Extended emission around CFHQSOJ2329+0301 at z=6.4

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Why QSO host galaxies are important?

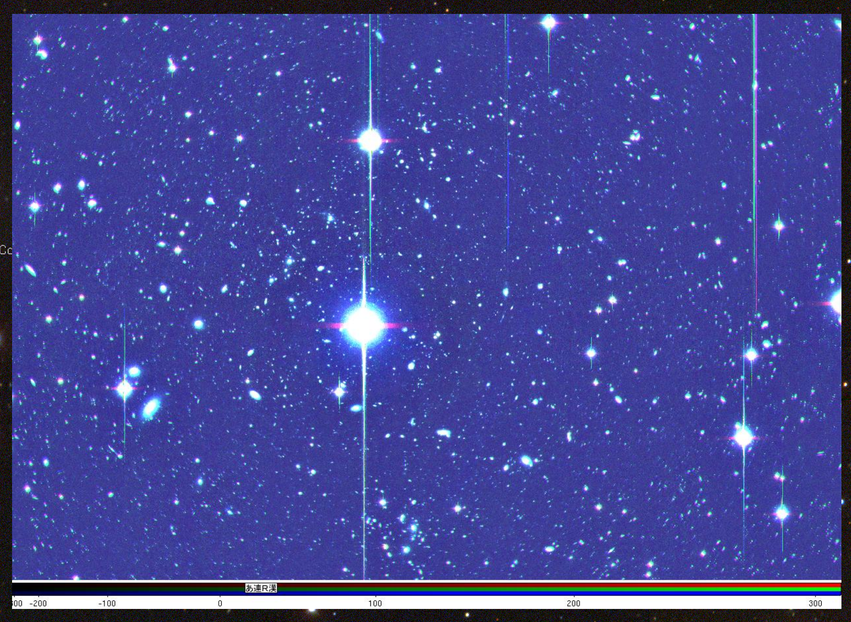
- M_{BH} – M_{bulge} relation: Most low z spheroidal galaxies have SMBH
- Many starburst galaxies and AGN co-exist (Heckman+ 2006).

→ 'Causal connection between SMBH and galaxy formation'
A key to understand AGN/galaxy formation.

However, no QSO host galaxy has been detected at z>6.
z～6 host galaxies are faint: z～26mag, and small, R_e=0.15"(1.5kpc; Bouwens+2004). Next to bright QSO: z～20mag

Pioneering attempt by Hutchings et al.(2005) with Gemini, did not resolve QSO hosts at z=6.23 and 6.35.
HST images of 4 QSOs did not show hosts (Richard+2004)

Subaru S-Cam imaging



Limiting magnitude
i':26.73
z':25.79
z_R:25.09
PSF ～0.5"

Radial profile

z' *zR*

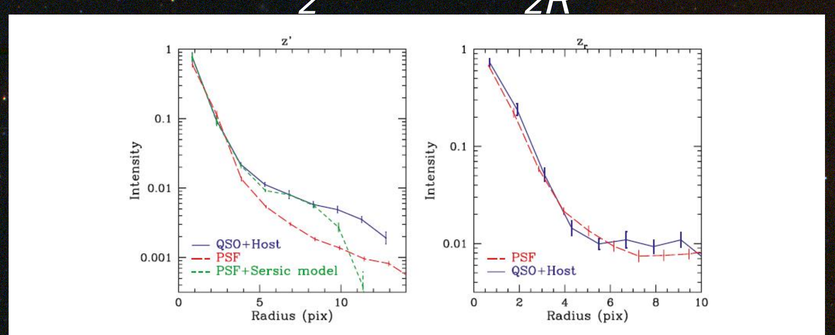
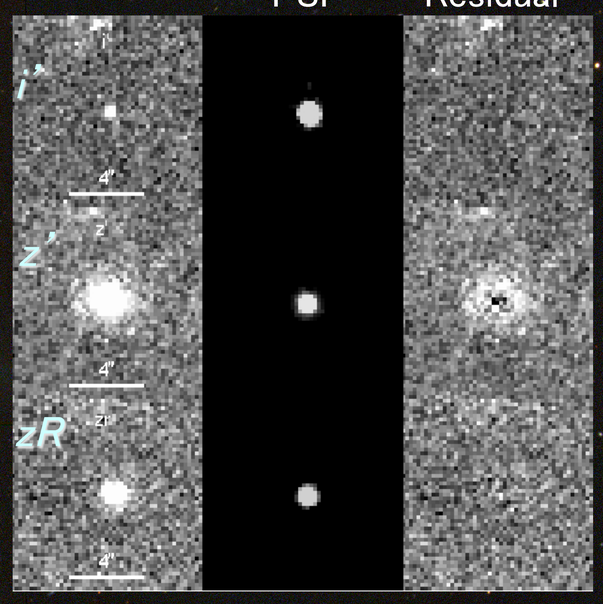


