Weak Winds in AGN host galaxies at $z \sim 1$

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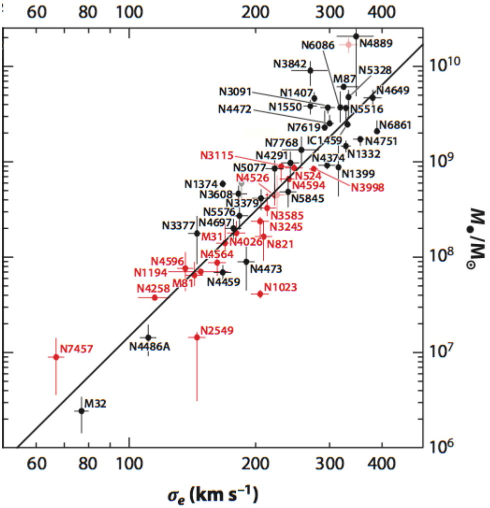
Raise your hand if your answer is NO

- Question: are the wind velocities of AGNs at $z \sim 1$ significantly different from non-AGNs ?
- Data: CANDELS Survey & deep Keck DEIMOS restframe NUV spectroscopy

Does the observed $M - \sigma$ relation mean causation ?

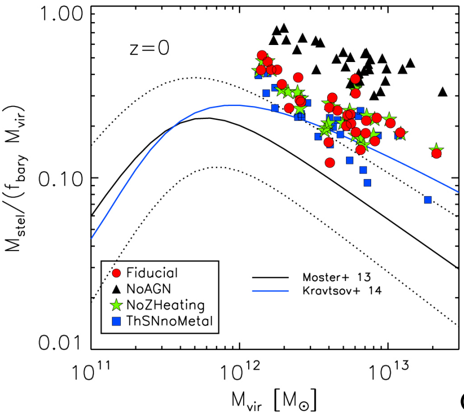
- Possible co-evolution of black holes and their host galaxies.
- The correlation arises as AGN-triggered outflows limit the gas reservoir for spheroid star formation (Silk & Rees, 1998; Silk, 2005; Murray et al., 2005).

Kormendy & Ho (2013)



AGN feedback is an essential component of current galaxy formation and evolution theory

- Complex physics govern gas and stars in galaxies.
- Without AGN feedback the star-formation rate efficiency is too high.



Choi et al. (2017); Silk & Rees

The Horizon-AGN cosmological simulation

- Cosmic gas accretion and galaxy mergers determine galaxy morphology; Without AGN feedback galaxies reform discs.

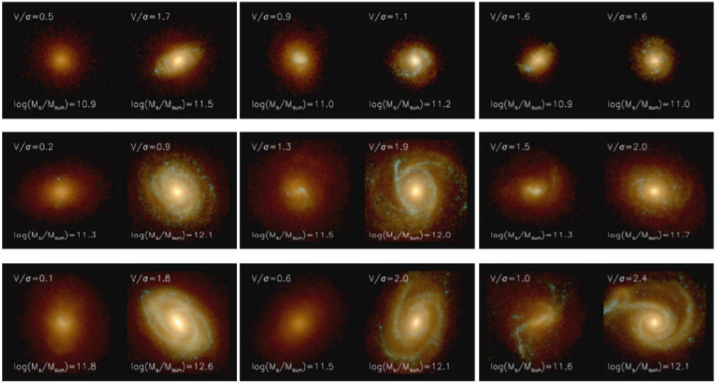
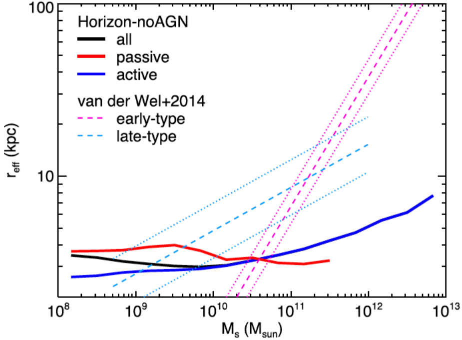
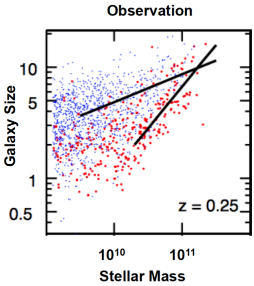


Figure: Column 1, 3 & 5 with AGN feedback; Column 2, 4 & 6 with NO AGN feedback (Dubois et al., 2016)

Without AGN feedback the Horizon-AGN simulation fails to reproduce CANDELS data.

