Does the jet in PG1700+518 drive a molecular outflow?

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Background and Motivation

Feedback from AGN could drive the co-evolution of supermassive black holes and their host galaxies but many aspects remain mysterious. We are investigating the multi-phase kiloparsec-scale outflows in a variety of type 1 AGN and present our initial results for PG 1700+518 as a case study of the direct impact of a radio jet on the interstellar medium of the host galaxy. Simulations of jets interacting with a multi-phase, clumpy disk suggest that they may ultimately suppress star formation via heating and ablation of dense clumps (Wagner & Bicknell 2011). Observational evidence for this kind of direct interaction has proven rare, but not completely elusive with examples of jet-driven molecular outflows like Mrk 231 (Rupke & Veilleux 2011) and IC 5063 (Tadhunter et al. 2014). New observational constraints are sorely needed.

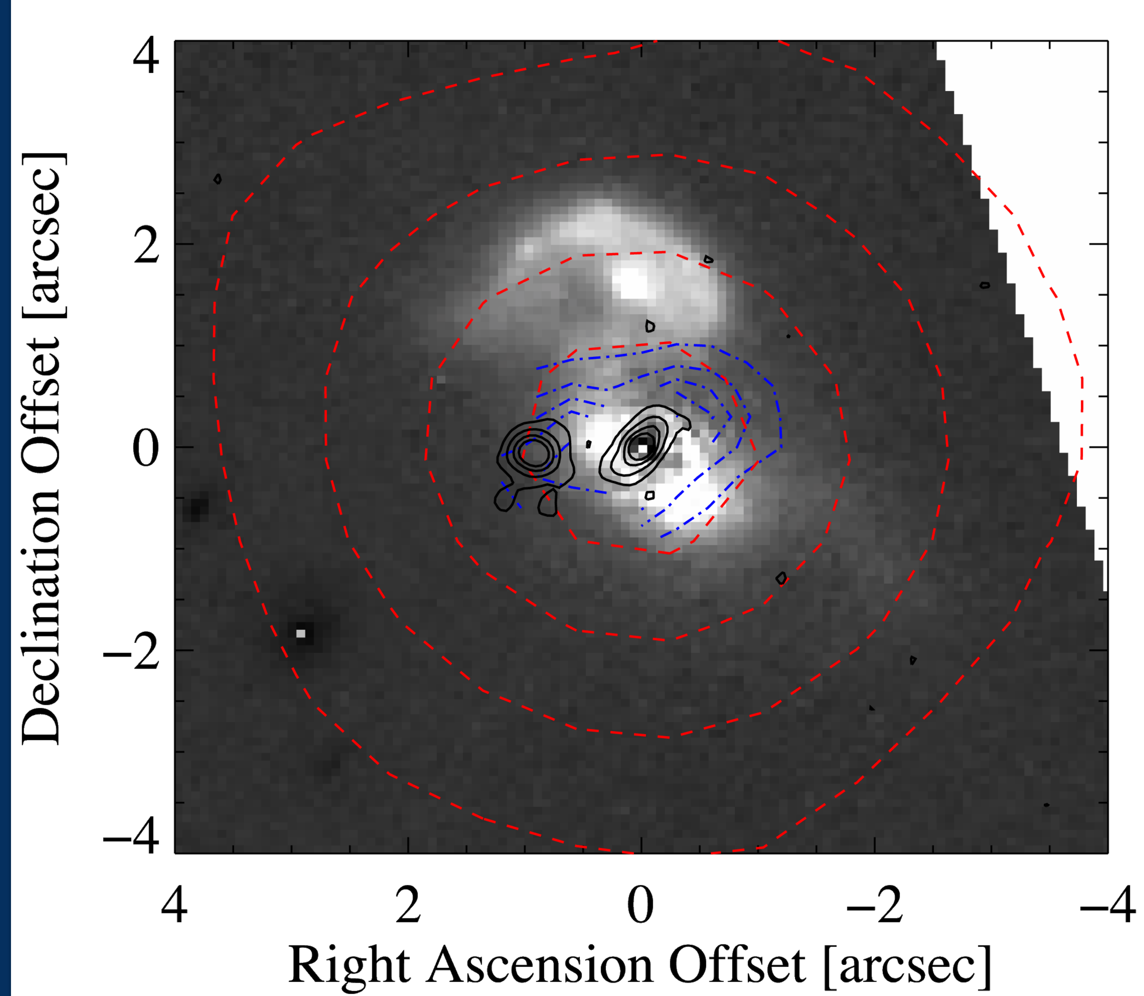


Figure 1 – The multi-wavelength view of PG 1700. The grayscale shows the wide H-band image from *HST*. The contours are VLA (solid black), IFS [O III] λ5007 (dashed-dotted blue), and NOEMA (dashed red). The western (right) VLA source has been resolved into a compact two-sided radio jet and radio core, with the jet axis along the direction of elongation.

