AGN-enhanced outflows of low-ionization gas in star-forming galaxies at 1.7<z<4.6

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*The Galaxy Ecosystem*
*Flows of Baryons through Galaxies*
*Munich, 24-28 July 2017*
Large scale gas outflows

WHAT?  Large-scale gas flows moving out from galaxies.

**Starburst-driven**

→ Massive stars end their lives exploding like Supernovae
→ The explosion causes a *shock* in the surrounding ISM

**AGN-driven**

→ Much of the energy released during accretion may be tapped to drive a galactic wind; this can occur through several processes not yet fully understood

→ An expanding *shell* of perturbated gas forms
→ The *bubble* may succeed in getting the gas into the IGM

WHY?  - IGM metal enrichment
       - Influence on the chemical evolution of the host galaxy
       - Star Formation quenching

HOW?  - ...
CO & [CII] emission lines (molecular phase) [e.g. Cicone+’14]
Optical emission lines (ionized phase) [e.g. Brusa+’15, Perna+’15, Cicone+’16]
UV absorption lines (neutral/low-ionized phase) [e.g. Shapley+’03, Hainline+’11, Talia+’12, Cimatti+’13]

Stacked spectrum of 74 SFGs at z=2

Talia et al. 2012

Stellar photospheric absorption lines
Nebular emission lines
Low-ionization IS absorption lines
High-ionization IS absorption lines
Which is the driving mechanism of the outflow?

**UV absorption lines**

**Velocities**
- ~ 70-100 km/s in SFGs (e.g. Shapley+'03, Weiner+'09, Talia+'12)
- ~ 600-800 km/s in AGN (e.g. Hainline+'11, Cimatti+'13)

![Graph showing UV absorption lines and velocities in SFGs and AGN](image1.png)

1.7<z<3.0
AGN (X-ray, no em. lines)
non-AGN

![Graph showing absorption features in AGN and non-AGN](image2.png)
Which is the driving mechanism of the outflow?

**UV absorption lines**

**Velocities**

- **70-100 km/s** in SFGs
  (e.g. Shapley+'03, Weiner+'09, Talia+'12, Cicone+'16)
- **600-800 km/s** in AGN
  (e.g. Hainline+'11, Cimatti+'13)

**Similar trend in all the phases of the outflow:**
Neutral, Ionized, and Molecular
(at $z > 1.5$)

(e.g. Förster Schreiber+'13, Cicone+'15, Brusa+'15, Harrison+'16) // (Cicone+'14, Yesuf+'17, Concas+,17)

AGN (X-ray, no em. lines)
non-AGN

Hainline+'11

Cimatti+'13
**The Data**

GOODS-South + COSMOS fields

$K < 24$

[Grazian+'06, Ilbert+'13]

$1.7 < z < 4.6$

AGN identification based on X-ray from CHANDRA:

CDFS 7Ms

COSMOS-Legacy

[Luo+'17, Civano+'16, Marchesi+'16]

~ 1400 spectra from:

VUDS

Public ESO Surveys

zCOSMOS

[Szokoly+'04, Mignoli+'05, Lilly+'07, Vanzella+'08, Popesso+'09, Silverman+'10, Trump+'09, Kurk+'13, Le Fevre+'15]
SFGs vs. AGN

- Individually detected X-ray AGN
- Total SFGs sample

Wavelength [Å]
SFGs vs. AGN

SFGs in the same mass range of the AGN sample
$\lg(\text{Mass}) > 10.2$

Same result

AGN have, on average, lower SFR than SFGs (at fixed stellar mass)

SF cannot be the only driver of the outflow
Dependence of $\Delta v$ on $L_x$?

- $\lg L_x > 43.6$
- $\lg L_x < 43.6$

X-ray AGN ($L_x > 10^{43.6}$ erg/s)
TY2 AGN ($L_x < 10^{43.9}$ erg/s)
TY2
Dependence of $\Delta v$ on $L_x$?

$\lg(L_x) \ [\text{erg/s}]$

$\Delta v \ [\text{km/s}]$

$F_\lambda \ [\text{arbitrary}]$

Wavelength [Å]

$X$–ray AGN ($L_x > 10^{43.6} \text{erg/s}$)

$SFGs$

$\lg(L_x > 43.6)$

$\lg(L_x < 43.6)$
Dependence of $\Delta v$ on $L_x$?

No dependence of outflow velocity on $L_x$.
Dependence of $\Delta v$ on $L_x$?

e.g. Perna et al. 2017, Zakamska & Greene (2014)

see talks by Perna, Concas
Summary

1) Outflows are faster in galaxies hosting an AGN w.r.t. “inactive” SFGs

2) In the AGN sample there is no dependence of outflow velocity on L_x

3) Different behavior of different gas outflow phases (?)
Summary

1) Outflows are faster in galaxies hosting an AGN w.r.t. “inactive” SFGs

2) In the AGN sample there is no dependence of outflow velocity on Lx

3) Different behavior of different gas outflow phases (?)

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