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Supplementary information

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A hidden population of high-redshift double quasars unveiled by astrometry

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Supplementary Information

The target coordinates, Gaia DR2 parameters, separations and flux ratios measured from HST imaging are provided in Supplementary Table 1. We also estimate the expected pair separations, using surrogates of astrometric jitter and photometric variability from Gaia DR2 cataloged parameters. The astrometric jitter is estimated using the quadratic sum of Gaia measured parallax, proper motion$\times$time, and astrometric excess noise. The total fractional photometric variability is estimated using Gaia reported photometric uncertainties and the number of observing epochs[1] since Gaia DR2 did not publish photometric variability.

For J0749 and J0841, both components are quasars and we assume the same fractional photometric variability. Using the average flux ratio in the HST bands, and Eqn. 3 in [1], we estimate the expected pair separations. For J0905, the companion is a non-variable star, so we used Eqn. 5 in [1] to estimate the pair separation, using a flux ratio of 0.1 in Gaia G band from our modeling in Methods. J1326 does not have flux ratio measurement, so we used Eqn. 2 in [1] assuming that both (unresolved) components are quasars with equal mean fluxes. Given the assumptions in these estimations and the use of surrogates from Gaia DR2, the agreement between the expected and observed pair separations is not great, but consistent in the ballpark.

Table 1: Summary of Targets

Target	z	$\sigma_{\rm AEN}$ [mas]	$\sigma_{\rm photo}$	parallax [mas]	PM (RA/DEC) [mas/yr]	flux ratio	$D_{\rm obs}$ [″]	$D_{\rm exp}$ [″]
J074922.97+225511.8	2.17	1.452	0.14	-0.38 ± 0.40	$-0.93 \pm 0.64/1.91 \pm 0.37$	4.4 (F475W) 3.6 (F814W)	0.46	0.11
J084129.77+482548.3	2.95	3.399	0.09	-1.49 ± 1.02	$-3.68 \pm 1.17/8.54 \pm 1.33$	1.3 (F475W) 1.7 (F814W)	0.46	0.41
J090501.12+585902.3	2.39	1.676	0.08	-0.29 ± 0.34	$0.03 \pm 0.48/-0.52 \pm 0.48$	46 (F475W) 4.5 (F814W)	0.61	0.27
J132614.08+063909.9	2.17	1.604	0.03	-0.18 ± 0.55	$1.07 \pm 0.98/0.71 \pm 0.48$	N.A.	< 0.1	0.19

Notes: The astrometric jitter is estimated by the quadratic sum of astrometric excess noise ($\sigma_{\rm AEN}$), parallax and proper motion distance over 22 months (observing period of Gaia DR2). The expected pair separation $D_{\rm exp}$ is estimated using the astrometric jitter, Gaia fractional photometric RMS variability ($\sigma_{\rm photo}$) and mean flux ratio. For J0749 and J0841 we use Eqn. 3 in [1]; for J0905 we use Eqn. 5 in [1] since the companion is a non-variable star; for J1326 we use Eqn. 2 in [1] since the flux ratio is unknown. All quoted error bars are 1σ standard deviations.

1. Hwang, H.-C., et al. Varstrometry for Off-nucleus and Dual sub-Kpc AGN (VODKA): Methodology and Initial Results with Gaia DR2. *Astrophys. J.* **888**, 73 (2020).