



7436 - The Last Neutral Islands at the End of Reionization? Characterizing the Nature of the Longest Dark Gaps in IGM Transmission at $z \sim 5.3$

Cycle: 4, Proposal Category: GO

INVESTIGATORS

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Dr. Haowen Zhang (CoI)	University of Arizona
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OBSERVATIONS

<i>Folder</i>	<i>Observation</i>	<i>Label</i>	<i>Observing Template</i>	<i>Science Target</i>
Observation Folder				
	1		NIRCam Wide Field Slitless Spectroscopy	(1) PSOJ340-18
	2		NIRCam Wide Field Slitless Spectroscopy	(2) PSOJ183-12

ABSTRACT

Understanding when and how reionization happened is crucial for studying early structure formation and the properties of first galaxies in the Universe. During cosmic reionization, ionized regions gradually grew and overlapped in the IGM. At $z > 6$, complete Gunn-Peterson troughs observed in the Ly- α forest of quasar spectra indicate ongoing reionization. At $z \sim 5.5$, the average Ly- α effective optical depth suggests that most of the IGM is already highly ionized. However, some quasar sightlines still exhibit long troughs with no detectable flux (so-called “dark gaps”) in Ly- α forests even at $z < 5.5$. These long dark gaps could be the last remaining neutral islands in the IGM at the end of a highly inhomogeneous reionization process. If confirmed, it will have profound impact on the physics of reionization. We propose for joint JWST and Keck observations to study galaxy properties around two lowest-redshift long dark gaps known detected quasar absorption spectra at $z = 5.3$. NIRCam/WFSS will measure the H- α redshift of ~ 230 galaxies (~ 75 in dark gap regions) and joint Keck observations will probe Ly- α emission from detected galaxies.

If long dark gaps are indeed neutral islands, we expect a significant lower Ly- α visibility, and a large Ly- α /H α velocity offset, among JWST-detected H- α emitters in the dark gap regions due to saturated IGM absorption. We will also characterize the galaxy density field around long dark gaps. This joint program will allow us to directly test the ultra-late reionization model and to place robust constraints on the topology of reionization and the nature of inhomogeneous reionization.

OBSERVING DESCRIPTION

We will use 18.4 hours of JWST time and 2 dark/grey Keck nights in 2026A to carry out JWST/NIRCam Wide-Field Slitless Spectroscopy (WFSS) and joint Keck/DEIMOS multi-object spectroscopy in two quasar fields at $z \sim 6$. Two long troughs with no detectable flux (so-called “dark gaps”) at $z \sim 5.3$ have been identified in Lyman-alpha forests of these two quasars. We will perform WFSS observations with Grism R and F410M filter, detecting $z \sim 4.9-5.6$ H-alpha emission, covering the redshift range of two long dark gaps. Deep imaging in F090W will be obtained simultaneously with WFSS. We will perform NIRCam direct imaging in F200W and F410M to achieve a source identification of H-alpha emitters detected in WFSS F410M and to constrain the physics properties of detected H-alpha emitters together with F090W imaging. The identification of $z \sim 5$ H-alpha emitters can be achieved through color-selection using proposed imaging together with a single line detection in F410M WFSS. We expect to detect ~ 230 H-alpha emitters at $z \sim 4.9-5.6$ in two quasar fields.

JWST Proposal 7436 (Created: Friday, June 13, 2025, 5:00:23PM Eastern Standard Time) - Overview

We will use both module A and B to increase the sky coverage. For each quasar field, we will have four visits to compose a 2*2 mosaic with a 10% row overlap and a 73% column overlap. This will achieve a full-spectrum coverage in F410M within a field of view size of 6.2*4.0 arcmin². The quasar will be placed at the center of the mosaic. We will employ the SHALLOW4 readout pattern and 3-point INTRAMODULEX, with 2-point subpixel positions for WFSS exposures. The total exposure time of WFSS F410M (SW F090W imaging) for each visit is 3156.2s. The total direct imaging exposure time for each visit (including out-of-field imaging) in F200W and F410M will be 1578.3s.

We will perform direct Lyman-alpha spectroscopy of detected H-alpha emitters with joint Keck/DEIMOS observations. We will use the GG455 order-blocking filter and the 830G grating to ensure the highest efficiency to observe Lyman-alpha emission of H-alpha emitters. This will measure the Lyman-alpha visibility and Lyman-alpha velocity of the JWST-detected H-alpha emitters around the long dark gap. We will use one night to observe Lyman-alpha emission from detected H-alpha emitters in each quasar field with DEIMOS. We request 2 Keck/DEIMOS nights in 2026A in total to observe the two proposed quasar fields.

Proposal 7436 - Targets - The Last Neutral Islands at the End of Reionization? Characterizing the Nature of the Longest Dark Gaps in...

Fixed Targets	#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
	(1)	PSOJ340-18	RA: 22 40 49.0000 (340.2041667d) Dec: -18 39 43.80 (-18.66217d) Equinox: J2000 <i>Comments:</i> Category=Galaxy Description=[High-redshift galaxies, Quasars] Extended=NO		
(2)	PSOJ183-12	RA: 12 13 11.8000 (183.2991667d) Dec: -12 46 3.50 (-12.76764d) Equinox: J2000 <i>Comments:</i> Category=Galaxy Description=[High-redshift galaxies, Quasars] Extended=NO			

Proposal 7436 - Observation 1 - The Last Neutral Islands at the End of Reionization? Characterizing the Nature of the Longest Dark G...

Fri Jun 13 22:00:23 GMT 2025

Observation	Proposal 7436, Observation 1 Diagnostic Status: Warning Observing Template: NIRCam Wide Field Slitless Spectroscopy																																								
	(Observation 1) Warning (Form): For Module=ALL the default target location is in the gap between the modules. (Observation 1) Warning (Form): Use of only one of GRISMR or GRISMC may result in spectral overlap from multiple sources that can't be corrected. Users should address this issue in their proposal text. (Visit 1:1) Warning (Form): Overheads are provisional until the Visit Planner has been run. (Visit 1:2) Warning (Form): Overheads are provisional until the Visit Planner has been run. (Visit 1:3) Warning (Form): Overheads are provisional until the Visit Planner has been run. (Visit 1:4) Warning (Form): Overheads are provisional until the Visit Planner has been run.																																								
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	1	F200W	F410M	SHALLOW4	10	1	1	526.102		GRISMR	Direct Image	1																													
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Special Requirements

Before Date 01-FEB-2026:00:00:00
Sequence Visits within 53.0 Days
Visits Same PA

Proposal 7436 - Observation 2 - The Last Neutral Islands at the End of Reionization? Characterizing the Nature of the Longest Dark G...

Fri Jun 13 22:00:23 GMT 2025

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