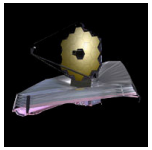

2282 - A Strongly Magnified Individual Star and Parsec-Scale Clusters Observed in the First Billion Years at z = 6

Cycle: 1, Proposal Category: GO

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OBSERVATIONS

Folder	*Observation*	*Label*	*Observing Template*	*Science Target*
Observation Folder				
	10	NIRCam Imaging	NIRCam Imaging	(1) WHL0137-08
	20	NIRCam Imaging	NIRCam Imaging	(1) WHL0137-08
	21	NIRSpec MSA1	NIRSpec MultiObject Spectroscopy	(21) WHL0137-MSA
	22	NIRSpec MSA2	NIRSpec MultiObject Spectroscopy	(22) WHL0137-MSA-OBS2

Folder	*Observation*	*Label*	*Observing Template*	*Science Target*
	23	NIRSpec MSA3	NIRSpec MultiObject Spectroscopy	(23) WHL0137-MSA-OBS3
	120	NIRCam Imaging	NIRCam Imaging	(1) WHL0137-08

ABSTRACT

JWST was designed to study the first stars. Until recently, we assumed that meant populations of stars within the first galaxies. But in the past 3 years, 3 individual strongly lensed stars have been discovered at z~1. This offers a new hope of directly observing individual stars at cosmological distances with JWST. Here we propose JWST observations of a candidate strongly lensed star at z~6, dubbed LSz6. For the past 3 years, LSz6 has been steadily magnified by a factor of ~9000 on the lensing critical curve directly between multiple images of a bright star forming clump. The clump is also remarkable as the most distant known bound massive star cluster, with a radius < 6 pc, the size of local star clusters. This unprecedented spatial resolution is afforded us by the most highly magnified z=6 galaxy known, dubbed the "Sunrise Arc".

We propose 3 hours of NIRCam imaging in 2 epochs and 3 hours of NIRSpec MOS PRISM spectroscopy of 12 positions along the arc. These observations will:

1) Confirm LSz6 is an individual star at z=6 and place it on the H-R diagram with measurements of luminosity and temperature

2) Confirm the lensed clumps are bound massive star clusters, constrain their histories and fates, and measure their individual ionizing strengths

3) Confirm the existence of a galaxy core and measure outward gradients of mass, metallicity, and age for the first time in detail at z=6

Observations from this program will inform future JWST proposals to study the Sunrise Arc in even greater detail and provide time monitoring for years to come. We waive exclusive access to all data obtained from this program to benefit the community.

OBSERVING DESCRIPTION

We are obtaining NIRCam imaging and NIRSpec MSA prism on one target field: WHL0137. The NIRCam imaging is serving as pre-imaging for NIRSpec that will follow at least 60 days later.

This APT submission includes fully prepared NIRSpec MSA PRISM observations. 3 observations are obtained, each with a different set of targets, and each with 3 dithers, for 9 MSA configurations altogether. These observations should obtain spectra of 174 science targets and 281 background

locations. These include 13 spectra along our primary science target: the 15" long z=6 Sunrise Arc, including the lensed star Earendel.

All MSA observations have similar pointings within < 1 arcmin due to various constraints. We avoid an 8th magnitude star, positioning in behind the solid metal between the MSA quadrants Q1 and Q2. We also roughly center the primary science targets in the dispersion direction on the Q1 detector, maximizing the spectral coverage.

Our primary science targets are densely packed along the 15" long Sunrise Arc. To observe all of these targets, we use single slitlets (with midpoint centering constraints) and 3 MSA observations.

Each observation performs 3 fixed dithers, each with an updated MSA configuration attempting to keep all targets within slitlets. Some targets will be lost in some dithers (due to failed shutters or moving just out of the slitlet). We carefully designed the dithers for each observation to ensure all primary science targets (in the Sunrise Arc) are observed in all 3 dithers.

Our first observation selects weighted targets from our primary MSA catalog. We then downweight / 100 all targets (except Earendel) observed in the first observation. Our second observation uses this new catalog. Then for the third observation, we again downweight / 100 all observed targets, this time including Earendel, enabling us to target the star clusters nearest to it along the arc.

Our MSA catalogs include entries for blank sky regions where we will obtain spectra to measure backgrounds. Most were identified as blank in JWST or HST imaging. Some were outside those fields of view and could contain objects, yielding serendipitous spectra.

The catalogs also include reference objects, measured to be compact (or have compact cores) and isolated as determined in NIRCam images and HST F814W (obtained November 2019) for wider coverage.

