Proposal: Trace extremely fast molecular (or multi-phase) outflows in BEARS SMGs

Key questions:

1. It is important to understand how feedback happens in the most active phase at cosmic noon.

2. The spatially-resolved study on molecular outflow at high-z is still rare.

3. BEARS provide a unique sample to search for and study in details on extreme outflows at z∼2–4. We can analyze 3–6 SMGs with the broadest CO lines ever reported in the literature (see the two reference figures).

Necessary graphs:

Scientific context:

1. Select line tracers: 1) CO(3-2) or CO(4-3) for molecular gas; 2) [CI]492GHz for neutral gas; 3) [NII]205μm for ionized gas; 4) some absorption line(?) to measure shifted velocity. Do we need all of them?

2. In order to spatiailly resolved the central starburst region, propose a physical resolution of ∼1 kpc.

3. The immediate objective is to measure the extent of the broad component of lines, i.e., outflowing region.

4. With the velocity map, we can estimate the mass-loss rate, kinetic energy ejection rate, mass-loading factor, etc.

Technical justification:

1. Band coverage should be checked. CO(4-3) and [CI]492GHz may be covered simultaneously?

2. Need to check the available array configuration for 1 kpc resolution.

What sources are necessary?

1. HerBS-200 with CO FWHM of 1290 km/s is considered with the 1st priority,

2. HerBS-54/58/89a also have CO FWHM of ∼1000 km/s, while they are in Northern sky (Dec of 24–28°).

3. HerBS-77/182 are also considered, they also possess relatively large FWHM compared to the two refered table.

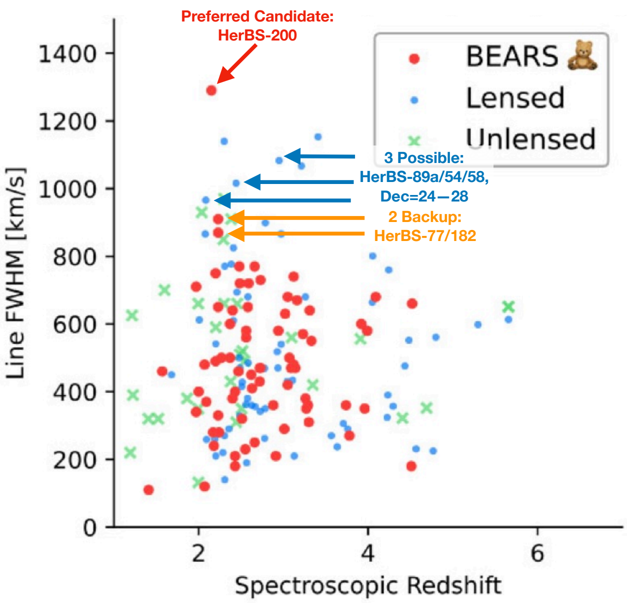

Figure 1: Selected candidates, modified from Fig.5 of BEARS Paper-I (Urquhart et al. 2022).

Table 2. Properties of continuum and line (CO or [CII]) emission for the WISSH QSOs analysed here.

ID	Transition	$z_{\rm cold}$	*FWHM* (km s^{-1})	$S\,\Delta v$ (Jy km s^{-1})	$L'_{\rm CO}$ (10^{10} K km s^{-1} pc^2)	$L_{\rm [CII]}$ (10^9 $L_\odot$)	$S_{\rm cont}$ (mJy)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
J0209–0005	CO(5–4)	2.870	435 ± 95	1.4 ± 0.3	2.15 ± 0.46	–	0.38 ± 0.04
	CO(1–0)	2.870	440 ± 85	0.062 ± 0.012	2.39 ± 0.46	–	0.039 ± 0.005
J0801+5210	CO(5–4)	3.256	685 ± 70	3.68 ± 0.40	6.99 ± 0.76	–	<0.30 [b]
	CO(1–0)	–	–	<0.095 [a]	<4.48	–	0.091 ± 0.010
J1433+0227	[CII]	4.728	400 ± 40	5.40 ± 0.24	–	3.72 ± 0.16	7.7 ± 0.3
J1538+0855	CO(4–3)	3.572	320 ± 90	0.36 ± 0.11	1.23 ± 0.38	–	<0.087 [b]
J1549+1245	CO(4–3)	2.374	245 ± 40	0.27 ± 0.03	0.47 ± 0.05	–	0.12 ± 0.01
J1555+1003	CO(4–3)	3.529	605 ± 90	0.87 ± 0.14	2.94 ± 0.68	–	0.10 ± 0.02
J1639+2824	CO(4–3)	3.846	615 ± 90	0.92 ± 0.15	3.55 ± 0.66	–	<0.090 [b]
J1701+6412	CO(5–4)	2.753	595 ± 120	1.50 ± 0.34	2.15 ± 0.49	–	0.60 ± 0.06
J1015+0020 [*]	[CII]	4.407	340 ± 40	0.47 ± 0.05	–	0.29 ± 0.03	0.60 ± 0.06
Comp$_{\rm J0209}$	CO(5–4)	2.881	600 ± 95	1.1 ± 0.3	1.74 ± 0.46	–	0.14 ± 0.03
	CO(1–0)	–	–	<0.044 [a]	<1.71	–	<0.014 [b]
Comp$_{\rm J0801}$	CO(5–4)	3.271	385 ± 65	0.71 ± 0.26	1.36 ± 0.49	–	<0.30 [b]
	CO(1–0)	–	–	<0.058 [a]	<2.78	–	<0.30 [b]
Comp$_{\rm J1433}$	[CII]	4.728	100 ± 43	0.11 ± 0.02	–	0.08 ± 0.02	<0.015 [b]
Comp1$_{\rm J1549}$	CO(4–3)	2.363	540 ± 95	0.29 ± 0.05	0.49 ± 0.08	–	0.12±0.01
Comp2$_{\rm J1549}$	CO(4–3)	2.374	540 ± 110	0.046 ± 0.013	0.08 ± 0.02	–	<0.021 [b]
Comp$_{\rm J1555}$	CO(4–3)	3.531	370 ± 70	0.29 ± 0.06	0.98 ± 0.20	–	<0.084 [b]
Comp$_{\rm J1701}$	CO(5–4)	2.753	130 ± 60	0.50 ± 0.19	0.84 ± 0.27	–	<0.30 [b]

Source	$S_\nu \Delta V$ Jy km s^{-1}	$M_{\rm H2}$ $\times\ 10^9\ M_\odot$	$R_{\rm out}$ kpc	$V_{\rm out}$ km s^{-1}	$V_{\rm FWHM}$ km s^{-1}
4C 05.84	0.1 ± 0.03	1.4 ± 0.2	8.6	653 ± 30	382.2 ± 47.4
3C 318	0.25 ± 0.03	3 ± 0.3	20.2	1132 ± 44	528.7 ± 67.4
3C 298	0.3 ± 0.03	3 ± 0.3	1.6	394 ± 64	624.0 ± 49.0
4C 09.17 A	0.11 ± 0.01	1.3 ± 0.1	2.8	852 ± 77	439.1 ± 122.6
4C 09.17 B	2.3 ± 0.2	27 ± 3	4.9	456 ± 26	870.6 ± 47.2

Figure 2: Two refered studies Bischetti et al. (2021) and Vayner et al. (2021). The typical CO FWHM of these luminous QSO hosts is <800 km/s.

How long to observe per source?

To be checked...