Observational constrains on the physical conditions of SMBH growth

Antonis Georgakakis (MPE, Athens Observatory) P.G. Perez-Gonzalez, N. Fanidakis, M. Salvato, H. Messias and the AEGIS collaboration

The physics of AGN evolution



- Rapid decline since $z \sim 1$
- Broad plateau at z~1-3
- What is the physical process driving this evolution?
 - Smaller BHs at lower redshift
 - Decreasing accretion rate
 - Decline of gaseous mergers
 - Different accretion modes at different epochs

Johannes Buchner et al. in prep.: AGN evolution including <u>Compton Thick</u> sources also Buchner et al. 2014, A&A, 564, 125

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Black hole fuelling modes to z=1: large Scale Clustering of AGN



GALFORM Semi Analytic Model: Fanidakis+11, 12

Black hole fuelling modes at z=0



Kauffmann & Heckman 2009

But not at z~1 (Aird+12, Bongiorno+12)

UVJ diagram



Multi-wavelength surveys

- AEGIS-XD, CDFS-4Ms C-COSMOS:
- ✓ Chandra X-ray
- ✓ Optical/near-IR SEDs
- ✓ Large spec-z surveys
- ✓ HST (morphology)
- ✓ Spitzer mid/far-IR
- ✓ Herschel far-IR
- ✓ Sub-mm
- ✓ Radio (1.4GHz)





X-ray data re-analysed in a homogeneous way using methods described in Laird+09

X-ray AGN UVJ diagram



Contours: galaxies Red symbols: X-ray AGN in passive part of UVJ diagram Blue symbols: X-ray AGN in SF part of UVJ diagram Crosses: Broad-line AGN

X-ray AGN UVJ diagram

Quiescent AGN hosts: mostly bulges



Star-forming AGN hosts: 50% disks

Eddington ratio distributions



 $M_{\rm BH}$ =0.002* $M_{\rm Bulge}$ (local scaling relation), $M_{\rm bulge}$ ~ $M_{\rm Star}$ for bulges $M_{\rm bulge}$ ~0.5* $M_{\rm Star}$ for disks (i.e. typical for Sbc galaxies)

Accretion density split into quiescent and star-forming hosts



Bulk of accretion density associated with star-formation

Quiescent hosts: 15-20% of accretion density independent of redshift

Georgakakis et al., 2014, MNRAS, 440, 339

XMM/SDSS: serendipitous X-ray survey at *z*<0.2

XMM/SDSS survey

- Public XMM data within the SDSS
- Area: ~120deg²
- $f_{\chi}(0.5-2\text{keV}) \sim 10^{-15} \text{cgs}$
- ~40,000 X-ray sources

Extension

- >1000 X-ray AGN with spec-z<0.2
- UKIDSS-LAS: YJHK
 band photometry



Georgakakis & Nandra 2011

Future: eROSITA All Sky Survey

AGN population studies

- 3x10⁶ AGN
- $-f_{\chi}(0.5-2\text{keV})\sim 10^{-14}$
- In combination with large multi-λ surveys



Merloni+12; Kolodzig+13a, b



Subaru-Elv<35deg

MPE(D)

Summary

- Evidence for two BH accretion modes to $z\sim 1$
 - Star-forming hosts, include 50% disks, dominate at high Eddington ratios
 - Quiescent hosts, bulges, become important at low Eddington ratios.
- 15-20% of the accretion density at z<1 is associated with quiescent host. This fraction does not evolve with redshift

Accretion density: Galform Semi-Analytic Model comparison



- Bulk of accretion density associated with star-formation
- Quiescent hosts: 15-20% of accretion density independent of redshift

XLF split into quiescent and star-forming hosts







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