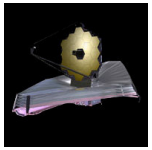

12396 - What Lies at the Hearts of the Little Red Dots? Efficient, Ultra-Deep Observations of the ''Black Hole Stars'' MoM-BH*-1 and The Cliff

Cycle: 5, Proposal Category: GO

INVESTIGATORS

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OBSERVATIONS

Folder	*Observation*	*Label*	*Observing Template*	*Science Target*
NIRCam Imaging				
	1		NIRCam Imaging	(3) MidPoint
MIRI/LRS Spectroscopy				
	3	MoMBHs-MIRI	MIRI Low Resolution Spectroscopy	(2) MoM-BHstar
NIRSpec				

Folder	*Observation*	*Label*	*Observing Template*	*Science Target*
	5	plan1	NIRSpec MultiObject Spectroscopy	(4) cliff-bhstar

ABSTRACT

Perhaps the most stunning surprise from JWST this year has been the discovery of two so-called ``black hole stars" (BH*s). These objects have singular spectra with no comparison. They are marked by extreme Balmer breaks, blackbody-like SEDs, and appear like *single stars* with extraordinary luminosity -- but lying at z=3.5 and z=7.8! The most successful models able to match these objects invoke accreting black holes that are so blanketed in dense gas that they effectively radiate like 1000 AU stars. These objects have electrified the community. Are these truly black hole "stars"? Have we finally found the elusive Super-Eddington intermediate mass black holes? Might BH*s solve the mystery of the Little Red Dots?

Exploiting the remarkable fortune that these sources lie within 60 arcsec of each other, here we propose efficient, ultra-deep observations of these sources at all wavelengths JWST can cover. We will:

(i) Test whether ``stellar atmospheres" truly describe BH* physics with sensitive measurements of the Balmer break, the Calcium Triplet, Iron lines and the full shape of their UV-IR SEDs.

(ii) Bracket their black hole masses using multiple Balmer and Paschen lines that will help deconvolve the motions of a broad-line region (if it exists) from scattering in the atmosphere.

(iii) Reveal their almost invisible host galaxies, which may be among the most primordial galaxies discovered with JWST yet.

This program will establish *the* benchmark for the detailed physics powering a new class of astrophysical objects. With these observations we may then unravel the LRDs to place this exciting new population in our picture of black hole growth across the cosmos.

OBSERVING DESCRIPTION

We propose to observe two remarkable Little Red Dots, The Cliff (de Graaff+ 2025) and MoM-BH*-1 (Naidu+ 2025), which are located just 60 arcseconds apart in the UDS field.

We will obtain a complete, in-depth view of these two sources, using multiple JWST instruments.

NIRCam imaging: We will observe a single blue filter (F150W) for 6.0h reaching a 3 nJy point source depth (5sigma) in order to obtain deep contraints on the rest-UV flux from a possible host galaxy. The exposures are divided such that we will observe four long-wavelength filters, divided equally between F277W, F356W, F410M and F444W. We use a 3-point dither pattern, integrating for 9 groups in the DEEP8 readout mode.

MIRI low-resolution spectroscopy: We will obtain MIRI LRS spectra to obtain constraints on the Halpha line (for MoM-BH*). The exposure time is 4.5 hours, chosen to ensure a 5-sigma detection in the most conservative scenario, i.e. case B recombination from the reddest available HI transition in the NIRSpec spectrum. Our observing strategy is similar to other deep MIRI/LRS extragalactic programs, using 115 groups/integration 13 integrations per exposure, and a 2-point nodded dither. We perform target acquisition using a nearby bright Gaia star. We request a verification image in F560W as per recommended best practice.

NIRSpec/MSA spectroscopy: The two targets are conveniently located on the sky, such that they can be observed simultaneously in a single MSA quadrant. We will observe with the G235M grating for 9.3 hours to constrain the rest-optical of the Cliff and the rest-UV of MoM-BH*. The depth was chosen to ensure continuum SNR>5/pix up to the Hdelta Balmer transition. We will also observe with the G395H grating to obtain detailed kinematic constraints of the Hbeta and OIII lines of MoM-BH*, with a depth chosen to ensure that absorption features and kinematics can be robustly constrained (expected SNR~10/pix around Hbeta). We open 5 shutters using a 3-point nodding pattern, to allow for optimal background subtraction.

Because all our observations are background limited, we request backgrounds no higher than the 20th percentile above the minimum.

Updates on April 28th, 2026: 1) Added Category and Description information on targets; 2) Restored the Gaia TA star for MIRI LRS that was deleted when the Cliff was nixed from this program (being observed by GO-10445); 3) Added F560W LRS verification image as per recommendation of instrument scientist; 4) Updated this observing description.