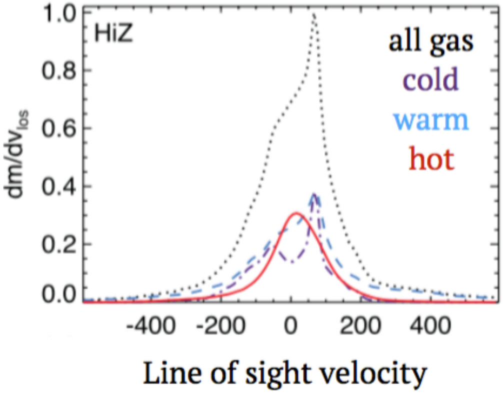




van der Wel et al. (2014)
Dubois et al. (2016)

Velocity distribution of starformation-driven winds

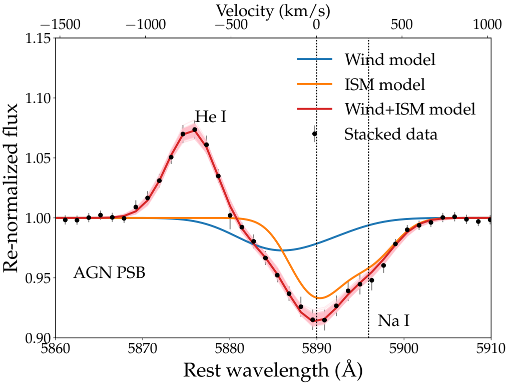
- pc-scale resolution simulations with detailed models for stellar feedback that self-consistently generate winds.



Hopkins et al. (2013)

Weak AGN winds at $z \sim 0.1$

- Local AGN winds, detected in Na I doublet absorption, have moderate outflow velocities $\sim 100 - 300$ km/s and are similar to star-formation-driven winds (e.g., in my talk at the galaxy workshop you will hear more on the figure below.)



Weak AGN winds in distant galaxies ?

- Absorption lines studies of winds are hard and expensive to undertake in distant galaxies.
- Coil et al. (2011) studied 10 $z = 0.2 - 0.5$ AGNs: $v \sim -200$ km/s
- Hainline et al. (2011) stacked 33 $z \sim 2 - 3$ AGNs: $v \sim -850$ km/s

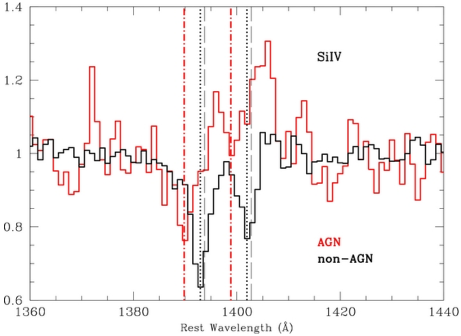


Figure: AGN and non-AGN Lyman break galaxies (Hainline et al., 2011).

X-ray AGNs at $z \sim 1$ selected for the wind study

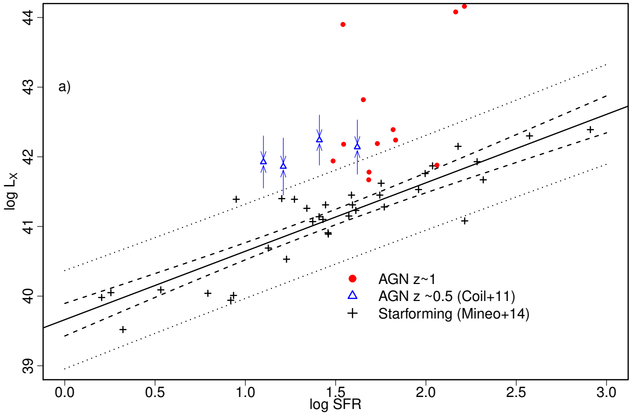


Figure: Starformation rate versus X-ray luminosity

AGNs are matched in mass, axis ratio, & redshift

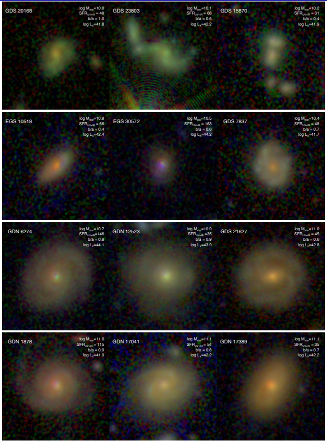


Figure: False RGB images of AGNs

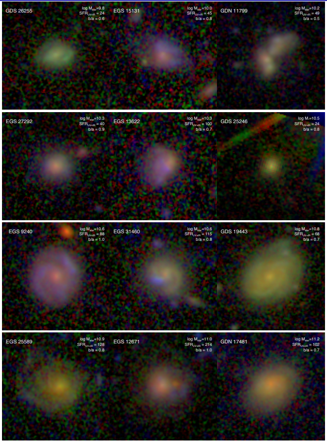
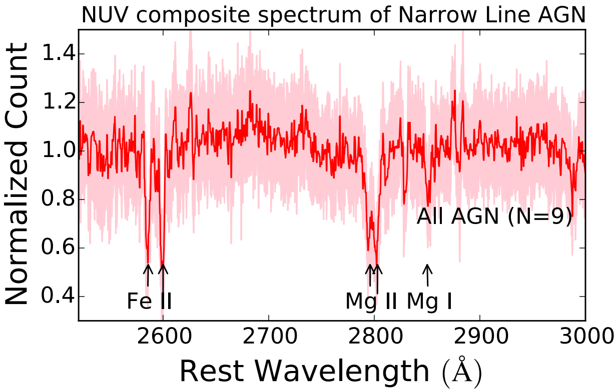


