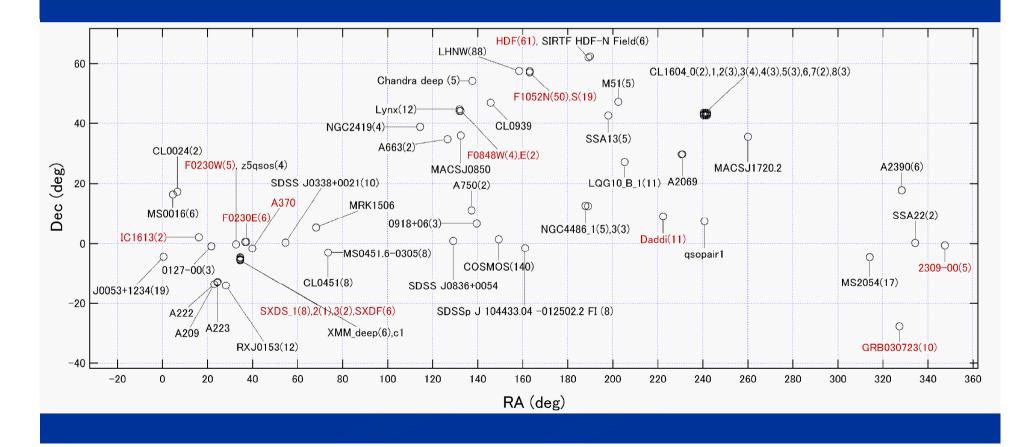
Object List for QSO_SEARCH_20060810230320359

Register Edit Param/Config for SExtractor									
Object	RA	Dec	Mag	z	Band	Image	Create Catalog	Catalog	Register
Q 0014+1559	00 17 10.4	+16 15 44	20.2	2.2	W-C-IC	<u>Image</u>	SExtractor>	<u>2.cat</u>	☑ : Image ☑ : Catalog
Q 0014+1559	00 17 10.4	+16 15 44	20.2	2.2	W-C-RC	<u>Image</u>	SExtractor>	<u>3.cat</u>	□ : Image □ : Catalog
00151+160	00 17 45.1	+16 19 52	19.9	2.2	W-C-IC	<u>Image</u>	SExtractor>	not present	Catalog
00151+160	00 17 45.1	+16 19 52	19.9	2.2	W-C-RC	<u>Image</u>	SExtractor>	not present	□ : Image □ : Catalog
Q 0015+0239	00 18 11.4	+02 56 39	19.7	2.469	W-S-Z+	<u>Image</u>	SExtractor>	not present	□ : Image □ : Catalog
00159+155	00 18 30.0	+15 52 27	20.6	2.3	W-C-IC	<u>Image</u>	SExtractor>	not present	□ : Image □ : Catalog
00159+155	00 18 30.0	+15 52 27	20.6	2.3	W-C-RC	<u>Image</u>	SExtractor>	not present	□ : Image □ : Catalog
E 0015+162	00 18 31.9	+16 29 26	18.79	0.554	W-C-IC	<u>Image</u>	SExtractor>	not present	□ : Image □ : Catalog
E 0015+162	00 18 31.9	+16 29 26	18.79	0.554	W-C-RC	<u>Image</u>	SExtractor>	not present	Catalog
ISS 35	00 19 14.4	+15 55 56	18.3	2.27	W-C-IC	<u>Image</u>	SExtractor>	not present	□ : Image □ : Catalog
ISS 35	00 19 14.4	+15 55 56	18.3	2.27	W-C-RC	<u>Image</u>	SExtractor>	not present	Catalog
IZw 1	00 53 34.9	+12 41 36	14.03	0.061	W-C-IC	<u>Image</u>	SExtractor>	not present	□ : Image □ : Catalog
I Zw 1	00 53 34.9	+12 41 36	14.03	0.061	W-J-V	<u>Image</u>	SExtractor>	not present	Catalog
IZw 1 完了	00 53	+12 41	14.03	0.061	W-S-Z+	<u>Image</u>	SExtractor>	not	
完了									

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SuprimeCam QSO Fields

- Three wide band filters, Exposure > 1000 sec
- ~60 out of 1599 fields (17 Fields alanlyzed)
- ~700 out of 108080 QSOs/AGNs (100 QSOs/AGNs analyzed)



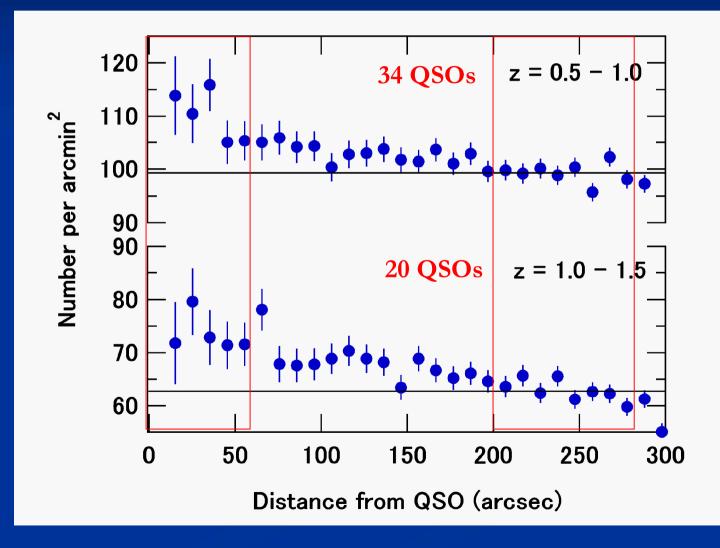
Number of QSOs in each field (#QSO>=3)

