JWST Proposal 2249 (Created: Thursday, September 29, 2022 at 1:00:53 PM Eastern Standard Time) - Overview



# 2249 - Monster in the Early Universe: Unveiling the Nature of a Dust Reddened Quasar Hosting a Ten-Billion Solar Mass Black Hole at z=7.1

Cycle: 1, Proposal Category: GO

# **INVESTIGATORS**

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Minghao Yue (CoI)	University of Arizona	yuemh@email.arizona.edu

# **OBSERVATIONS**

Folder	Observation	Label	Observing Template	Science Target
Observa	ation Folder			
	1	NIRSPEC_IFU	NIRSpec IFU Spectroscopy	(1) J0038-0653
	2	MIRI_Imaging	MIRI Imaging	(1) J0038-0653
	3	MIRI_Imaging	MIRI Imaging	(1) J0038-0653
	4	MIRI_F2550W_Imagin	MIRI Imaging	(3) J0038-0653-COPY-MIRI
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	5	MIRI_im_sky	MIRI Imaging	(2) MIRI-SKY

# ABSTRACT

The discovery of z>7 quasars hosting billion solar mass supermassive black holes (SMBHs) places the strongest constraints on the formation of the earliest SMBHs in the universe. These quasars are also signposts of the assembly of the early massive galaxies during the epoch of reionization. Is

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there an upper limit on BH masses and the rate of their growth in the early universe? Recently, a luminous quasar at z=7.1 has been discovered to host a SMBH with at least 10 billion solar masses. It also shows evidence of strong dust reddening based on ground-based spectroscopy. Its rest-frame UV continuum shape is highly unusual, suggestive of extinction due to supernova produced dust. However, the total extinction is completely unconstrained with ground-based data, therefore the SMBH mass is only a lower limit. We propose to carry out JWST observations to obtain its rest-frame optical spectrum and broad-band SED in the near-infrared. The first goal is to accurately measure its BH mass based on its H-beta line and bolometric luminosity fully corrected for extinction, in order to confirm the first detection of a BH with mass exceeding 10 billion solar masses in the early universe. The same data will be used to characterize the nature of dust extinction and test whether supernova dust can explain its continuum shape. The modest JWST program proposed here will unveil the nature of this remarkable quasar at the epoch of reionization, and provide new insight in the growth of the most massive BHs in the early universe and their connections to galaxy formation.

#### **OBSERVING DESCRIPTION**

We will use NIRSpec IFU Prism and G395H/F290LP and MIRI imaging modes to observe a new z=7.06 reddened quasar. Given our science goals, estimated using the JWST ECT, the total science time is 2.2 hours, and the total charged time is 5.5 hours.

#### 1. NIRSpec IFU, 1.9 hours sicence, 3.1 hours total

We choose IFU instead of Fixed Slit mode becuase there is not slit-loss and the overhead time is shorter. Slit-loss will significantly affect the accuracy of extinction curve measurement and also quasar continuum fitting. NRSIRS2RAPID readout mode CYCLING dither are used.

- IFU Prism: this mode is chosen to take spectrscopy in the full wavelength for the study of dust extcintion. With only 0.5 hour on-source integration, we can detect the quasar continuum from 1 micron to 5 micron at S/N > 20 per pixel, which will allow a precise measurement of the dust extinction curve.

- G395H/F290LP: we request 4,726s on-source time to detect the continuum around H-beta and [OIII] lines at S/N  $>\sim$  20 per pixel. This S/N is required to measure the continuum and broad line width to 5-10% precision, corresponding to  $\sim$ 20% accuracy in black hole mass measurement.

#### 2. MIRI imaging, 0.3 hours sicence, 2.4 hours total

All filters will be used with total on-source time of 0.3 hours to have a full wavelength coverage of high quality SED from 5 to 25 micron (rest-frame 0.6 - 3 micron). Four-point dither and FAST readout mode will be used.

# Proposal 2249 - Targets - Monster in the Early Universe: Unveiling the Nature of a Dust Reddened Quasar Hosting a Ten-Billion Solar.

	#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
	(1)	J0038-0653	RA: 00 38 3.7820 (9.5157583d)		
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Pro	posal 2249 - Observat	tion 4 - Monste	er in the Ear	rly Universe:	Unveiling th	ne Natu	ire of a Dust R	eddened Qu	asar Hosting a	a Ten-Billion
servation	Proposal 2249, Observation 4: MI Diagnostic Status: Warning Observing Template: MIRI Imaging Background Observations: [MIR] in	g m. sky (Obs 5)]	;	.,	<u> </u>				Thu Sep 29	9 18:00:53 GMT 2022
ğ	Dackground Observations.[iviii(i_ii	m_sky (003 5)]								
s	(MIRI F2550W Imaging (Obs 4))	Warning (Form): Use o	f background targe	ts not expected with	this template					
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#### Proposal 2249 - Observation 5 - Monster in the Early Universe: Unveiling the Nature of a Dust Reddened Quasar Hosting a Ten-Billion... Thu Sep 29 18:00:53 GMT 2022 Proposal 2249, Observation 5: MIRI\_im\_sky Observation Diagnostic Status: Warning Observing Template: MIRI Imaging Background Observation For: [MIRI\_F2550W\_Imaging (Obs 4)] Diagnostics Visit 5:1) Warning (Form): Overheads are provisional until the Visit Planner has been run. Name **Target Coordinates** Targ. Coord. Corrections Miscellaneous **Fixed Targets** (2) RA: 00 37 44.5600 (9.4356667d) MIRI-SKY Dec: -06 52 56.10 (-6.88225d) Equinox: J2000 Comments: Category=Calibration Description=[Telescope/sky background] Template Subarray FULL Dithers **Dither Type Starting Point** Number of Points Points **Starting Set** Number of Sets **Optimized For** Direction Pattern Size EXTENDED SOURCE 6 POSITIVE DEFAULT 4-Point-Sets 1 **Spectral Elements** ETC Wkbk.Calc ID Filter Readout Pattern Groups/Int Integrations/Exp Exposures/Dith Dither **Total Dithers** Total Total Exposure Integrations Time 23 1 1 255.304 F2550W FASTR1 Dither 1 4 4 **Special Requirements** Sequence Observations 2, 3, 4, 5, Non-interruptible