AGN feedback on molecular gas reservoirs in quasars at $z \sim 2.4$

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ABSTRACT

We present new ALMA observations aimed at mapping molecular gas reservoirs through the CO(3-2) transition in three quasars at $z \simeq 2.4$. LBQS 0109+0213, 2QZ J002830.4-281706, and [HB89] 0329-385. Previous [OIII]λ5007 observations of these quasars showed evidence for ionised outflows quenching star formation in their host galaxies. Systemic CO(3-2) emission has been detected only in one quasar, LBQS 0109+0213, where the CO(3-2) emission is spatially anti-correlated with the ionised outflow, suggesting that most of the molecular gas may have been dispersed or heated in the region swept by the outflow. In all three sources, including the one detected in CO, our constraints on the molecular gas mass indicate a significantly reduced reservoir compared to main-sequence galaxies at the same redshift, supporting a negative feedback scenario. In the quasar 2QZ J002830.4-281706, we tentatively detect an emission line blob blue-shifted by $v \sim -2000$ km/s with respect to the galaxy systemic velocity and spatially offset by 0.2″ (1.7 kpc) with respect to the ALMA continuum peak. Interestingly, such emission feature is coincident in both velocity and space with the ionised outflow as seen in [OIII]λ5007. This tentative detection must be confirmed with deeper observations but, if real, it could represent the molecular counterpart of the ionised gas outflow driven by the AGN. Finally, in all ALMA maps we detect the presence of serendipitous line emitters within a projected distance ~ 160 kpc from the quasars. By identifying these features with the CO(3-2) transition, the serendipitous line emitters would be located within $|\Delta v|<500$ km/s from the quasars, hence suggesting an overdensity of galaxies in two out of three quasars.

❖Introduction

- AGNのoutflowによってホスト銀河の分子ガスが取り除かれて星形成が抑制されるプロセスが考えられているがはっきりとした証拠は未発見
- SINFONI/VLTにより、z~1.5–2.5のQSOで電離ガスのoutflowと星形成率の空間的反相関が示唆されたが、可視光の観測はダスト減光の影響を強く受けている可能性がある
- ALMAを用いた（サブ）ミリ波の観測によりCO輝線を捉えることで、分子ガスに対するfeedbackの影響を直接調べることができる

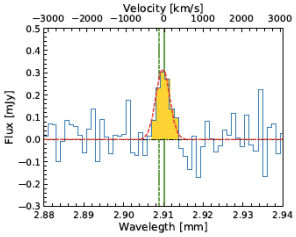
❖Sample & Observations

- SINFONIの[OIII]λ5007観測によりfast ionized outflow (> 1000 km/s)が確認されているhigh-luminosity QSO (Cano-Diaz+12)

QSO	z	RA	DEC	$\mathrm{Log}_{10}(\frac{L_{AGN}}{\mathrm{erg/s}})$	M_{BH}	SFR	Ionised outflow properties v	R	$M_{[OIII]}$	$\dot{M}_{[OIII]}$
					[10^{10} $M_\odot$]	[$M_\odot$ yr^{-1}]	[km/s]	[kpc]	[10^7 $M_\odot$]	[$M_\odot$ yr^{-1}]
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
LBQS0109	2.35	01:12:16.99	+02:29:47.7	47.5	1.0	50	1850	0.4	1.2	60
2QZJ0028	2.40	00:28:30.42	-28:17:05.4	47.3	1.2	100	2300	0.7	3.8	140
HB8903	2.44	03:31:06.41	-38:24:04.6	47.5	1.3	90	1450	1.9	0.7	6

- ALMA Band 3 (~100 GHz) によりCO(3-2)を観測
  - on source time 40 minutes, 40–44 12-m antennas, four spectral windows of ~1.875 GHz (total bandwidth 7.5 GHz)
- 輝線を含まないチャンネルからcontinuum image at 3 mmを作成
- $L_{CO(3-2)}/L_{CO(1-0)}$=1.0±0.5と仮定
- α_{CO}=4 (MS) or 0.8 (starburst) $M_\odot$/K km/s pc^2 を使用

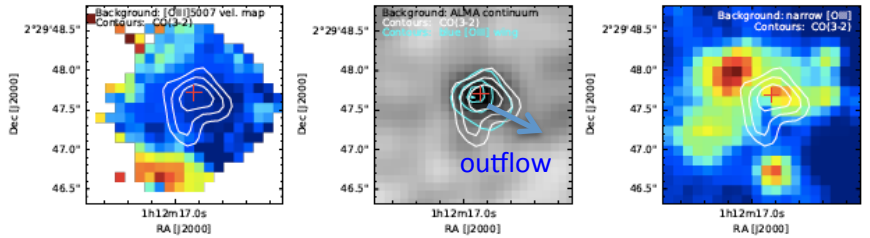
LBQS0109



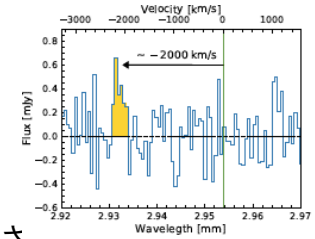
CO輝線の位置はHα、O[III]から予想される位置と合う
→ ホスト銀河の分子ガスをトレースしている

COと[OIII]ともにionized outflowの方向に沿って輝度が小さくなっている

outflowによるガスの除去

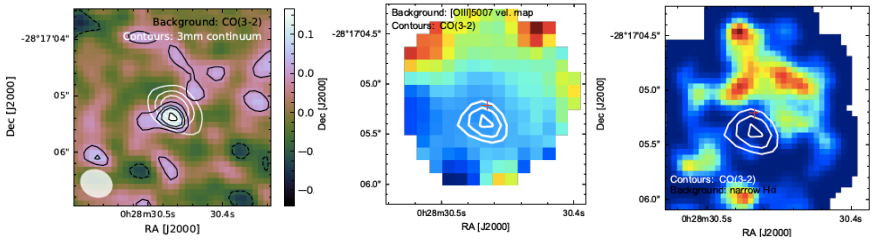


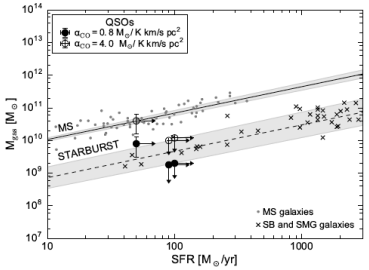
2QZJ0028



Hαから予想される位置でCO(3-2)非検出だが、約-2000 km/sずれた位置に輝線が存在
COからのずれと[OIII]で測定したionized outflowの速度（-2300 km/s）及び空間分布が合う

molecular outflowを見ている





SFR vs. Mのプロットではstarburstと似た位置を占める
depletion timescaleはz~2.5のSMGやreddened QSOとconsistent
依然としてstarburst phaseにある可能性
negative/positive feedbackが別の領域で同時に起きているかもしれない