The X-ray properties of z~6 quasars

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High-z QSOs: how many?

259 detected QSOs at $z \geq 5.5$

Decarli et al. 2018

Fan et al. 2012
Optical/NIR spectral properties

ULAS J1342 at $z \sim 7.5$

Bañados et al. 2018

ULAS J1120 at $z \sim 7.1$

Barnett et al. 2015
259 QSOs at $z > 5.5$

37 QSOs observed in X-ray
(20 by Chandra, 10 by XMM-Newton, 6 by both, 1 by Swift)

19 QSOs X-ray detected
Few X-ray spectra measured: similar to lower-z objects

\[ N(E) \propto E^{-\Gamma} \]

\[ 1.6 < \Gamma < 2.4 \]

(see also Farrah et al. 2004; Moretti et al 2014; Page et al. 2014; Gallerani et al. 2016)
X-ray spectral properties

- Just et al. 2007
- Vignali et al. 2005
- Shemmer et al. 2006
- Nanni et al. 2017
BH formation: simulations

Masses from $10^8$ to $10^{10} \, M_{\odot}$

Early SMBHs most likely form in the most overdense regions with extension up to 10 pMpc
(e.g., Overzier et al. 2009; Costa et al. 2014; Barai et al. 2017)
The evidence of overdense regions around $z\sim 6$ QSOs is unclear. (e.g., Stiavelli et al. 2005; Willott et al. 2005; Kim et al. 2009; Mazzucchelli et al. 2017)

Problem related to small scale observations? AGN feedback?
iJ1030+0524 X-ray field

Chandra image (0.5-7 keV), ~500ks, >220 detections
Chandra observation

Jan-May 2017, Cycle 17

![Graph showing exposure time vs redshift (Z)]
~125 photons detected in 0.5-7 keV band
$\Gamma = 1.81 \pm 0.18$

J1030 X-ray spectrum

Nanni et al. 2018

SDSSJ1030+0524 ($z=6.31$)
J1030 X-ray variability

Nanni et al. 2018

\[ f_{0.5-7\text{ keV}} = (9.8^{+0.4}_{-1.2}) \cdot 10^{-15} \text{ erg/s/cm}^2 \]

\[ f_{0.5-7\text{ keV}} = (4.0^{+0.2}_{-0.8}) \cdot 10^{-15} \text{ erg/s/cm}^2 \]
The southward diffuse emission: QSO feedback?

Nanni et al. 2018

\[ \text{SNR} \sim 6, \quad L_{2-10 \text{ keV}} = 5 \times 10^{44} \text{ erg s}^{-1} \]
Conclusions

1) X-ray/optical/NIR properties do not significantly evolve through the passing of time, so the interplay between the disk and hot corona is already in place at \( z \sim 6 \)

2) J1030 is the first evidence of a variable AGN in the primordial Universe

3) Evidence of diffuse emission southward the QSO: AGN feedback?

4) The J1030 deep-field is likely the best place to study the properties and environment of \( z \sim 6 \) SMBHs
Do you want to collaborate with us or just be updated on this work?

Visit: http://www.oabo.inaf.it/~LBTz6/1030/

Thanks for the attention!