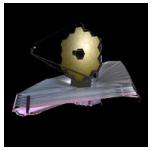

2701 - Unveiling the Nature of CID-42. The Best Candidate for a Gravitational Wave Recoiling Supermassive Black Hole

Cycle: 1, Proposal Category: GO

INVESTIGATORS

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OBSERVATIONS

Folder	*Observation*	*Label*	*Observing Template*	*Science Target*
Observation Folder				
	1		NIRSpec IFU Spectroscopy	(1) 2XMM-J100043.1+020637

ABSTRACT

COSMOS J100043.1+020637.2 (or CID-42) is a galaxy with exceptional properties: two optical nuclei separated by ~0.5", a long tidal tail, X-ray emission from only one optical source, and a broad H emission-line centered at 1300 km/s from the systemic velocity. These properties make CID-42

the best candidate gravitational wave (GW) recoiling supermassive black hole (SMBH) to date, but other scenarios, such as an inspiraling active galactic nucleus (AGN) pair, accretion disk kinematics, or a gravitational slingshot recoil resulting from a triple-SMBH encounter cannot be excluded. With spatially resolved JWST NIRSpec integral-field unit (IFU) spectroscopy, it is now possible to definitively determine whether this galaxy hosts a GW recoiling SMBH by mapping the 2D kinematics of the stars and the broad and narrow emission lines of ionized gas. We will be able to determine in a straightforward way three main kinematic properties of GW recoiling SMBHs: (i) the kinematically-offset broad emission lines should be spatially coincident with the spatially-offset AGN, (ii) the kinematic center of the galaxy should be spatially coincident with the central stellar cusp left behind by the recoiling SMBH, and (iii) the velocities of the narrow emission lines should be close to the systemic velocity of the galaxy at all spatial positions in the field-of-view and not close to the kick velocity of the merged SMBH. The proposed observations will have a tremendous impact on our knowledge of SMBH mergers and the associated emission of GWs. In fact, with a small investment of ~5 hours, this experiment could confirm the existence of GWs from SMBH mergers.

OBSERVING DESCRIPTION

This proposal focuses on the most compelling recoiling supermassive black hole (SMBH) candidate in the Universe: COSMOS J100043.15+020637.20, also known as CID-42. The two main properties of a gravitational wave (GW) recoiling SMBH have been observed in this galaxy: it exhibits an active galactic nucleus (AGN) that is spatially offset from the galaxy center, and it has velocity shifts >1000 km/s between broad and narrow lines. Over the last 7 years, our group has observed this object with the most powerful current-generation telescopes, including the HST and the Keck telescopes, and we have found that they are inadequate for pinning down the nature of this galaxy. With spatially-resolved JWST NIRSpec integral-field unit (IFU) spectroscopy, it is now possible to definitively determine whether this galaxy hosts a GW recoiling SMBH.

We will observe the Paα 1.87 μm emission line to trace the spatial distribution and kinematics of the broad-line and narrow-line emission regions in CID-42. Since Hα lies in the optical (even at the redshift of CID-42), Paα is our best option (this line is the strongest recombination line of hydrogen in the near-IR, and therefore a good tracer of the ionized gas in galaxies). We will also study the kinematics of the [Si VI] 1.96 μm and [He I] 2.05 μm emission lines to constrain the properties of outflows of ionized gas. Finally, we will trace the rotational component of the galaxy and the kinematics of the tidal tails (which possibly shows signatures of inflows) by mapping the 2D kinematics of the molecular hydrogen (H$_2$) emission line at 2.12 μm. Given the redshift of our target, we will use the grating-filter combination G235H/F170LP. We will cover the nuclear region most efficiently with the 0.1" plate scale. The 3"x3" field-of-view available with this configuration will be oriented along a position angle of 0 degrees.

Since the $H-$band magnitude of this COSMOS galaxy is well known ($H\sim18.8$ in an aperture of 1 arcsec), integration times are based on a

surface brightness of 18.8 mag arcsec^{-2} in $H-$band. The ETC indicates that a total exposure time of 17286 s (4.8 hours) with a 2-Point dither strategy and assuming a galxy spectrum similar to NGC 6240 is sufficient to reach a S/N of ~5 at 2.1μm, and $15-25$ at larger wavelengths - as required, given the typical depths of stellar absorption features, to measure stellar kinematics (Davies et al. 2007).

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
(1)	2XMM-J100043.1+020637	RA: 10 00 43.1318 (150.1797158d) Dec: +02 06 37.39 (2.11039d) Equinox: J2000	Epoch of Position: 2015.5	

Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.
Category=Galaxy
Description=[Active galactic nuclei, Active galaxies, Galaxy nuclei, Interacting galaxies, Quasar-galaxy pairs]

Observation

Proposal 2701, Observation 1

Fri Sep 17 22:00:38 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
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Description=[Active galactic nuclei, Active galaxies, Galaxy nuclei, Interacting galaxies, Quasar-galaxy pairs]

Template

TA Method
NONE

Dithers

#	Dither Type	Size	Starting Point	Number of Points	Points
1	4-POINT-DITHER				

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	30	2	false	true	NONE	4	8	17623.379	