Figure 3. Radial profiles of QSO+host (blue solid line), the constructed PSF (red dashed line) and the PSF+Sérsic model (green short-dashed line) in the z' band (left). The right-hand panel is for the z_r band. Profiles are normalized at a maximum value. The pixel scale is 0.2 arcsec pixel^{-1}.

PSF subtraction



zR-band residual: 3σ

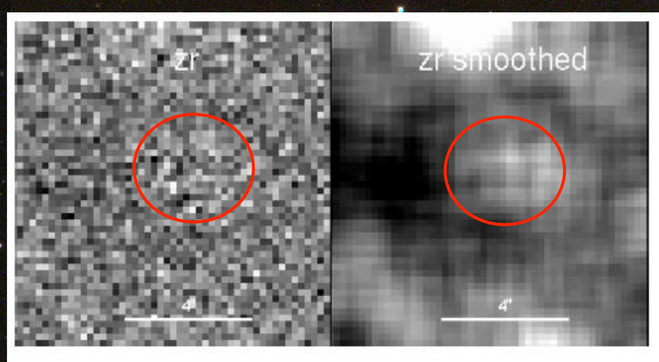


Figure 4. Both panels show residuals from the PSF subtraction in the z_r band. The right-hand panel is box-car smoothed with 10 pixel. The figures are north up, east left.

SED

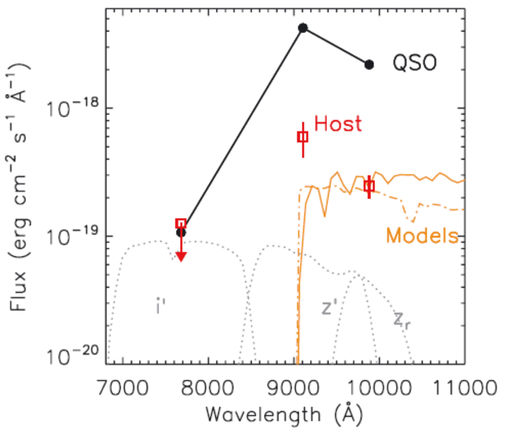


Figure 5. SEDs of QSO and its host galaxy. Overplotted are SED models of constant SFR and delta starburst with 100 Myr of age. The host is not detected in i' band, where 1σ upper limit is shown.

- 40% of z' light is from continuum
- 60% is from Ly α emission

Properties
- → M_{1450A}=-23.9
- → *Re*>11kpc
- → SFR(Ly α)>1.6 M_{sun}/yr
- → Or illuminated by QSO

Table 3. Magnitudes and results of the fit.

Object	i'_{AB}	z'_{AB}	z_{rAB}
QSO+host	25.54 ± 0.02	21.165 ± 0.003	21.683 ± 0.007
Host	>25.34 (1σ limit)	23.5 ± 0.3 (16σ)	24.3 ± 0.2 (3σ)
1σ sky	25.44 (26 pixel diameter)	24.90 (26 pixel diameter)	25.46 (18 pixel diameter)

Followup spectroscopy with Keck/DEIMOS

Table 2. Properties of Lyα emission from the extended region.

