Fast outflows quenching star formation at high redshift

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Outflows

Evidence of outflows at high and low redshift but...

Evidence of AGN feedback?
Quasars $z \approx 2.4$

- A sample of 6 QSOs at $z = 2.3-2.5$
- SINFONI@VLT H-band
- Seeing limited resolution (0.5")
- $L_{\text{bol}} \approx 10^{46} - 10^{47}$ erg/s
- Broad [OIII]
  - (FWHM > 1000 km/s)
Kinematic analysis

- Spatially resolved [OIII] kinematical maps in 5/6 objects
- Velocity dispersion up to 900 km/s
- Outflow velocities 300-700 km/s
Ionized outflows
Ionized outflows

outflow model
Ionized outflows

Velocity maps confirm the presence of outflows

outflow model
Ionized outflows

Outflow rate

Molecular outflows in local AGN
(Cicone+14)

[OIII] outflows in Type 2 local AGN
(Harrison+14)

[OIII] outflows in z≈2.5 quasars

\[ \dot{M} \approx \frac{M_{outflow} v_{out}}{R_{out}} \]

Physical properties of outflows
-> only ionized gas is traced
Faint narrow [OIII]

Presence of a faint narrow [OIII] around the QSO
Faint narrow [O III]

Subtract broad (> 1000 km/s) [O III] component -> Outflows
Faint narrow [OIII]

Subtract broad (> 1000 km/s) [OIII] component  ->  Outflows

Faint narrow (≈ 150 km/s) [OIII] component
Subtract broad (> 1000 km/s) [OIII] component → Outflows

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Subtract broad (> 1000 km/s) [OIII] component -> Outflows

Faint narrow (≈ 150 km/s) [OIII] component -> Star formation?
Origin of narrow [OIII]?

K-band observations targeting Hα

SINFONI@VLT

Seeing limited resolution (0.6")
Origin of narrow [OIII]?

K-band observations targeting Hα

SINFONI@VLT

Seeing limited resolution (0.6")

Subtract broad Hα and outflow components
Origin of narrow [OIII]?
No [NII], upper limit on [NII]/Hα excludes AGN excitation → star formation!
Narrow Hα/[OIII] emission traces star formation and is anti-correlated with the presence of fast outflows!

Fast outflows “quench” star formation → feedback revealed!
Conclusions

- Ionized outflows sweep away gas in host galaxies
- Star formation is suppressed in the region affected by outflow processes
- Feedback mechanisms do not significantly depress star formation over the whole galaxy

Next Steps
- Improve outflow model to compare with our results
- Compare molecular and ionized outflows using future ALMA observations

SFR $\sim 180 M_\odot/yr$  
SFR $\sim 100 M_\odot/yr$