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Supplementary information

A Lyman-α protocluster at redshift 6.9

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LETTER

A Lyman-α protocluster at redshift 6.9 Supplementary Information

Weida Hu, Junxian Wang, Leopoldo Infante, James E. Rhoads, Zhen-Ya Zheng, Huan Yang, Sangeeta Malhotra, L. Felipe Barrientos, Chunyan Jiang, Jorge González-López, Gonzalo Prieto, Lucia A. Perez, Pascale Hibon, Gaspar Galaz, Alicia Coughlin, Santosh Harish, Xu Kong, Wenyong Kang, Ali Ahmad Khostovan, John Pharo, Francisco Valdes, Isak Wold, Alistair R. Walker, XianZhong Zheng

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Supplementary Table 1 | Properties of LAEs in the LAGER-z7OD1. We list the 21 member LAEs in LAGER-z7OD1. Column 1 lists the source IDs of 21 LAEs. Columns 2 and 3 are the coordinates. Column 4 is the Lyα photometric luminosity. Column 5 lists the redshifts inferred from the line center for spectroscopic confirmations. Columns 6 – 8 show their AUTO magnitude in the narrowbands DECam-NB964, HSC-NB973, and underlying broadband HSC-y (2σ upper limits for non-detections). Column 9 lists the bubble size inferred using the relation in ref.[1]. Column 10 is the source IDs in ref.[2] (hereafter H19).