PG 1700: a laboratory for jet-host interaction

PG 1700 (Fig. 1) presents an excellent opportunity to investigate how jets interact with AGN host galaxies in practice. PG 1700 is a 0.2902 redshift, type 1 Seyfert nucleus with high- and low-ionization broad absorption lines (Wampler 1985), hosted by a galaxy undergoing a merger with a nearby companion (Evans et al. 2009). It is X-ray weak and has a steep spectrum indicative of either absorption or a strong reflection component (Ballo et al. 2011). Radio observations show that it is radio quiet, with two sources resolved by the VLA at only at high frequencies (Kukula et al. 1998). Radio interferometry resolves the western (right) source into a radio core with a two-sided jet and resolves out the eastern source (Yang et al. 2012), which is likely an aging hotspot or redirected jet but not a background AGN.

PG 1700 has is a one-sided extended narrow-line region (Husemann et al. 2013). The IFS data cube was re-analyzed as part of our ongoing effort to characterize kiloparsec-scale outflows in type 1 AGN (Rupke et al. submitted; see Thurs. talk) and reveals a jet-driven outflow in ionized gas (Fig. 2). The nature of the low-velocity ionized gas is less clear.

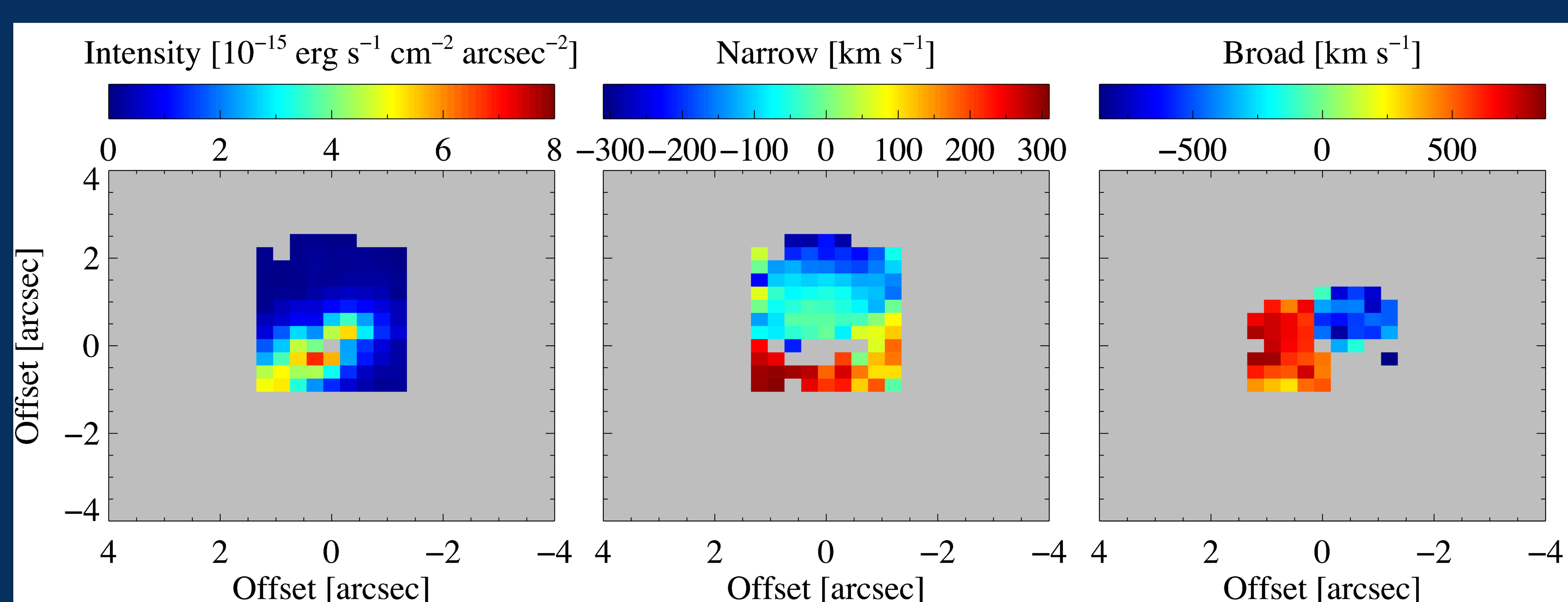


Figure 2 – Maps of the spatially resolved [O III] λ5007 from Rupke et al. (submitted, see Thurs. talk). Panels show the total flux, narrow, and broad peak velocity components. In these maps, up is 14 east of north. The [O III] flux traces the jet axis. The narrow velocity component may result from jet interaction, tidal motions, or a disk that is misaligned with the stellar bulge. The broad component shows an outflow driven by the jet.

