Hiding in Plain Sight
AGN Echoes of Low-Redshift Lyman Alpha Blobs

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take-home themes

- AGN duty cycle
- Lyman alpha blobs in the local Universe
discovery of [OIII] luminous, extended emission

- CFHT/Megaprime $gri$ image
- $z = 0.326$
- $8 \times 18$ kpc cloud extent
- green colors, similar to “green peas” but larger
- $[\text{O III}]$ luminosity $= 5.6 \times 10^{43}$ erg/s
- extended narrow-line region
- AGN diagnostic line ratios in spectrum

Schirmer+ 2013
sample of 17 objects

- selected in SDSS for color and size
- spectroscopy to confirm AGN nature and luminous [O III] \((\gtrsim 10^{43} \text{ erg/s})\)
- galaxy-scale emission line regions 15–20 kpc
- \(z \sim 0.3\)
  - sensitive to \(z = 0.12\), but lowest \(z = 0.19\)
- typically radio quiet
- rare
  - 1 per 1000 deg\(^2\)
- not viewing AGN continuum directly
under-luminous in MIR compared with [O III]

still mid-infrared luminous
one example in the Chandra archive

- Compton thick
- strong Fe Kα line
- flat continuum (reprocessed)
new Chandra observations of 10 galaxies

- predicted X-ray flux based on IR-X-ray correlation
- considered possibility of Compton thick to set exposure times
- all galaxies detected, but faint 10–20 times weaker than predicted
- no significant spectroscopy possible typically flat hardness ratios

Ichikawa+ 2012
AGN power source, with unusual features

**properties**
- [O III]: extremely luminous
- IR: luminous, but lower than usual [O III] relations
- X-ray: faint

**response timescale**
- light-crossing time > $10^4$ years
- thermal response $\sim 10^3$ years
- $\sim$ intrinsic

**AGN duty cycle**

thermal + ionization echoes:
AGN faded by factors of $10^3$–$10^4$
over last 10,000 to 100,000 years
high-z Lyman alpha blobs

- typical Ly$\alpha$ luminosity $10^{42} - 10^{44}$ erg/s
- 20–200 kpc scales
- $z \gtrsim 2$
- direct optical detection of rest-frame Ly$\alpha$
- sites of massive galaxy formation
- ionization escapes host

What is the ionizing source?

- (buried) photoionization – AGN or starburst?
- shock – starburst superwind?
- collisional – collapse of dark matter haloes?
Lyman alpha in GALEX band

Effective Area [cm^2]

Wavelength [Å]

1300  1400  1500  1600  1700  1800

GALEX FUV

redshifted Lyα
Lyman alpha detected and strong

14/15 observed sources detected
Is it Lyman alpha?
Consider other sources of UV emission:
  stars? nebular continuum?

estimate 75% observed flux is Lyman alpha

typical luminosities > $10^{43}$ erg/s
  similar to Lyman alpha blobs
low-z Lyman alpha blob differences

extended ionization regions, but smaller
low-z Lyman alpha blob differences

lower density environments
isolated, or small groups
masses $\leq 10^{13} M_\odot$, not $10^{15} M_\odot$
low-z Lyman alpha blob differences

evolution

- regular “LABs” gone by $z=0.3$
- comoving density here much lower - 3.3 Gpc$^{-3}$
  - these aren’t the same objects
- suggest these evolve like AGN
Lyman alpha emission

- useful to study physical processes, not direct analogs
- Lyman alpha emission lags ionization multiple scatterings to escape timescales up to $10^6$ years
- Lyman alpha emission can be spatially broader than UV continuum

Yang+ 2017
conclusions and next steps

• ionization and thermal echoes indicate AGN duty cycle

• need more measurements to be quantitative e.g., corresponding unobscured sources, which are missed by selection criteria

• caution: offset in MIR-X-ray relation does not imply obscuration

• Lyman alpha also lags AGN cycle

• physical processes of Lyman alpha blobs available for detailed study

• but not direct examples, given differences in environment, evolution, and ionizing source