The AGN fueling/feedback cycle: a multi-phase study of a sample of local radio galaxies

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Scientific context

The suppression of star formation in early-type galaxies (ETGs) and the formation of their kinematic sub-structures are debated issues in galaxy formation theories. The AGN jets feedback ([5]), and the radiation from the accretion disk are thought to be essential to the suppression of star formation ([3]), while the accreting interstellar gas may form decoupled stellar components. The SAURON and ATLAS^{3D} optical surveys, and associated CO follow-ups have demonstrated a causal link between the two processes in radio-quiet ETGs (e.g. [1], [2], [8]), but a similar study of a sample of radio-loud ETGs is needed to provide a comparison to these works. The main aim is to identify kinematical signatures of feeding/feedback loops that can be related to the presence of radio jets; such a study will enable a better understanding of the AGN fueling/feedback cycle and its role in the overall formation and evolution of ETGs.

The sample

From the Southern Parkes 2.7-GHz survey (PKS) we have selected all the radio-loud ETGs (i.e. radio galaxies, RGs) with i) redshift z < 0.03, and ii) an ETG (i.e. E/S0) optical counterpart. This resulted in a volume-limited sample of 11 RGs characterized by low-power ($P_{1.4GHz} \leq 10^{25}$ W Hz^{-1}), low accretion rate, and FRI or (arcsec-scale) compact morphology.

The data

We have already obtained VLT/VIMOS IFS observations ([9]) and $CO_{(2-1)}$ integrated spectra with APEX ([7], [6]) for all sources. Here we present ALMA Cycle 3 $CO_{(2-1)}$ observations of 9 targets, with resolutions ranging from 0.6 to 1 arcsec. Data were calibrated and imaged using CASA software (version 4.7) and their analysis is still ongoing.

