Extreme Gas Dynamics in z=2-3.5, Starburst-AGN Composite Galaxies

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Abstract

Understanding the intimate connection between Active Galactic Nuclei (AGN) activity and the evolution of galaxies is an important challenge in astronomy. Theoretical models predict star forming gas could be removed from the host galaxy through large-scale AGN driven outflows (e.g. Di Matteo 2005). Our IFU observations of seven starburst-AGN composite galaxies (z=2-3.5) show turbulent and high velocity [O III] λ4959,5007 gas across galaxy-wide scales; indicative of energetic outflows. It is likely that these will have an impact on the star formation in the galaxy.

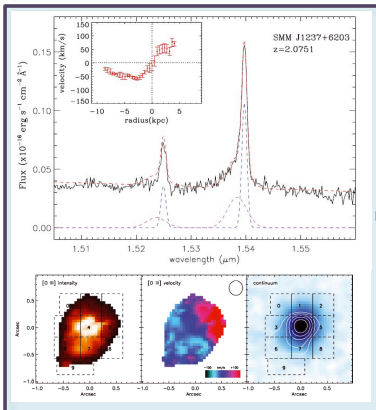

Fig. 1: IFU observations of SMMJ1237+6203 (Alexander et al. 2010). The collapsed, one-dimensional spectrum (top) shows both a broad and narrow [O III] component; the inset shows the narrow velocity field. Also shown is the [O III] morphology (left), narrow [O III] velocity map (middle) and continuum image (right). The contours represent the broad emission. The broad [O III] emission is de-coupled (v ≈ 300 km/s) from the host galaxy's rotation and detected over 8 kpc, indicating a galaxy-wide outflowing wind.

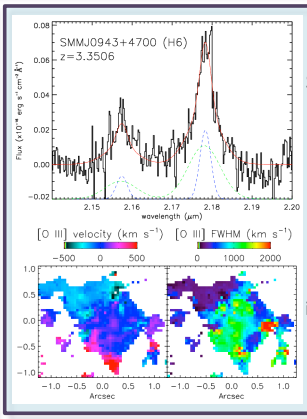

Fig. 2: IFU observations of SMMJ0943+4700. The collapsed, one-dimensional spectrum (top) shows both a broad (FWHM ≈ 1300 km/s) and narrow [O III] component. The velocity map (left) and FWHM map (right) shows the [O III] emission is complex and dynamic. There is extremely broad emission in the central regions with narrow emission in the top left. There are large velocity gradients (≈ 700 km/s) across the galaxy.

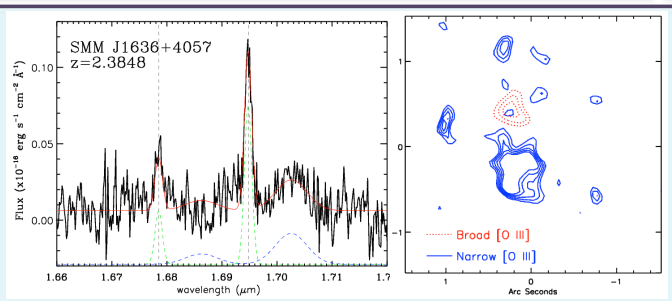

Fig. 3 : IFU observations of SMMJ1636+4057. The integrated spectrum (left) shows both a narrow and broad (FWHM ≈ 1200 km/s) [O III] component. This red-shifted (v ≈ 1400 km/s) broad component is unresolved and spatially offset from the brightest narrow emission (≈ 8 kpc) (contours in right panel). The narrow emission shows signs of tracing galaxy rotation while the broad emission could be an outflow.

Extreme dynamics: A large diversity is observed in the [O III] dynamics of infrared luminous galaxies that host AGN. Three of the seven objects are presented here (Fig. 1-3). Very broad (up to 1500 km/s) and high velocity (up to 1400 km/s) emission is seen across kpc scales. In most cases the broad emission is blue-shifted (e.g. Fig 1) with respect to the narrow emission but in two of our sample it is red-shifted (e.g. Fig. 3). Due to inclination effects we could be observing the near and far-sides of an outflow respectively.

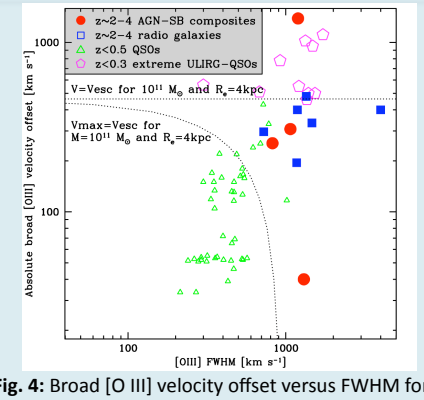

Fig. 4: Broad [O III] velocity offset versus FWHM for our highest quality one-dimensional IFU spectra (red dots), high redshift radio galaxies (Nesvadba et al. 2008), z < 0.3 ULIRGs (Zheng et al. 2002) and z < 0.5 quasars (Boroson 2005; Komossa et al. 2008). The dashed lines show the escape velocity for a massive galaxy at 4 kpc.

Impact on the host galaxy: The large velocities and widths of the extended [O III] emission observed suggest energetic outflows are disrupting the interstellar medium of the host galaxies. The *maximum* velocities (v_{max} = v + ½ FWHM) are often greater than the typical escape velocity of a massive galaxy; however, the velocity offsets are generally modest ($v < v_{esc}$; see Fig. 4).

Summary

- Our IFU observations show a large diversity in the [O III] dynamics of starburst-AGN composite galaxies at z=2-3.5.
- Broad, high velocity and spatially extended [O III] emission suggests outflowing gas in at least some of the sample.
- These outflows are disrupting the interstellar medium over kpc scales and could potentially shut down star formation in the host galaxy.

References

Alexander et al. 2010, MNRAS, 402, 2211 | Boroson 2005 AJ, 130, 381 | Di Matteo et al. 2005, Nat. 433, 604 |Komossa et al. 2008, ApJ, 680, 926 | Nesvadba et al. 2008, A&A, 491, 407 | Zheng et al. 2002, AJ, 124, 18