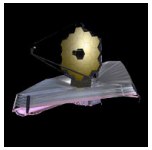

2228 - Probing the M87 Supermassive Black Hole with Parsec-Scale Stellar Dynamics

Cycle: 1, Proposal Category: GO

INVESTIGATORS

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OBSERVATIONS

Folder	*Observation*	*Label*	*Observing Template*	*Science Target*
Observation Folder				
	1	Galaxy	NIRSpec IFU Spectroscopy	(1) M-87

ABSTRACT

The central black hole (BH) of the giant elliptical galaxy M87 has been studied for more than 40 years. Similar to Sgr A* at the Galactic Center, the remarkable increase in angular resolution over the years, culminating in the Event Horizon Telescope image of the M87 BH shadow, has paved the way for a deeper understanding of the compact object and the immediate surrounding environment. The EHT image also provided an independent measurement of the M87 BH mass, which is consistent with the most recent stellar-dynamical result but differs by a factor of ~2 from the gas-dynamical determination. On the surface, the agreement between the EHT and most recent stellar-dynamical BH mass provides an important validation of the stellar-dynamical technique, but it is pressing to scrutinize the apparent agreement further because both measurements relied on extensive modeling and built-in assumptions. We propose to acquire the best high angular resolution spectra to date at the center of M87 using the NIRSpec integral field unit (IFU). We will study parsec-scale stellar dynamics around the M87 BH and extract reliable kinematics deep within the BH gravitational potential. When combined with existing large-scale IFU stellar kinematics and a new, fully general, triaxial, orbit-based modeling

approach, we will obtain the most robust stellar-dynamical BH mass for M87. We will further carry out a comprehensive analysis of the error budget, incorporating possible systematic effects. M87 is a pivotal anchor for the upper end of the BH mass - host galaxy relations, and it is crucial to obtain the best possible BH mass measurement.

OBSERVING DESCRIPTION

We will observe the center of M87 using NIRSpec in IFU mode with the G235H/F170LP grating and filter. The wavelength range will cover the K-band CO bandheads, from which we will measure the stellar kinematics as a function of spatial location. We will obtain dithered NIRSpec exposures using the cycling pattern and small extent, thereby improving the sampling of the NIRSpec point spread function. We select the NRIRS2 readout mode to reduce correlated noise and increase sensitivity for long exposures, while keeping the data volume low to ensure schedulability.

Our work requires high signal-to-noise (S/N) spectra in order to fully characterize the stellar line-of-sight velocity distribution. We will measure not only the velocity and velocity dispersion, but also higher order moments (h_3, h_4, and beyond) that quantify the distribution's asymmetric and symmetric deviations from a Gaussian. Using the JWST ETC, and the surface brightness profile from Kormendy et al. 2009, we estimate that ~6.6 hrs is needed to reach a S/N ~ 100 at 2.3 microns in a circular aperture with a radius of 0.014" located 0.15" from the nucleus. The aperture was selected to mimic a single spaxel, which will be 0.025"x0.025" in size with our dithering strategy. We will construct spatial bins in the outer regions of the NIRSpec IFU to reach a similarly high S/N. We will use 20 groups (each consisting of 5 frames with our readout mode), 1 integration, and 16 (dithered) exposures.

We will obtain a LeakCal exposure composed of 20 groups with the NRIRS2 readout mode at the first science dither postion. This exposure will be used to remove MSA leakage. Since we expect the background to be fairly uniform over the small extent of the dither pattern, we chose not to obtain LeakCal exposures at every dither position. We also will perform a target acquisition to ensure precise centering on the galaxy nucleus.

Proposal 2228 - Targets - Probing the M87 Supermassive Black Hole with Parsec-Scale Stellar Dynamics

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
(1)	M-87	RA: 12 30 49.4232 (187.7059300d) Dec: +12 23 28.03 (12.39112d) Equinox: J2000		

Comments: This object was generated by the targetselector and retrieved from the NED database.
Category=Galaxy
Description=[Active galactic nuclei, Galaxy bulges, Galaxy nuclei, Giant elliptical galaxies]
Extended=YES

Observation

Proposal 2228, Observation 1: Galaxy

Mon Oct 04 13:00:21 GMT 2021

Diagnostic Status: Warning

Observing Template: NIRSpec IFU Spectroscopy

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
(1)	M-87	RA: 12 30 49.4232 (187.7059300d) Dec: +12 23 28.03 (12.39112d) Equinox: J2000		

Comments: This object was generated by the targetselector and retrieved from the NED database.
Category=Galaxy
Description=[Active galactic nuclei, Galaxy bulges, Galaxy nuclei, Giant elliptical galaxies]
Extended=YES

Template

TA Method
NONE

Dithers

#	Dither Type	Size	Starting Point	Number of Points	Points
1	CYCLING	SMALL	1	16	

Spectral Elements

#	Grating/Filter	Readout Pattern	Groups/Int	Integrations/Exp	Leakcal	Dither	Autocal	Total Dithers	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID
1	G235H/F170LP	NRSIRS2	20	1	false	true	NONE	16	16	23575.646	58346
2	G235H/F170LP	NRSIRS2	20	1	true	false	NONE	1	1	1473.478	