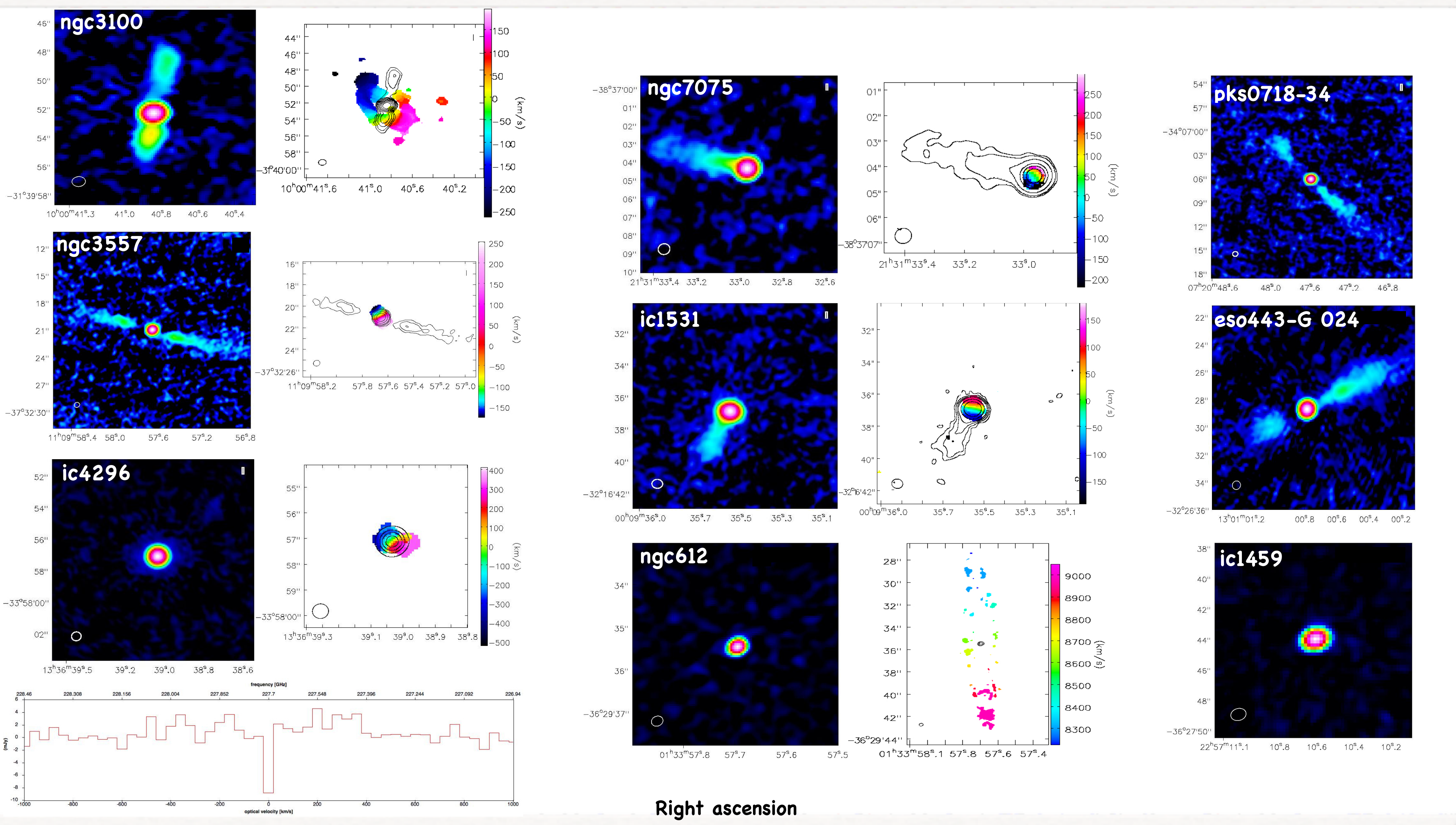

Figure 1. Continuum maps of the nine observed sources (left side of each column), and moment 1 maps (mean velocity) of the $CO_{(2-1)}$ line detections with continuum contours superimposed (right side of each column). Contours are drawn at ±1,±2,±4...the 3σ rms noise level. At the bottom of the first column we also show the ic4296 CO integrated spectrum. On the extreme right column we show the three non CO-detected sources (only continuum detection).

Preliminary Results

The $CO_{(2-1)}$ line emission was detected in 6 out of 9 targets with detection significance ranging from 8 to 35σ; The main observational properties are summarized in table 1. $CO_{(2-1)}$ maps show regular rotating disk structures in the majority of the sources (e.g. ngc3557, ngc7075) , but we have also peculiar cases (e.g. ngc3100) in which the gas disk shows a disturbed morphology; the distorted gas structure seems to suggest an interaction the jets: a modeling of the molecular disk is ongoing to verify this hypothesis ([4]). We also found a prominent absorption feature in the ic4296 CO spectrum which is under investigation to establish its origin.

Source name	Redshift	CO (2-1) peak flux (mJy/beam)	SNR	Δv_{res} (km/s)	M_{H2} ($M_\odot$)	ϑ_{synth} '' (pc)
ngc3100	0.0088	30	55	10	8×10^7	0.6 (110)
ngc3557	0.0103	16.2	35	22	5×10^7	0.6 (132)
ic4296	0.0125	1.85	8	40	1×10^6	0.6 (154)
ic1531	0.0256	8	20	20	6×10^7	0.5 (260)
ngc7075	0.0185	3	12	65	1.3×10^7	0.7 (265)
ngc612	0.0298	13	10	75	3×10^{10}	0.3 (180)
pks0718-34	0.0284	<1	-	-	-	-
eso443-G 024	0.0170	<1	-	-	-	-
ic1459	0.0060	<2	-	-	-	-

Table 1. ALMA Cycle 3 $CO_{(2-1)}$ main observational properties.

REFERENCES: [1] Alatalo K., et al., 2013, MNRAS, 432, 1796; [2] Cappellari M., et al., 2011, MNRAS, 413, 813; [3] Fabian A. C., 2012, ARA&A, 52, 589; [4] Fragnito F., et al., in prep. [5] Heckman T. M., & Best P. N., 2014, ARA&A, 52, 589; [6] Laing R. A., et al., in prep; [7] Prandoni I., et al., 2010, A&A, 523, A38; [8] Young L. M., et al., 2011, MNRAS, 414, 940; [9] Warren J., et al., in prep;