Field name	#filter	#QSO	Field name	#filter	#QSO
COSMOS	4	140	SXDF	-++ 3	6
LHNW	3	92	A2390	5	6
HDF	4	62	SSA13	4	5
F1052N	3	50	NGC4486_1	3	5
J0053+1234	3	19	F0230W	3	5
F1052S	3	19	Chandra deep	3	5
MS2054	3	17	2309-00	3	5
Lynx	3	12	M51	3	5
RXJ0153	4	12	NGC2419	3	4
Daddi	3	11	z5qsos	3	4
GRB030723	4	10	F0848W	3	4
SDSS J0338+0021	4	10	CL1604_3	3	4
SXDS_1	5	8	CL1604_2	3	3
SDSSp J 104433.0	4	8	CL1604_5	3	3
MS0451.6-0305	3	8	CL1604_4	4	3
XMM_deep	3	6	0918+06	3	3
MS0016	5	6	0127-00	3	3
SIRTF HDF-N Field	4	6	CL1604_8	3	3
F0230E	3	6	NGC4486_3	3	3

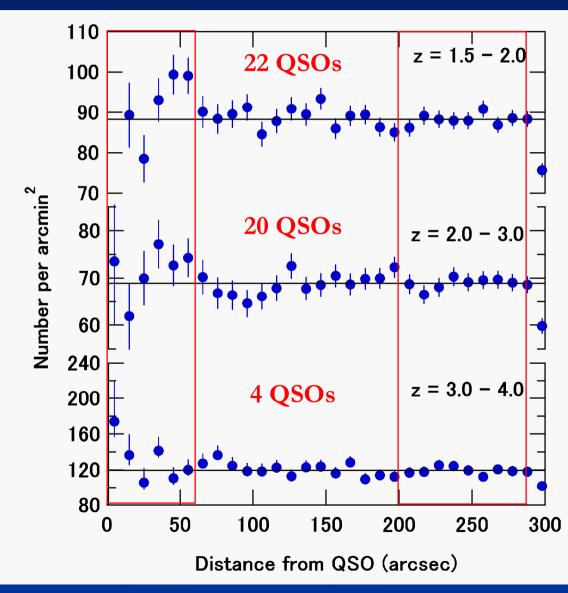
Analysis

Reject images whose coverage is less than 50% of 10x10 armin² area centered at QSO position. Check if there are at least three-bands images. Source Catalog around QSOs (SExtractor) Calculate redshift probability P(z) (HyperZ) Select objects with $P(z_{OSO}) > 0.5$ Radial distribution. (dead pix, bright objects) Spatial QSO-Galaxy cross-correlation amplitude Bg

Average Radial Profile for $z = 0.5 \sim 1.5$



Average Radial Profile for $z = 1.5 \sim 4.0$



Spatial QSO-Galaxy cross-correlation amplitude B_{gq}

Number density of Galaxy at a distance r from a QSO

$$n(r)\delta V = \rho_g [1 + \xi_{qg}(r)]\delta V$$

Average Number density of Galaxy at QSO redshift

$$\xi_{qg}(r) = B_{gq}r^{-\gamma}$$

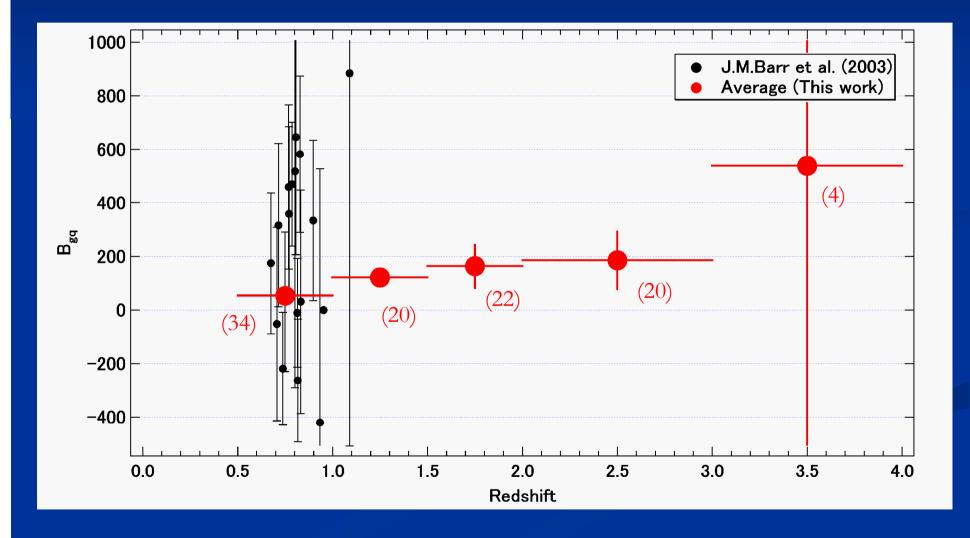
Total Number within 60 arcsec (0.5 Mpc)

Number expected from BG region (200~280 arcsec)

$$B_{gq} = \frac{3 - \gamma}{2\pi} \frac{N_{tot} - N_{bg}}{\phi(m_{lim}, z)I_{\gamma}} (0.5 \text{Mpc})^{\gamma - 3}$$

Number density brighter than limiting magnitude at QSO redshift

B_{gq} vs Redshift



Summary

Data discovery of deep images around known QSOs is easily achieved. ■ 700 QSOs are imaged by Subaru SuprimeCam ■ 100 QSOs are analyzed. \blacksquare B_{gq} is derived for z = 0.5 ~ 4.0 • Tendency of increase of B_{gq} at higher redshifts ■ Clustering seems to be significant for M < -25 **Future** Work ■ Analyze more data (only 20% of data is anlyzed) Incorporate IR data (Subaru MOIRCS etc.) Better Photometric redshift estimate. Early type galaxies.