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
(2)	MoM-BHstar	RA: 02 17 35.3962 (34.3974842d) Dec: -05 08 6.42 (-5.13512d) Equinox: J2000	Epoch of Position: 2000	
Comments: *Category=Galaxy* *Description=[Active galactic nuclei, High-redshift galaxies]*				
(3)	MidPoint	RA: 02 17 35.7559 (34.3989829d) Dec: -05 07 32.28 (-5.12563d) Equinox: J2000		
Comments: *Category=Galaxy* *Description=[Active galactic nuclei, High-redshift galaxies, Infrared galaxies]*				
(4)	cliff-bhstar	RA: 02 17 38.5798 (34.4107492d) Dec: -05 07 46.79 (-5.12966d) Equinox: J2000		
Comments: *Description=[]*				
(5)	TA_LRS	RA: 02 17 38.1836 (34.4090983d) Dec: -05 08 24.54 (-5.14015d) Equinox: J2000	Epoch of Position: 2000	
*Comments: Target acquisition (TA) star for Cliff and MoM-BH** *Coordinates are from Gaia DR3 with identification 2489654282199721088.* *Alternate names are PS1 101830344089802205 and SDSS13 1237679322324205740.* *Proper motions and annual parallax are unknown for this source according to Gaia DR3.* *(G = 21.266575 mag; BP = 19.647886 mag; RP = 18.407818 mag; BP - RP = 1.240068 mag)* *Category=Star* *Description=[G stars]*				

Observation

Proposal 12396, Observation 1

Fri May 01 01:00:16 GMT 2026

Diagnostic Status: Warning

Observing Template: NIRCam Imaging

Diagnostics

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

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
(3)	MidPoint	RA: 02 17 35.7559 (34.3989829d) Dec: -05 07 32.28 (-5.12563d) Equinox: J2000		

Comments:
Category=Galaxy
Description=[Active galactic nuclei, High-redshift galaxies, Infrared galaxies]

Template

Module	Subarray	Target Placement
ALL	FULL	Module A center (small extended source)

Dithers

#	Primary Dither Type	Primary Dithers	Subpixel Dither Type	Dither Size	Subpixel Positions
1	INTRAMODULEBOX	3	STANDARD		1

Spectral Elements

#	Short Filter	Long Filter	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Dithers	Total Exposure Time	Optional ETC ID
1	F150W	F444W	DEEP8	9	1	3	3	5411.332	
2	F150W	F277W	DEEP8	9	1	3	3	5411.332	
3	F150W	F356W	DEEP8	9	1	3	3	5411.332	
4	F150W	F410M	DEEP8	9	1	3	3	5411.332	

Special Requirements

Background Limited. Background no more than 20th percentile above minimum
Fiducial Point Override NRCAS_FULL

Observation

Proposal 12396, Observation 3: MoMBHs-MIRI

Fri May 01 01:00:16 GMT 2026

Diagnostic Status: Warning

Observing Template: MIRI Low Resolution Spectroscopy

Diagnostics

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

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
(2)	MoM-BHstar	RA: 02 17 35.3962 (34.3974842d) Dec: -05 08 6.42 (-5.13512d) Equinox: J2000	Epoch of Position: 2000	

Comments:
Category=Galaxy
Description=[Active galactic nuclei, High-redshift galaxies]

Acquisition

#	Target	Filter	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Exposure Time	Optional ETC ID
1	5 TA_LRS	F560W	FAST	10	1	1	27.75	274795

Template

Subarray	Obtain Verification Image?
FULL	true

Mosaic

Rows	Columns	Row Overlap %	Column Overlap %	Row shift (deg)	Column shift (deg)	Tile Order
1	2	100.0	100.0	0.0	0.0	DEFAULT

Dithers

#	Dither Type	No. Spectral Steps	Spectral Step Offset	No. Spatial Steps	Spatial Step Offset
1	ALONG SLIT NOD				

Pointing Verification

#	PV Readout Pattern	PV Groups/Int	PV Integrations/Exp	PV Total Integrations	PV Exposures/Dith	PV Total Dithers	PV Total Exposure Time	Optional ETC ID	Filter
1	FASTR1	119	1	1	1	1	330.23		F560W

Spectral Elements

#	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Exposures/Dith	Total Dithers	Total Exposure Time	Optional ETC ID
1	FASTR1	115	13	26	1	2	8363.971	

