

Evidence of AGN-driven Outflows in Young Radio Quasars Selected from the Wide-field Infrared Survey Explorer

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Abstract. We present near-infrared spectra of young radio quasars selected by cross-correlating the Wide-field Infrared Survey Explorer (WISE) all-sky survey catalog with the radio catalog [Faint Images of the Radio Sky at Twenty cm (FIRST) and NRAO VLA Sky Survey (NVSS)]. The objects have typical redshifts of $z \approx 2$ and [O III] luminosities of 10^{47} erg s⁻¹ comparable to those of luminous quasars. The observed flux ratios of narrow emission lines indicate that these objects appear to be powered by active galactic nuclei. The [O III] line is broad, with full width at half maximum ~ 1300 to 2100 km s⁻¹, significantly larger than that of ordinary quasars. These large line widths might be explained by jet-induced outflows.

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1. Introduction & Sample Selection

Supermassive black holes (BHs) and their host galaxies appear to be closely linked in their formation and evolution (e.g., Magorrian *et al.* 1998; Gebhardt *et al.* 2000; Ferrarese & Merritt 2000). Theoretical models often invoke feedback from active galactic nuclei (AGNs) as a crucial mechanism for establishing the correlation. AGN feedback is widely believed to be associated with outflows, which regulate the growth of BHs and quench star formation by expelling gas (e.g., Di Matteo *et al.* 2005). Despite the potential importance of AGN feedback, direct observational evidence of this process is limited (e.g., Nesvadba 2007; Harrison *et al.* 2012). Here we propose that the presence of a strong, compact radio source (Fanti *et al.* 1990) can serve as an effective indicator of AGN activity. Our goal is to see whether *young* radio quasars show signatures of outflows that might be indicative of AGN feedback during the early stages of their evolution.

We use the *Wide-Field Infrared Survey Explorer* (WISE; Wright *et al.* 2010) to find dusty luminous quasars (C. J. Lonsdale *et al.*, in preparation). The sample is selected to be bright in $22 \mu\text{m}$ ($S_{22 \mu\text{m}} > 4$ mJy) and to have extremely red colors in the mid-infrared, $1.25[m(3.4 \mu\text{m}) - m(4.6 \mu\text{m})] + [m(4.6 \mu\text{m}) - m(12 \mu\text{m})] > 7$ in the Vega magnitude system. Then we match the red objects from WISE to the NRAO VLA Sky Survey (Condon *et al.* 1998) and Faint Images of the Radio Sky at Twenty Centimeters (Becker *et al.* 1995) to select sources with $S_{1.4 \text{ GHz}}/S_{22 \mu\text{m}} > 1$. Finally, we only include sources with no extended radio structure, in order to avoid evolved radio galaxies.

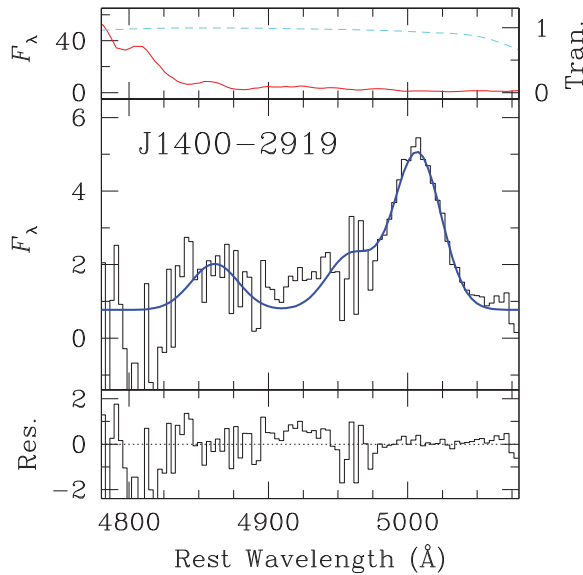


Figure 1. Example of a FIRE spectrum in the rest frame for one of the sample objects (J1400–2919). The model for $H\beta$ and $[O\ III]$ is plotted as a blue thick line; residuals of the best fit are shown in the bottom panel. We plot the sky lines (red solid line) and the atmospheric transmission (cyan dashed line) in the top panel.

2. Sign of Outflows

We obtained near-infrared spectra for 24 objects using the Folded-port InfraRed Echellette on the Baade 6.5 meter telescope at Las Campanas Observatory. Figure 1 shows a sample spectrum of J1400–2919. We detected emission lines in seven out of the 24 objects. The redshifts line in the range $z \approx 1.6 - 2.5$. The high flux ratios of $[O\ III]\ \lambda 5007$ to $H\beta$ ($\approx 3.4 - 7.0$) indicate that the ionizing source of our sample is likely to be AGNs rather than young stars. Interestingly, the $[O\ III]$ lines are exceptionally broad. The FWHM of the line ranges from 1320 to 2120 km s^{-1} . The explanation for the high velocities might be that they reflect the kinematics of AGN-driven outflows, which seem to be prevalent in young radio quasars (See Kim *et al.* 2013 for detail).

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