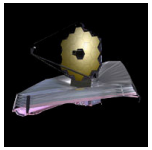

4287 - Deep Spectroscopy of the First Ionized Bubbles: New Insight into the Beginning of Reionization

Cycle: 2, Proposal Category: GO

INVESTIGATORS

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OBSERVATIONS

Folder	*Observation*	*Label*	*Observing Template*	*Science Target*
Observation Folder				
	1	EGSYz8p7-Pointing-1_replanned	NIRSpec MultiObject Spectroscopy	(12) EGSbubbles_aptcat_v7
	2	EGSYz8p7-Pointing-3_replanned	NIRSpec MultiObject Spectroscopy	(12) EGSbubbles_aptcat_v7
	3	EGSYz8p7-Pointing-4_replanned	NIRSpec MultiObject Spectroscopy	(12) EGSbubbles_aptcat_v7

ABSTRACT

The detection of Lyman-alpha (Lya) in two z~9 galaxies, separated by just 3.6 pMpc, challenges our understanding of Reionization. These are the only known galaxies detected with Lya emission above z>8 and the region around them is likely overdense at z~9. It is has been suggested that they both reside within one of the Universe's first large ionized bubbles, allowing Lya to propagate without significant attenuation by intergalactic neutral hydrogen. However, given our current understanding of reionization and early star formation, such large bubbles are not predicted to exist at z~9. Here we propose to take a significant step in our understanding of the beginning of reionization by performing deep NIRSpec spectroscopy in the region around these galaxies, with the goal of verifying whether the entire large region is ionized.

We propose to target 20 UV-faint (m<28.5) galaxies selected from NIRCam imaging and obtain deep rest-frame UV to optical spectra with NIRSpec/MSA. This will spectroscopically confirm z~9 galaxies in this unique region via [OIII]5007 and test the existence of a large ionized bubble, previously impossible before JWST. These observations will enable us to: (1) confirm or rule out the existence of a large (>1-3.6 pMpc) ionized bubble; (2) spectroscopically confirm the candidate z~9 overdensity and map the distribution of galaxies in 3D; (3) infer the ionizing properties of these galaxies, allowing us to understand how such a bubble formed at such early times. This will provide a critical step for understanding the first stages of reionization, with significant implications for our understanding of early (z>9-15) star formation and structure formation.

OBSERVING DESCRIPTION

We will target the the region around the z~8.7 LAE EGSY8p7 using NIRSpec with NIRCam imaging in parallel. We will observe in 3 pointings.

Our science goal requires the high resolution gratings, with 4 hours of exposure in G140H/F100LP, and 1 hour of exposure in G395H/F290LP. In order to create MOS configurations, we compiled a catalog of photometrically selected sources from existing JWST/NIRCam and HST imaging in the field. Due to the deep photometric data in this field we are able to make efficient use of the MSA multiplexing.

We use the MSA planning tool to design the MOS configurations and create the observations.

For dithering, we choose to nod in the 3-shutter slitlet, which is appropriate for our spatially compact high redshift galaxy targets. This approach has less overhead and maximizes multiplexing efficency, compared to the fixed or flexible dithering options that require additional MSA configurations. At the time of flight-ready program submission, we will include extra background shutters in empty parts of the MSA, in order to ensure reliable background subtraction.

We set up our NIRSpec exposures using NRSIRS2, which is recommended for deep observations. Each NIRSpec exposure is given 16 groups per

integration.

For the pointing (Obs 3) which overlaps with existing NIRCam imaging we divide our observations into 2 exposure slots. Exposure 1 contains 4 integrations of G140H/F100LP and Exposure 2 contains 1 integration of G395H/F290LP. NIRCam imaging will be obtained in parallel to the 2 exposures in F090W and F480M using readout pattern MEDIUM8, with 10 groups per integration. This corresponds to a total exposure time of ~4.5 hours for each NIRCam band.

For the pointings which do not overlap with existing NIRCam imaging, we divide our NIRSpec observations into 3 exposure slots. Exposures 1 and 2 each contain 2 integrations of G140H/F100P and Exposure 3 contains 1 integration of G395H/F290LP. In Exposure 1 we will obtain NIRCam parallel imaging in F115W and F444W (6635 seconds) with 7 groups per integration, in Exposure 2 will obtain imaging in F150W and F356W (6635 seconds) with 7 groups per integration, and in Exposure 3 imaging in F200W and F277W with 10 groups/integration (3157 seconds).

All NIRCam observations are taken in MEDIUM8 and reach 5sigma depths of m~28.9-29.4 AB in the wide bands and m~28.1 in F480M for a point source.