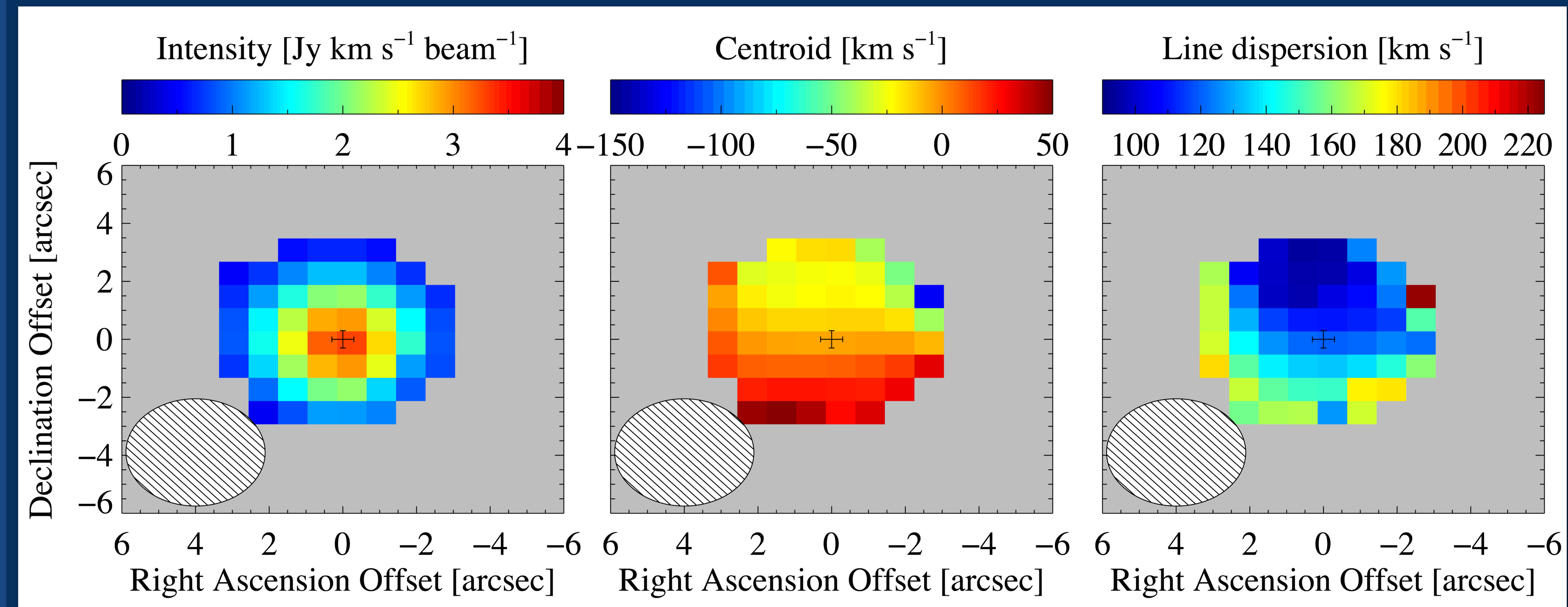


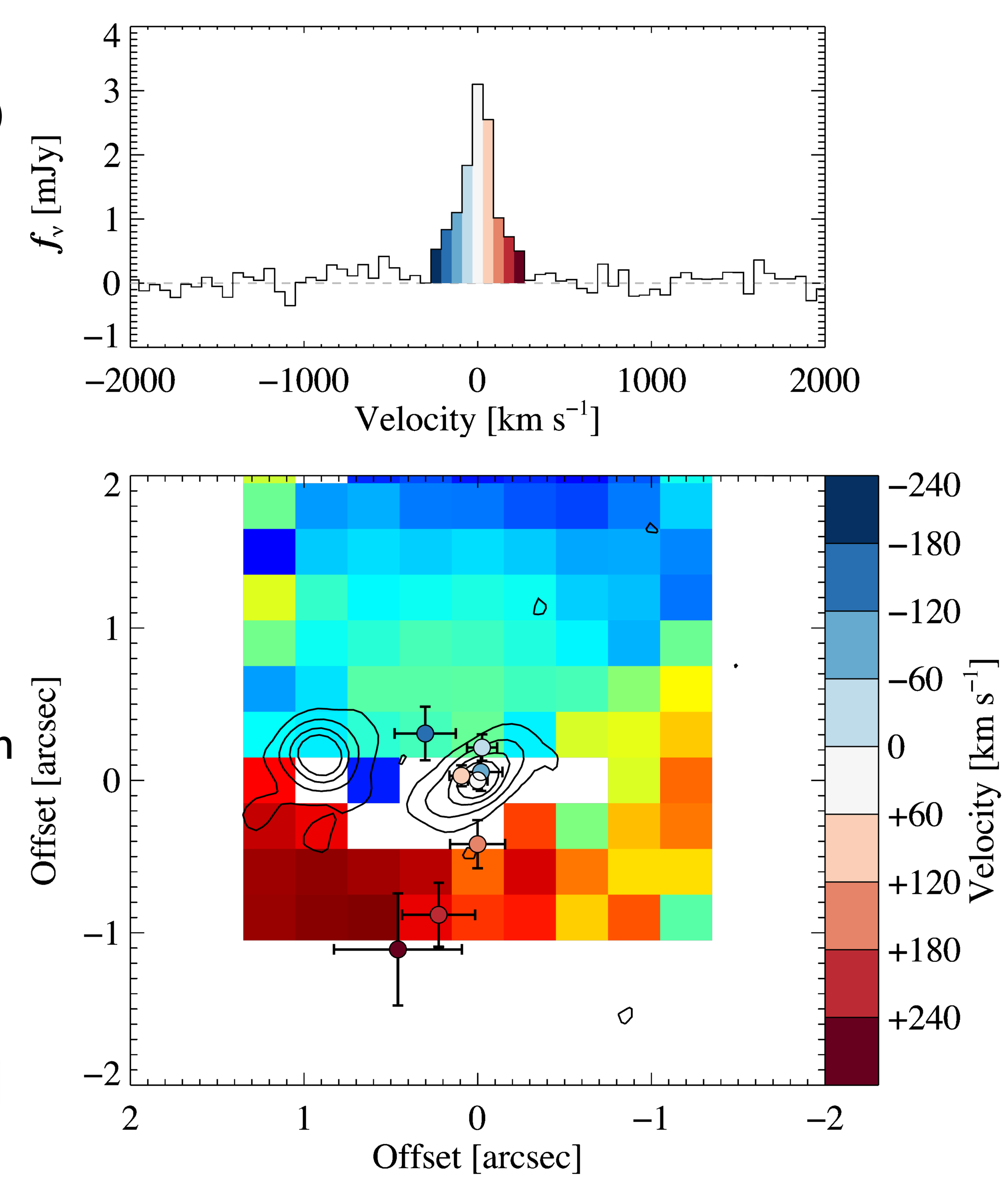
Figure 3 – Maps of the CO (1-0) emission line from NOEMA. Panels show the integrated flux, velocity centroid, and velocity dispersion. The systematic drift in the centroid and smooth trend in dispersion may be subtle indications of interaction between the compact radio jet and molecular gas. Higher spatial resolution observations are required to be sure.

New CO (1-0) observations from NOEMA

Single-dish CO observations with a 26" beam show that PG 1700 is among the most molecular gas rich hosts of the PG quasars, with emission at velocities of hundreds of km s^{-1} (Evans et al. 2009). We observed PG 1700 in CO (1-0) with the NOrthern Extended Millimeter Array (NOEMA) in July 2016. The observations were made in C+D configuration in two tracks, one with 8 antennas and one with 7. The final data product after reduction is a data cube (Fig. 3). The synthesized beam size is 3.78x3.70" and spatial pixels are 0.8". Each spectrum covers the continuum on either side of the CO line and is binned to 60 km s^{-1} in velocity. The CO spatial centroid is well defined, so we show its drift with velocity across the line profile to look for signs of interaction with the radio jet (Fig. 4).

Figure 4 – Changes in the spatial centroid of CO (1-0) as a function of velocity across the emission line. Notably, the CO (1-0) centroids in the two most redshifted bins match the axis of the radio jet and jet-driven [O III] outflow.

Top: the total integrated CO (1-0) spectrum with color coded velocity bins. **Bottom:** the spatial position of the CO (1-0) centroid. Black contours show VLA and background map shows [O III] narrow velocity component. The frame is rotated to match the [O III] map position angle.



Interpretation

As part of an ongoing effort to characterize multi-phase kiloparsec-scale outflows in type 1 AGN, we present initial results for PG 1700:

- There are two radio sources. The western source is a compact radio core with two-sided jet. The eastern source is diffuse and may be a aging hotspot or the result of jet redirection.
- The high-velocity [O III] emission shows a jet-driven outflow. Emission at low velocities may result from jet interaction, tidal motions, or a disk that is misaligned with the stellar bulge.
- New NOEMA CO (1-0) observations show subtle indications of interaction between the compact jet and molecular gas. Higher spatial resolution observations will have the deciding power to look for concrete evidence of an outflow in this gas phase.