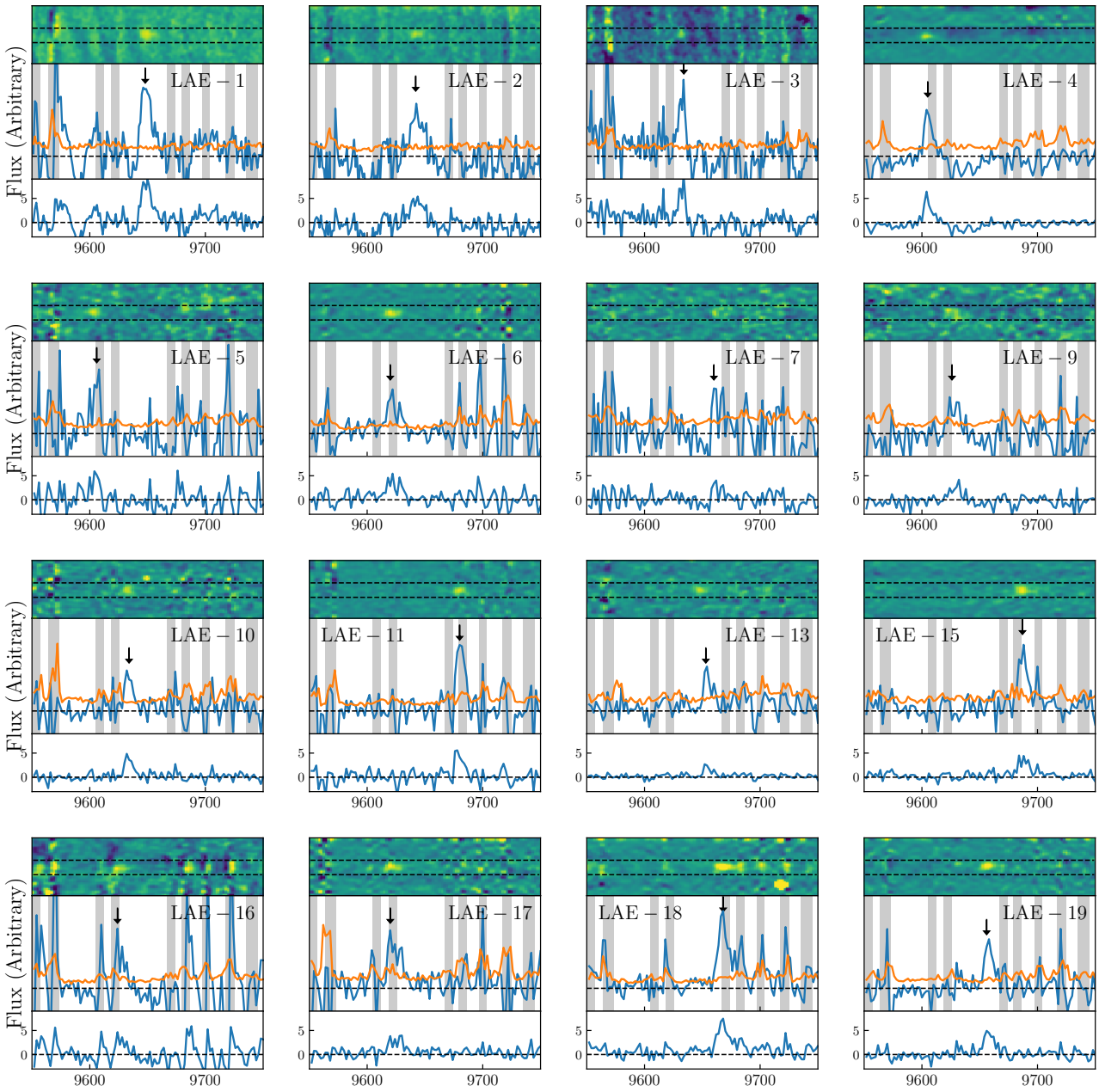
ID	RA	DEC	$\log L_{\mathrm{Ly}\alpha}$ (erg s^{-1})	Redshift	DECam-NB964 (mag)	HSC-NB973 (mag)	HSC-y (mag)	R (cMpc)	ID in H19
Spectroscopically Confirmed									
LAE-1	10:02:06.0	+02:06:46.3	$43.54^{+0.03}_{-0.03}$	6.938	23.08 ± 0.06	23.77^{c}	25.30 ± 0.33	14.5	COSMOS-1
LAE-2	10:01:53.5	+02:04:59.8	$43.33^{+0.07}_{-0.08}$	6.932	23.22 ± 0.10	24.75^{c}	24.11 ± 0.12	11.5	COSMOS-3
LAE-3	10:03:10.5	+02:12:30.8	$43.49^{+0.04}_{-0.05}$	6.923	23.17 ± 0.08	**	25.15 ± 0.33	13.7	COSMOS-2
LAE-4	10:03:32.7	+02:09:25.1	$43.04^{+0.09}_{-0.11}$	6.900	24.33 ± 0.16	**	26.42 ± 0.70	8.5	COSMOS-10
LAE-5	10:03:30.7	+02:14:08.5	$43.03^{+0.07}_{-0.08}$	6.899	24.37 ± 0.13	**	26.63 ± 0.58	8.0	N[a]
LAE-6	10:03:28.0	+02:08:51.3	$43.03^{+0.10}_{-0.14}$	6.915	24.34 ± 0.23	**	26.45 ± 0.34	7.3	N[a]
LAE-7	10:03:05.2	+02:09:14.7	$42.79^{+0.12}_{-0.17}$	6.945	24.69 ± 0.19	24.28 ± 0.18	25.81 ± 0.35	6.1	N[b]
LAE-9	10:03:16.0	+02:15:42.3	$42.70^{+0.13}_{-0.20}$	6.920	24.95 ± 0.21	**	26.13 ± 0.45	6.4	N[a]
LAE-10	10:02:42.3	+02:06:55.2	$42.56^{+0.13}_{-0.18}$	6.922	25.29 ± 0.22	**	26.42 ± 0.28	5.8	N[a]
LAE-11	10:02:39.4	+02:07:12.1	$42.69^{+0.11}_{-0.15}$	6.962	25.13 ± 0.21	24.78^{c}	26.84 ± 0.53	6.4	COSMOS-41
LAE-13	10:02:33.5	+02:07:09.5	$42.68^{+0.12}_{-0.16}$	6.936	25.14 ± 0.20	**	26.85 ± 0.69	6.4	COSMOS-42
LAE-15	10:02:23.4	+02:05:04.8	43.38^{d}	6.971	25.04 ± 0.19	23.68^{c}	26.41 ± 0.34	12.1	COSMOS-49
LAE-16	10:02:32.9	+02:05:52.8	$42.85^{+0.08}_{-0.10}$	6.915	24.82 ± 0.18	**	> 27.2	7.3	COSMOS-29
LAE-17	10:03:33.5	+02:07:19.8	$42.94^{+0.09}_{-0.11}$	6.917	24.61 ± 0.20	**	> 27.2	7.9	COSMOS-17
LAE-18	10:03:37.3	+02:07:36.7	$42.86^{+0.08}_{-0.10}$	6.953	24.81 ± 0.18	**	> 27.2	7.3	COSMOS-27
LAE-19	10:03:39.3	+02:07:47.2	$42.69^{+0.16}_{-0.25}$	6.943	24.91 ± 0.22	**	25.93 ± 0.50	6.4	COSMOS-34
Not Yet Confirmed									
LAE-8	10:02:09.0	+02:04:11.0	$42.84^{+0.11}_{-0.14}$	**	24.81 ± 0.21	**	26.8 ± 0.62	7.2	COSMOS-25
LAE-12	10:03:00.1	+02:14:49.5	$42.81^{+0.10}_{-0.14}$	**	24.76 ± 0.20	**	26.24 ± 0.28	7.0	COSMOS-24
LAE-14	10:02:08.3	+02:06:59.6	$42.79^{+0.14}_{-0.21}$	**	24.86 ± 0.25	**	26.45 ± 0.67	6.9	COSMOS-30
LAE-20	10:02:47.1	+02:10:40.1	43.05^{d}	**	25.40 ± 0.24	24.52^{c}	26.86 ± 0.44	7.0	N[b]
LAE-21	10:03:15.6	+02:18:11.3	$42.87^{+0.09}_{-0.11}$	**	24.79 ± 0.20	25.73 ± 0.51	> 27.2	6.9	N[b]