Proposal 4287 - Targets - Deep Spectroscopy of the First Ionized Bubbles: New Insight into the Beginning of Reionization

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
(12)	EGSbubbles_aptcat_v7	RA: 14 19 36.9548 (214.9039783d) Dec: +52 52 20.68 (52.87241d) Equinox: J2000		

Comments:
Description=[]

Observation

Proposal 4287, Observation 1: EGSYz8p7-Pointing-1_replanned Thu Feb 29 17:00:50 GMT 2024

Diagnostic Status: Warning

Observing Template: NIRSpec MultiObject Spectroscopy

Coordinated Parallel Template(s): NIRCam Imaging

Diagnostics

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

(Visit 1:1) Warning (Form): The recommended value is 8 Reference Stars for this template.

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
(12)	EGSbubbles_aptcat_v7	RA: 14 19 36.9548 (214.9039783d) Dec: +52 52 20.68 (52.87241d) Equinox: J2000		

Comments:
Description=[]

Acquisition

NIRSpec MultiObject Spectroscopy	Reference Star Bin	Target	Filter	MSA Configuration	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
1	Filter: F140X; Readout: NRSRAPIDD6; 7 sources in 3 quads; [Optimal TA Accuracy]	SAME	F140X	Auto Acq MSA Config	NRSRAPIDD6	3	1	4	687.153	

Template

NIRSpec MultiObject Spectroscopy	NIRCam Imaging
TA Method: MSATA	Module: ALL
Obtain Confirmation Images: No	Subarray: FULL
Science Aperture: MSA Center	Target Placement: Module Gap
Primary Candidate List: EGSbubbles_allhighprio (91 sources)	
Filler Candidate List: null	
Spectral Overlap Map: jwst-nirspec-hr	
Spectral Overlap Threshold: 1.5	

Reference Stars

Visit	ID	RA	Dec	Magnitude	Visit	ID	RA	Dec	Magnitude
1	50835	214.987216	52.856114	22.758760587108192	1	80618	215.012321	52.907329	23.39941389852575
1	57508	214.959841	52.867804	23.033361926099538	1	80741	214.970336	52.907090	22.557541201322984
1	57961	214.977597	52.868527	23.84444270738204	1	82068	215.018275	52.909748	23.614840350214177
1	75263	215.019817	52.900675	23.7652654357437					

Dithers

#	Dither Type
1	NONE

Spectral Elements

NIRSpec MultiObject Spectroscopy	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 (G140H/F100LP)	c1	3 Shutter Slitlet	215.0046225 Degrees 52.881591666666 665 Degrees	359.72624111774 65			3	6	7090.201
2	1 (G140H/F100LP)	c1	3 Shutter Slitlet	215.0046225 Degrees 52.881591666666 665 Degrees	359.72624111774 65			3	6	7090.201
3	2 (G395M/F290LP)	c1	3 Shutter Slitlet	215.0046225 Degrees 52.881591666666 665 Degrees	359.72624111774 65			3	3	3545.1

Spectral Elements

NIRCam Imaging	Short Filter	Long Filter	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Dithers	Total Exposure Time	ETC Wkbk.Calc ID
1	F115W	F444W	MEDIUM8	7	3	9	3	6635.324	
2	F150W	F356W	MEDIUM8	7	3	9	3	6635.324	
3	F200W	F277W	MEDIUM8	10	1	3	3	3156.61	

Special Requirements

No Parallel Attachments
MSA Scheduled Aperture PA 359.6461 to 359.6461 Degrees (V3 221.07149 to 221.07149)

Observation

Proposal 4287, Observation 2: EGSYz8p7-Pointing-3_replanned Thu Feb 29 17:00:50 GMT 2024

Diagnostic Status: Warning

Observing Template: NIRSpec MultiObject Spectroscopy

Coordinated Parallel Template(s): NIRCam Imaging

Diagnostics

(Visit 2:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
(12)	EGSbubbles_aptcat_v7	RA: 14 19 36.9548 (214.9039783d) Dec: +52 52 20.68 (52.87241d) Equinox: J2000		

Comments:
Description=[]

Acquisition

NIRSpec MultiObject Spectroscopy	Reference Star Bin	Target	Filter	MSA Configuration	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
1	Filter: F140X; Readout: NRSRAPIDD6; 8 sources in 3 quads; [Optimal TA Accuracy]	SAME	F140X	Auto Acq MSA Config	NRSRAPIDD6	3	1	4	687.153	

Template

NIRSpec MultiObject Spectroscopy	NIRCam Imaging
TA Method: MSATA	Module: ALL
Obtain Confirmation Images: No	Subarray: FULL
Science Aperture: MSA Center	Target Placement: Module Gap
Primary Candidate List: EGSbubbles_allhighprio (91 sources)	
Filler Candidate List: null	
Spectral Overlap Map: jwst-nirspec-hr	
Spectral Overlap Threshold: 1.5	