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
(1)	WHL0137-08	RA: 01 37 24.9760 (24.3540667d) Dec: -08 27 23.11 (-8.45642d) Equinox: J2000	Epoch of Position: 2015.5	
Comments: This object was generated by the targetselector and retrieved from the SIMBAD database. *Category=Clusters of Galaxies* *Description=[Rich clusters]*				
(21)	WHL0137-MSA	RA: 01 37 23.3360 (24.3472333d) Dec: -08 26 40.42 (-8.44456d) Equinox: J2000		
Comments: *Description=[]*				
(22)	WHL0137-MSA-OBS2	RA: 01 37 23.3360 (24.3472333d) Dec: -08 26 40.42 (-8.44456d) Equinox: J2000		
Comments: Downweighted / 100 most targets (except Earendel) that were observed in the first Observation *Description=[]*				
(23)	WHL0137-MSA-OBS3	RA: 01 37 23.3360 (24.3472333d) Dec: -08 26 40.42 (-8.44456d) Equinox: J2000		
Comments: Downweighted / 100 all targets (including Earendel) that were observed in previous Observations *Description=[]*				

Observation

Proposal 2282, Observation 10: NIRCam Imaging

Fri Dec 30 08:01:00 GMT 2022

Diagnostic Status: Warning

Observing Template: NIRCam Imaging

Diagnostics

(Visit 10:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
(1)	WHL0137-08	RA: 01 37 24.9760 (24.3540667d) Dec: -08 27 23.11 (-8.45642d) Equinox: J2000	Epoch of Position: 2015.5	

Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.
Category=Clusters of Galaxies
Description=[Rich clusters]

Template

Module	Subarray
ALL	FULL

Dithers

#	Primary Dither Type	Primary Dithers	Subpixel Dither Type	Dither Size	Subpixel Positions
1	INTRAMODULEBOX	4	STANDARD		1

Spectral Elements

#	Short Filter	Long Filter	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Dithers	Total Exposure Time	ETC Wkbk.Calc ID
1	F090W	F444W	SHALLOW4	10	1	4	4	2104.407	
2	F115W	F410M	SHALLOW4	10	1	4	4	2104.407	
3	F150W	F356W	SHALLOW4	10	1	4	4	2104.407	
4	F200W	F277W	SHALLOW4	10	1	4	4	2104.407	

Special Requirements

Offset 85.0 arcsec, 0.0 arcsec
Background Limited. Background no more than 40th percentile above minimum

Observation

Proposal 2282, Observation 20: NIRCam Imaging Fri Dec 30 08:01:00 GMT 2022

Diagnostic Status: Warning

Observing Template: NIRCam Imaging

Comments: between copies the desire of 20 after 10 by 60-250 days, which was causing trouble building the 360 STS.

Diagnostics

(Visit 20:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
(1)	WHL0137-08	RA: 01 37 24.9760 (24.3540667d) Dec: -08 27 23.11 (-8.45642d) Equinox: J2000	Epoch of Position: 2015.5	

Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.
Category=Clusters of Galaxies
Description=[Rich clusters]

Template

Module	Subarray
ALL	FULL

Dithers

#	Primary Dither Type	Primary Dithers	Subpixel Dither Type	Dither Size	Subpixel Positions
1	INTRAMODULEBOX	4	STANDARD		1

Spectral Elements

#	Short Filter	Long Filter	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Dithers	Total Exposure Time	ETC Wkbk.Calc ID
1	F090W	F277W	SHALLOW4	10	1	4	4	2104.407	
2	F115W	F356W	SHALLOW4	10	1	4	4	2104.407	

Special Requirements

Between Dates 2022.360 and 2023.095
Offset 85.0 arcsec, 0.0 arcsec
Background Limited. Background no more than 40th percentile above minimum

Group Observations 20, 21, 22, 23 within 3 Days

Observation

Proposal 2282, Observation 21: NIRSpec MSA1

Fri Dec 30 08:01:00 GMT 2022

Diagnostic Status: Warning

Observing Template: NIRSpec MultiObject Spectroscopy

Diagnostics

(NIRSpec MSA1 (Obs 21)) Warning (Form): Config c1 (#1) has 1 filler slits affected by failed closed shutters.

(NIRSpec MSA1 (Obs 21)) Warning (Form): Config c3 (#3) has 1 primary slits affected by failed closed shutters.