[a] LAE-5, 6, 9, 10 were not included in H19 as they are labelled as lower-grade candidates for various reasons (LAE-5: close to bad image regions; LAE-6: noisy signal in the NB image; LAE-9: adjacent to a foreground galaxy within $3''$; LAE-10: with DECam-NB964 signal lower than 5σ), but latterly got spectroscopically confirmed.

[b] LAE-7, 20, and 21 are selected using the stacked image of DECam-NB964 and HSC-NB973 images.

[c] We adopt the HSC-NB973 magnitudes given in ref.[3].

[d] We adopt the Lyα luminosities given in ref[3], because their Lyα lines locate in the red tail of the DECam-NB964 and their Lyα luminosities will be severely underestimated if using DECam-NB964 magnitude.



Supplementary Figure 1 | Two- and one-dimensional spectra of 16 confirmed LAEs in LAGER-z7OD1. In the top panel the two-dimensional spectra (yellow is high flux and blue is low flux) are smoothed by a Gaussian kernel with 1 pixel for better illustration. The two black dashed lines (separated by $1''$ vertically) represent the expected slit position of LAEs in the 2D spectra. In the middle panel, the blue lines are the one-dimensional spectra and the orange lines are the noise spectra. The grey regions represent the sky OH lines (imperfect sky line subtraction could yield artificial signals visible in the spectra). The dashed horizontal lines indicate zero-flux level and the black arrows mark the peak of the identified Lyα line profiles. In the bottom panel, we plot the S/N spectra with the dashed horizontal lines showing zero S/N. Due to the flaws in the slit, LAE-16 shows a noisy 2D spectrum. However, a clear broad red wing of the line is revealed which falls in the skyline free region, and the line is considerably broader than artificial line signals in the spectrum. Thus, we identify it as a Lyα line.