Special Requirements

Background Limited. Background no more than 20th percentile above minimum

Observation

Proposal 12396, Observation 5: plan1

Fri May 01 01:00:16 GMT 2026

Diagnostic Status: Warning

Observing Template: NIRSpec MultiObject Spectroscopy

Diagnostics

(plan1 (Obs 5)) Warning (Form): Config c1 (#1) has 1 primary slits affected by failed closed shutters.
(plan1 (Obs 5)) Warning (Form): Config c1 (#2) has 1 primary slits affected by failed closed shutters.
(plan1 (Obs 5)) Warning (Form): Config c1 (#3) has 1 primary slits affected by failed closed shutters.
(plan1 (Obs 5)) Warning (Form): Config c1 (#4) has 1 primary slits affected by failed closed shutters.
(plan1 (Obs 5)) Warning (Form): Config c1 (#5) has 1 primary slits affected by failed closed shutters.
(plan1 (Obs 5)) Warning (Form): Config c1 (#6) has 1 primary slits affected by failed closed shutters.
(plan1 (Obs 5)) Warning (Form): Config c1 (#7) has 1 primary slits affected by failed closed shutters.
(plan1 (Obs 5)) Warning (Form): Config c1 (#8) has 1 primary slits affected by failed closed shutters.
(plan1 (Obs 5)) Warning (Form): Config c1 (#9) has 1 primary slits affected by failed closed shutters.
(Visit 5:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.
(Visit 5:2) Warning (Form): Overheads are provisional until the Visit Planner has been run.
(Visit 5:3) Warning (Form): Overheads are provisional until the Visit Planner has been run.

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
(4)	cliff-bhstar	RA: 02 17 38.5798 (34.4107492d) Dec: -05 07 46.79 (-5.12966d) Equinox: J2000		

Comments:
Description=[]

Acquisition

#	Reference Star Bin	Target	Filter	MSA Configuration	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Exposure Time	Optional ETC ID
1		SAME	F140X	Auto Acq MSA Config	NRSRAPID	3	1	4	171.788	
2		SAME	F140X	Auto Acq MSA Config	NRSRAPID	3	1	4	171.788	
3		SAME	F140X	Auto Acq MSA Config	NRSRAPID	3	1	4	171.788	

Template

TA Method	HFF Readout Mode	Obtain Confirmation Images	Science Aperture	Primary Candidate List	Filler Candidate List	Spectral Overlap Map	Spectral Overlap Threshold
MSATA	false	No	MSA Center	cliff-bhstar (2 sources)		jwst-nirspec-hr	1.5

Reference Stars

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 (G235M/F170LP)	c1	5 Shutter Slitlet With Gaps	34.408599833333 334 Degrees - 5.1201205555555 59 Degrees	200.00017222481 438			3	12	16806.401
2	1 (G235M/F170LP)	c1	5 Shutter Slitlet With Gaps	34.408599833333 334 Degrees - 5.1201205555555 59 Degrees	200.00017222481 438			3	12	16806.401
3	2 (G395H/F290LP)	c1	5 Shutter Slitlet With Gaps	34.408599833333 334 Degrees - 5.1201205555555 59 Degrees	200.00017222481 438			3	12	16806.401
4	2 (G395H/F290LP)	c1	5 Shutter Slitlet With Gaps	34.408599833333 334 Degrees - 5.1201205555555 59 Degrees	200.00017222481 438			3	12	16806.401
5	2 (G395H/F290LP)	c1	5 Shutter Slitlet With Gaps	34.408599833333 334 Degrees - 5.1201205555555 59 Degrees	200.00017222481 438			3	12	16806.401
6	2 (G395H/F290LP)	c1	5 Shutter Slitlet With Gaps	34.408599833333 334 Degrees - 5.1201205555555 59 Degrees	200.00017222481 438			3	12	16806.401
7	2 (G395H/F290LP)	c1	5 Shutter Slitlet With Gaps	34.408599833333 334 Degrees - 5.1201205555555 59 Degrees	200.00017222481 438			3	12	16806.401
8	2 (G395H/F290LP)	c1	5 Shutter Slitlet With Gaps	34.408599833333 334 Degrees - 5.1201205555555 59 Degrees	200.00017222481 438			3	12	16806.401
9	2 (G395H/F290LP)	c1	5 Shutter Slitlet With Gaps	34.408599833333 334 Degrees - 5.1201205555555 59 Degrees	200.00017222481 438			3	12	16806.401

Special Requirements

Group Visits within 53.0 Days
Visits Same PA
Background Limited. Background no more than 20th percentile above minimum
MSA Planned Aperture PA 200.0000 to 200.0000 Degrees (V3 61.4254303 to 61.4254303)