(Visit 21:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
(21)	WHL0137-MSA	RA: 01 37 23.3360 (24.3472333d) Dec: -08 26 40.42 (-8.44456d) Equinox: J2000		

Comments:
Description=[]

Acquisition

#	Reference Star Bin	Target	Filter	MSA Configuration	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
1	Filter: F110W; Readout: NRSRAPIDD6; 8 sources in 3 quads; [Reduced Accuracy]	SAME	F110W	Auto Acq MSA Config	NRSRAPIDD6	3	1	4	687.153	

Template

TA Method	Obtain Confirmation Images	Science Aperture	Primary Candidate List	Filler Candidate List	Spectral Overlap Map	Spectral Overlap Threshold
MSATA	No	MSA Center	MSA weight 5 (2078 sources)	MSA weight 5 (2078 sources)	jwst-nirspec-prism	1.5

Reference Stars

Visit	ID	RA	Dec	Magnitude	Visit	ID	RA	Dec	Magnitude
1	144	24.352742	-8.474141	21.867952346801758	1	2252	24.345415	-8.444087	23.555919647216797
1	631	24.359165	-8.466754	23.619800567626953	1	2581	24.365786	-8.439703	23.698989868164062
1	733	24.339491	-8.465720	21.534959793090820	1	2776	24.326772	-8.429344	23.181724548339844
1	2056	24.360068	-8.446904	22.454309463500977	1	3078	24.349013	-8.423769	23.545631408691406

Spectral Elements

#	Exposure Specification	MSA Configuration	Nod Pattern	Pointing	Aperture PA	Dispersion Offset (Shutters)	Cross-Dispersion Offset (Shutters)	Total Dithers	Total Integrations	Total Exposure Time
1	1 (PRISM/CLEAR)	c1		24.335815416666666 Degrees -8.448213888888915 Degrees	197.21391736675213			1	1	1254.645
2	1 (PRISM/CLEAR)	c2		24.335452208333333 Degrees -8.448871388888904 Degrees	197.21397153661148			1	1	1254.645
3	1 (PRISM/CLEAR)	c3		24.334934041666667 Degrees -8.449020000000019 Degrees	197.214047401463			1	1	1254.645

Special Requirements	
	MSA Scheduled Aperture PA 197.2122457 to 197.2122457 Degrees (V3 58.637676 to 58.637676) Group Observations 20, 21, 22, 23 within 3 Days

Observation

Proposal 2282, Observation 22: NIRSpec MSA2

Fri Dec 30 08:01:00 GMT 2022

Diagnostic Status: Warning

Observing Template: NIRSpec MultiObject Spectroscopy

Diagnostics

(NIRSpec MSA2 (Obs 22)) Warning (Form): Config c3 (#3) has 1 primary slits affected by failed closed shutters.

(Visit 22:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
(22)	WHL0137-MSA-OBS2	RA: 01 37 23.3360 (24.3472333d) Dec: -08 26 40.42 (-8.44456d) Equinox: J2000		

Comments: Downweighted / 100 most targets (except Earendel) that were observed in the first Observation
Description=[]

Acquisition

#	Reference Star Bin	Target	Filter	MSA Configuration	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
1	Filter: F110W; Readout: NRSRAPIDD6; 8 sources in 4 quads; [Reduced Accuracy]	SAME	F110W	Auto Acq MSA Config	NRSRAPIDD6	3	1	4	687.153	

Template

TA Method	Obtain Confirmation Images	Science Aperture	Primary Candidate List	Filler Candidate List	Spectral Overlap Map	Spectral Overlap Threshold
MSATA	No	MSA Center	MSA weight 5 Obs2 (2025 sources)	MSA weight 5 Obs2 (2025 sources)	jwst-nirspec-prism	1.5

Reference Stars

Visit	ID	RA	Dec	Magnitude	Visit	ID	RA	Dec	Magnitude
1	238	24.358199	-8.472408	21.552982330322266	1	2755	24.330789	-8.430792	21.487110137939453
1	1251	24.350810	-8.458589	21.762935638427734	1	2776	24.326772	-8.429344	23.181724548339844
1	2174	24.358470	-8.445103	23.100425720214844	1	3885	24.321227	-8.413637	22.567779541015625
1	2498	24.356130	-8.441530	21.399438858032227	1	81151	24.325996	-8.460552	21.710283779504785

Spectral Elements

#	Exposure Specification	MSA Configuration	Nod Pattern	Pointing	Aperture PA	Dispersion Offset (Shutters)	Cross-Dispersion Offset (Shutters)	Total Dithers	Total Integrations	Total Exposure Time
1	1 (PRISM/CLEAR)	c1		24.337103333333335 Degrees -8.445841666666638 Degrees	197.51713530705023			1	1	1254.645
2	1 (PRISM/CLEAR)	c2		24.337112416666667 Degrees -8.446306666666658 Degrees	197.51713482556002			1	1	1254.645
3	1 (PRISM/CLEAR)	c3		24.3365665 Degrees -8.446289999999976 Degrees	197.51721443307048			1	1	1254.645