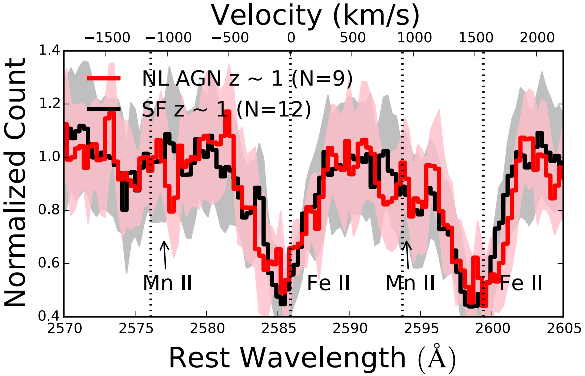
Figure: Star-forming galaxies

Deep Keck near UV average spectrum of AGNs at $z \sim 1$

- 9 Narrow-line AGN, total of $\sim$ 70 hours of Keck !



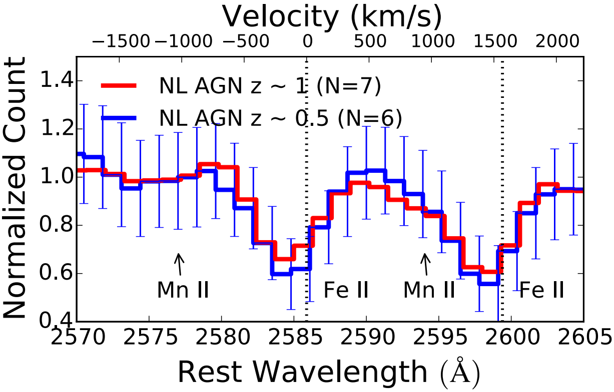
Comparison with star-forming galaxies at $z \sim 1$: unexceptional wind velocities in AGNs



- Fe II $\lambda 2586$ is more reliable.
- Mean velocity $v \sim -100$ km/s
- Velocity dispersion $\sigma \sim 115$ km/s
- Escape velocity $v_e \sim 600$ km/s

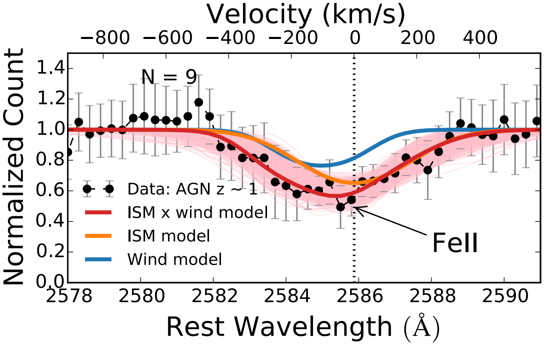
Figure: Black: X-ray undetected star-forming galaxies. Red: narrow line AGNs

Comparison with AGNs at $z \sim 0.5$



For z $\sim$ 0.5 see Coil et al. (2011)

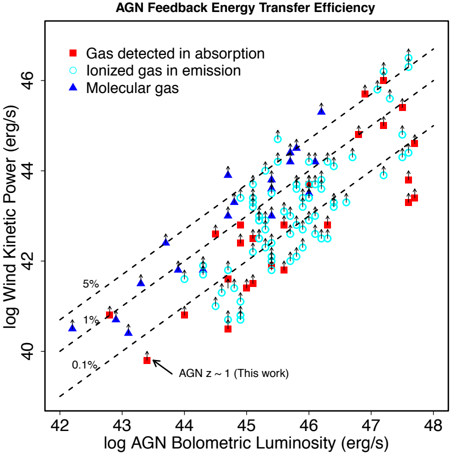
The two-component wind model



- Mean velocity posterior density has : $v_{50\%} = -109$ km/s $v_{84\%} = -238$ km/s
- Wind: 0.5 Å
- ISM: 1.3 Å
- There is still $(> 10^9\,?) M_\odot$) cool gas in the host galaxies.

For model details see Yesuf et al. (2017); Rupke et al. (2005)

Limits on feedback efficiency: $L_w = \epsilon L_{AGN}$



Section 3: Summary & conclusions

- The first AGN winds study of 12 low-luminosity AGN at $z \sim 1$, near the peak of cosmic activity for both AGN and SF galaxies.
- The centroid velocity shift in the composite spectrum of these AGN is $-109\,\mathrm{km\,s^{-1}}$ and its velocity dispersion is $115\,\mathrm{km\,s^{-1}}$.
- The wind velocities in the AGN are significantly lower than their escape velocities ($\sim 600\,\mathrm{km\,s^{-1}}$).
- The wind velocities in AGN are similar to those observed in star-forming non-AGN galaxies at a similar redshift.
- There is also strong ISM component in Fe II $\lambda2586$, implying substantial amount cold gas is present in the host galaxies.
- Thus, we do not find evidence for wind-mode AGN feedback in low-luminosity AGN host galaxies.

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