The Galactic Center: Feeding and Feedback in a Normal Galactic Nucleus
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Detection of a high brightness temperature radio core in the AGN-driven molecular outflow candidate NGC 1266

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Abstract. We present new Karl G. Jansky Very Large Array (VLA) HI absorption and Very Long Baseline Array (VLBA) continuum observations of the active galactic nucleus (AGN)-driven molecular outflow candidate NGC 1266. Although other well-known systems with molecular outflows may be driven by star formation in a central molecular disk, the molecular mass outflow rate reported in Alatalo *et al.* (2011) in NGC 1266 of 13 $M_\odot$ year^{-1} exceeds star formation rate estimates from a variety of tracers. This suggests that an additional energy source, such as an AGN, may play a significant role in powering the outflow. Our high spatial resolution HI absorption data reveal compact absorption against the radio continuum core co-located with the putative AGN, and the presence of a blueshifted spectral component re-affirms that gas is indeed flowing out of the system. Our VLBA observations at 1.65 GHz reveal one continuum source within the densest portion of the molecular gas, with a diameter d < 8 mas (1.2 pc), a radio power $P_{\rm rad} = 1.48 \times 10^{20}$ W Hz^{-1}, and a brightness temperature $T_{\rm b} > 1.5 \times 10^7$ K that is most consistent with an AGN origin. The radio continuum energetics implied by the compact VLBA source, as well as archival VLA continuum observations at lower spatial resolution, further support the possibility that the AGN in NGC 1266 could be driving the molecular outflow. These findings suggest that even low-level AGNs, with supermassive black hole masses similar to Sgr A*, may be able to launch massive outflows in their host galaxies.

Keywords. Galaxies – Active Galactic Nuclei

1. Introduction

AGNs have been implicated in the quenching of star formation (SF) by heating and driving out gas in recent simulations (e.g., Dubois *et al.* 2013). These simulations suggest that AGN feedback may play a critical role in the evolutionary transition from blue, gas-rich spirals to "red and dead" early-type galaxies, yet direct observational evidence of AGN-driven feedback in action has remained scarce. The discovery of a candidate AGN-driven massive molecular outflow in NGC 1266 represents a rare opportunity to carry-out a detailed case-study of AGN feedback in a nearby ($D = 29.9$ Mpc) galaxy. Single dish CO observations (Young *et al.* 2011) revealed the presence of broad wings requiring a double Gaussian spectral fit, and follow-up interferometric observations confirmed the presence of a molecular outflow ($M_{\rm outflow} > 2.4 \times 10^7$ $M_\odot$; Alatalo *et al.* 2011). Alatalo *et al.* (2013) showed that in addition to shock-like optical emission line ratios (Davis *et al.* 2012), NGC 1266 hosts a post-starburst stellar population (Alatalo *et al.* 2013), and suggested the AGN in NGC 1266 may be shocking and driving out cold gas, and subsequently suppressing SF.

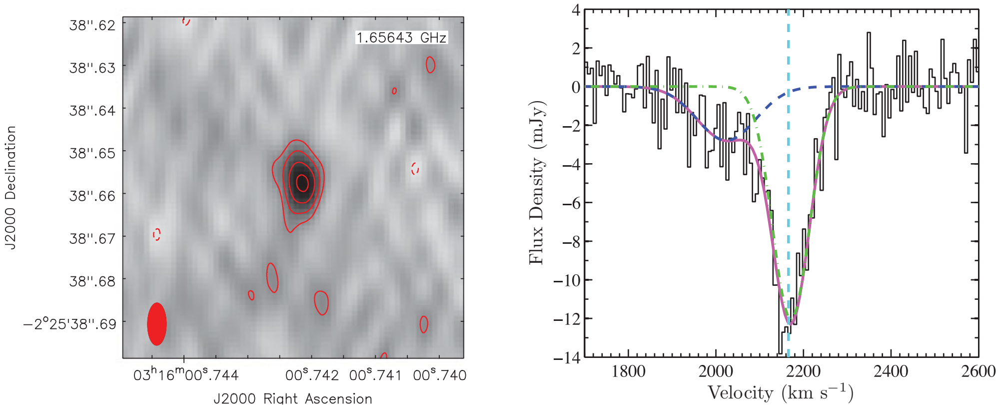

Figure 1. Left: NGC 1266 VLBA continuum image overlaid with contours. The VLBA beam is the ellipse in the lower left corner and has a major axis diameter of 9.75 mas (1.14 pc). The relative contour levels are [−3, 3, 6, 10, 14] and the unit contour level (RMS noise) is 42 μJy beam^{-1}. The emission is detected to 14σ significance and likely originates from the AGN. **Right:** HI absorption profile (black) in the central pixel of the data cube from VLA A-configuration observations. A double-Gaussian fit to the absorption profile is overlaid with a solid line (magenta). The two components consist of a shallow blueshifted outflowing component (blue dashed line) and a deeper absorption component near the systemic velocity (green dash-dot line). The vertical dotted line (cyan) marks the systemic velocity of 2165 km s^{-1}. [A COLOR VERSION IS AVAILABLE ONLINE.]

2. Overview

Recently, VLBA observations of NGC 1266 revealed compact, central emission (Figure 1a) with a brightness temperature far beyond what can be produced by a compact nuclear starburst, thus further strengthening the case for the presence of an AGN in NGC 1266 (Nyland *et al.* 2013). The location of the AGN derived from the VLBA data coincides with the kinematic center of the galaxy, and lies within the densest portion of the molecular gas. In addition, new high-spatial-resolution VLA spectral line observations showed the HI absorption spectrum is best fit by a double Gaussian, with a deep component near the systemic velocity and a shallow blueshifted component associated with the outflow (Figure 1b) with a mass of 1.4×10^6 $M_\odot$ and a relative velocity of −141.7 km s^{-1} (Nyland *et al.* 2013). Based on the compact morphology of the HI absorption and its relatively low outflow velocity, it is currently not clear whether the radio jet is driving this phase of the outflow. This is contrary to the results of recent estimates of the jet energy and mechanical power based on archival VLA continuum observations, which suggest that the radio jets may in fact be powerful enough to drive the outflow (Nyland *et al.* 2013). Although a more thorough analysis of this system is needed, the results of this study suggest that even low-level, nearby AGNs may be capable of launching massive outflows that significantly impact their host galaxies.

References

Alatalo, K., *et al.* 2011, *ApJ* 735, 88
Alatalo, K., *et al.* 2013, *ApJ* submitted
Davis, T. A. *et al.* 2012, *MNRAS* 426, 1574
Dubois, Y., *et al.* 2013, *MNRAS* 433, 329
Fabian, A. C. 2012, *ARAA* 50, 455
Greene, J. E., *et al.* 2012, *ApJ* 746, 86
Nyland, K., *et al.* 2013, *ApJ*, in press, arxiv:1310.7588
Young, L., *et al.* 2011, *MNRAS* 414, 940

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