FWHM (Å)	Flux (erg cm$^{-2}s^{-1}$Å^{-1})	Luminosity (erg s^{-1})	Velocity Dispersion$_{rest}$ (km s^{-1})
21±7	(3.6±0.2) ×10^{-17}	(2.3±0.1)×10^{43}	301±99

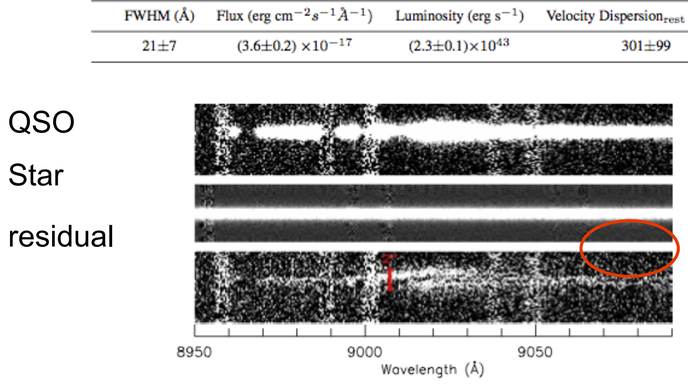


Figure 1. Subtracting stellar spectrum from QSO spectrum. The top panel shows the QSO spectrum. The middle panel is a reference PSF stellar spectrum. The bottom panel shows the residuals from the subtraction of the PSF spectrum and the smooth extended component from the QSO spectrum. Pixel scale in spatial direction is 0.1185" pix^{-1}.

1D spectra

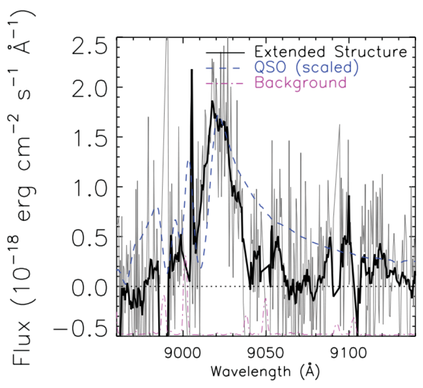


Figure 4. 1D spectra of the extended region of CFHQS J232908.28−030158.8 after subtracting the central QSO. The grey line shows the spectrum in the original resolution. The black line shows the binned spectrum with a 10-pixel box. The magenta dot–dashed lines show the sky spectrum in an arbitrary unit. The blue dotted line shows the arbitrary-scaled spectrum of the QSO.

Cutout at Ly α wavelength

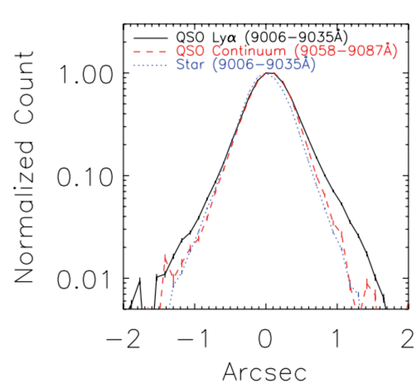


Figure 3. Comparison of the spatial profiles of the QSO spectrum over the Lyα line between 9006 and 9035 Å (black solid line), and over the continuum between 9058 and 9087 Å (red dotted line). The blue dotted line shows the spatial profile of a star between 9006 and 9035Å.

Summary

We found the most distant Lyα blob around QSO (R_e>11kpc) at z=6.4, and a possible extended continuum emission. These results present an important example that a super-massive black hole may resides in a large galaxy even in the early epoch when the Universe is ~840 Myr old. Quantifying the QSO host and fraction of ionized gas in more detail will provide us with an important constraint on how galaxies and AGN form in the early Universe, such as gas fraction, AGN geometry and covering factors.

References
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