Special Requirements	
	MSA Scheduled Aperture PA 197.5156557 to 197.5156557 Degrees (V3 58.941086 to 58.941086) Group Observations 20, 21, 22, 23 within 3 Days

Observation

Proposal 2282, Observation 23: NIRSpec MSA3

Fri Dec 30 08:01:00 GMT 2022

Diagnostic Status: Warning

Observing Template: NIRSpec MultiObject Spectroscopy

Diagnostics

(NIRSpec MSA3 (Obs 23)) Warning (Form): Config c1 (#1) has 1 primary slits affected by failed closed shutters.

(NIRSpec MSA3 (Obs 23)) Warning (Form): Config c3 (#3) has 1 filler slits affected by failed closed shutters.

(Visit 23:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
(23)	WHL0137-MSA-OBS3	RA: 01 37 23.3360 (24.3472333d) Dec: -08 26 40.42 (-8.44456d) Equinox: J2000		

Comments: Downweighted / 100 all targets (including Earendel) that were observed in previous Observations
Description=[]

Acquisition

#	Reference Star Bin	Target	Filter	MSA Configuration	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
1	Filter: F110W; Readout: NRSRAPIDD6; 8 sources in 4 quads; [Reduced Accuracy]	SAME	F110W	Auto Acq MSA Config	NRSRAPIDD6	3	1	4	687.153	

Template

TA Method	Obtain Confirmation Images	Science Aperture	Primary Candidate List	Filler Candidate List	Spectral Overlap Map	Spectral Overlap Threshold
MSATA	No	MSA Center	MSA weight 5 Obs3 (1974 sources)	MSA weight 5 Obs3 (1974 sources)	jwst-nirspec-prism	1.5

Reference Stars

Visit	ID	RA	Dec	Magnitude	Visit	ID	RA	Dec	Magnitude
1	631	24.359165	-8.466754	23.619800567626953	1	3078	24.349013	-8.423769	23.545631408691406
1	1251	24.350810	-8.458589	21.762935638427734	1	3885	24.321227	-8.413637	22.567779541015625
1	2464	24.355289	-8.441960	23.611047744750977	1	81151	24.325996	-8.460552	21.710283779504785
1	2776	24.326772	-8.429344	23.181724548339844	1	82316	24.354894	-8.432603	23.658239496217327

Spectral Elements

#	Exposure Specification	MSA Configuration	Nod Pattern	Pointing	Aperture PA	Dispersion Offset (Shutters)	Cross-Dispersion Offset (Shutters)	Total Dithers	Total Integrations	Total Exposure Time
1	1 (PRISM/CLEAR)	c1		24.337249999999997 Degrees -8.444952777777758 Degrees	197.51224629409935			1	1	1254.645
2	1 (PRISM/CLEAR)	c2		24.336730916666667 Degrees -8.445098611111112 Degrees	197.51232227950985			1	1	1254.645
3	1 (PRISM/CLEAR)	c3		24.33642675 Degrees -8.445311666666669 Degrees	197.51236703847028			1	1	1254.645

Special Requirements	
	MSA Scheduled Aperture PA 197.5107897 to 197.5107897 Degrees (V3 58.93622 to 58.93622) Group Observations 20, 21, 22, 23 within 3 Days

Observation

Proposal 2282, Observation 120: NIRCam Imaging Fri Dec 30 08:01:00 GMT 2022

Diagnostic Status: Warning

Observing Template: NIRCam Imaging

Comments: between copies the desire of 20 after 10 by 60-250 days, which was causing trouble building the 360 STS.

Diagnostics

(Visit 120:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
(1)	WHL0137-08	RA: 01 37 24.9760 (24.3540667d) Dec: -08 27 23.11 (-8.45642d) Equinox: J2000	Epoch of Position: 2015.5	

Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.
Category=Clusters of Galaxies
Description=[Rich clusters]

Template

Module	Subarray
ALL	FULL

Dithers

#	Primary Dither Type	Primary Dithers	Subpixel Dither Type	Dither Size	Subpixel Positions
1	INTRAMODULEBOX	4	STANDARD		1

Spectral Elements

#	Short Filter	Long Filter	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Dithers	Total Exposure Time	ETC Wkbk.Calc ID
1	F090W	F277W	SHALLOW4	10	1	4	4	2104.407	
2	F115W	F356W	SHALLOW4	10	1	4	4	2104.407	

Special Requirements

Between Dates 2022.360 and 2023.095
Offset 85.0 arcsec, 0.0 arcsec