Reference Stars

Visit	ID	RA	Dec	Magnitude	Visit	ID	RA	Dec	Magnitude
1	84348	214.951895	52.940693	24.37152332579662 7	1	87694	214.915541	52.933361	23.81810923643165
1	85945	214.895566	52.937332	23.68651867537908 4	1	89390	214.950067	52.929922	23.90950036490665
1	87529	214.957880	52.933923	24.09401587820067 2	1	124108	214.950018	52.961849	24.58901005583846 8
1	87546	214.953804	52.933686	24.75258875497920 7	1	125952	214.945211	52.957836	22.5369364505664

Dithers

#	Dither Type
1	NONE

Spectral Elements

NIRSpec MultiObject Spectroscopy	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 (G140H/F100LP)	c1	3 Shutter Slitlet	214.93550916666666 Degrees 52.945911111111 11 Degrees	359.6677215340388			3	12	14180.401
2	2 (G395M/F290LP)	c1	3 Shutter Slitlet	214.93550916666666 Degrees 52.945911111111 11 Degrees	359.6677215340388			3	3	3545.1

Spectral Elements

NIRCam Imaging	Short Filter	Long Filter	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Dithers	Total Exposure Time	ETC Wkbk.Calc ID
1	F090W	F480M	MEDIUM8	10	4	12	3	12723.072	
2	F090W	F480M	MEDIUM8	10	1	3	3	3156.61	

Special Requirements

No Parallel Attachments
MSA Scheduled Aperture PA 359.6425 to 359.6425 Degrees (V3 221.06795 to 221.06795)

Observation

Proposal 4287, Observation 3: EGSYz8p7-Pointing-4_replanned Thu Feb 29 17:00:50 GMT 2024

Diagnostic Status: Warning

Observing Template: NIRSpec MultiObject Spectroscopy

Coordinated Parallel Template(s): NIRCam Imaging

Diagnostics

(Visit 3:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.

(Visit 3:1) Warning (Form): The recommended value is 8 Reference Stars for this template.

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
(12)	EGSbubbles_aptcat_v7	RA: 14 19 36.9548 (214.9039783d) Dec: +52 52 20.68 (52.87241d) Equinox: J2000		

Comments:
Description=[]

Acquisition

NIRSpec MultiObject Spectroscopy	Reference Star Bin	Target	Filter	MSA Configuration	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
1	Filter: F140X; Readout: NRSRAPID; 7 sources in 4 quads; [Optimal TA Accuracy]	SAME	F140X	Auto Acq MSA Config	NRSRAPID	3	1	4	171.788	

Template

NIRSpec MultiObject Spectroscopy	NIRCam Imaging
TA Method: MSATA	Module: ALL
Obtain Confirmation Images: No	Subarray: FULL
Science Aperture: MSA Center	Target Placement: Module Gap
Primary Candidate List: EGSbubbles_allhighprio (91 sources)	
Filler Candidate List: null	
Spectral Overlap Map: jwst-nirspec-hr	
Spectral Overlap Threshold: 1.5	

Reference Stars

Visit	ID	RA	Dec	Magnitude	Visit	ID	RA	Dec	Magnitude
1	45829	214.830812	52.846662	22.091985791585437	1	59468	214.876880	52.870967	21.522393766631943
1	47877	214.887695	52.850924	22.749774783547725	1	66197	214.836601	52.881922	21.156521025772246
1	50331	214.905539	52.855459	22.52940093379893	1	69929	214.889421	52.890612	22.17129987579001
1	51001	214.895620	52.856497	22.909036114549174					

Dithers

#	Dither Type
1	NONE

Spectral Elements

NIRSpec MultiObject Spectroscopy	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 (G140H/F100LP)	c1	3 Shutter Slitlet	214.8620675 Degrees 52.863997222222 224 Degrees	359.4674572021369			3	6	7090.201
2	1 (G140H/F100LP)	c1	3 Shutter Slitlet	214.8620675 Degrees 52.863997222222 224 Degrees	359.4674572021369			3	6	7090.201
3	2 (G395M/F290LP)	c1	3 Shutter Slitlet	214.8620675 Degrees 52.863997222222 224 Degrees	359.4674572021369			3	3	3545.1

Spectral Elements

NIRCam Imaging	Short Filter	Long Filter	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Dithers	Total Exposure Time	ETC Wkbk.Calc ID
1	F115W	F444W	MEDIUM8	7	3	9	3	6635.324	
2	F150W	F356W	MEDIUM8	7	3	9	3	6635.324	
3	F200W	F277W	MEDIUM8	10	1	3	3	3156.61	

Special Requirements

No Parallel Attachments
MSA Scheduled Aperture PA 359.5008 to 359.5008 Degrees (V3 220.92627 to 220.92627)