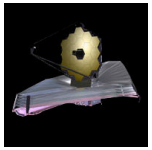

5766 - Probing the bar slowing down across cosmic time

Cycle: 3, Proposal Category: GO

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OBSERVATIONS

Folder	*Observation*	*Label*	*Observing Template*	*Science Target*
Observation Folder				
	1	gal EGS-24154	NIRSpec IFU Spectroscopy	(1) EGS-24154
	2	gal EGS-12823	NIRSpec IFU Spectroscopy	(2) EGS-12823

ABSTRACT

Bars are stellar structures common in the majority of galaxies in the nearby Universe. The secular evolution of barred galaxies is governed by the angular frequency of the bar rotation around the galaxy centre, i.e. the bar pattern speed. This parameter is strongly linked to the dark matter content

in the galaxy inner regions, due to dark matter halos slowing down bars through dynamical friction.
Observational studies of barred galaxies find that bars rotate fast, while simulations of galaxy evolution in the cold dark matter framework suggest that bars slow down excessively. This means a tension between fast bars and the standard cosmological paradigm. Several explanations have been proposed for the paucity of slow bars in the local Universe, but the lack of direct measurements of bar pattern speed for galaxies at z > 0.1 makes it impossible to test the efficiency of dynamical friction and the bar slowing down across cosmic time.
We propose to use the new capabilities of JWST to measure directly for the first time the bar pattern speed of two recently discovered barred galaxies at z > 1, some of the furthest bars known up to date. The proposed
observations based on near-infrared integral-field spectroscopy will allow us to compare directly values of bar pattern speed at the dawn of bar formation with analog results in the local Universe. This will put stringent
constraints on the evolution of the bar pattern speed across cosmic time, therefore limiting the nature (or even existence) of dark matter in galaxies.

OBSERVING DESCRIPTION

This program consists of NIRSpec IFU observations of two barred galaxies at z>1, recently discovered as some of the furthest bars known up to date. We will obtain very deep (up to 23.4 mag/arcsec^2 in F115W-JWST filter - corresponding to 22 mag/arcsec^2 in F444W-JSWT filter from Fig. 4 in Technical Justification, which is better suited to quantify the properties of bars) medium-resolution (R~1000) observations with G140M/F070LP. This allows us to target the most relevant spectral absorption features in the rest-frame optical wavelength range (i.e., Hbeta, Mg, Fe) to apply the Tremaine & Weinberg method (1984, hereafter TW) to
derive bar pattern speed and extract stellar kinematics (see Scientific Justification for the details of the methodology).
In order to achieve our scientific goals, we require at least S/N>5 outside the bar-dominated region of the galaxies (r ~0.8-1 arcsec), where the surface brightness of the galaxy is 23.4 mag/arcsec^2 in F115W-JWST
filter and the light of the disc dominates. We estimated the exposure times with the JWST ETC 3.0. To describe the light distribution of the disc of our galaxies outside the bar-dominated region, we adopted a template spectrum of a typical late-type spiral galaxy, a power law (with n=1) modeling the surface brightness profile, and a redshift z~1.2, as representative for our selected galaxies.
Our goal is to get a minimum signal-to-noise ratio per spectral resolution element in the inner disc region of ~2.5.
This is acheved in ~10h exposure times per each galaxy. We will then bin ~4 spaxels in the disc region to reach the minimum signal-to-noise ratio of 5 per bin to safely extract the stellar line-of-sight velocity and build the stellar line-of-sight velocity maps. In particular, we will adopt a Voronoi binning (or based on sectors of circles) to obtain a reasonable number of bins in the inner disc region (i.e. a minimum of 4 bins) with a sufficent S/N to measure the stellar velocity.
We then checked that the signal does not saturate in the central region of the galaxy, which we modeled with a Sérsic surface brightness profile.

We carefully checked that our targets will not duplicate any observation in the ERS and GO1 programs with the same instrumental configuration (NIRSpec IFU).

We ensured that our strategy minimizes the overhead charged time having ~80% of the total time spent on targets.

For our observations, no target acquisition (TA) is needed: guiding stars are present near the target galaxies.

We adopted a medium cycling with 8-point dither pattern. This strategy provides a good sub-pixel sampling and leaves a relatively large number of spaxels free from galaxy light to derive the background. Indeed, sky will be traced in the outer region of the NIRSpec IFS field-of-view, so no dedicated observations of the sky are needed.

We defined our observational strategy to reach the required minimum signal-to-noise. This is achieved adopting the NRSIRS2 readout pattern. We defined 62 groups and 1 integration/exposure (tot. of 8 integrations) for both the target galaxies. We would prefer to use NRSIRS2RAPID, which allows a better identification and removal of cosmic rays glitches, however this would translate into a big data volume, which is above the allowed maximum limit.

The pattern speed of the bars hosted in the two target galaxies will be determined by using the model-independent TW method. This technique requires the definition of at least three slits crossing the bar and

parallel to the disc major axis. Photometric and spectroscopic signal is then extracted along each slit from the reconstracted NIRSpec image and 1D spectrum.

In order to measure resolved signal along the slits, the slit width must be larger than the NIRSpec PSF, which has a FWHM ~0.15 arcsec. We performed a preliminary photometric analysis using publicly available JWST-

F444W images of the two barred galaxies to measure their bar lengths. EGS-24154 and EGS-12823 resulted to have bar lengths equal to 0.90 and 0.77 arcsec, respectively. We projected the bar length along the disc minor axis to check whether it is possible to define the requested three slits. The deprojected bar lengths along the disc minor axes become 0.79 and 0.58 arcsec, respectively. This allows to define three slits crossing the bar with widths of 0.26 and 0.19 arcsec, respectively, which are larger than the instrumental PSF.

Finally, NIRSpec@JWST field-of-view (~3 × 3 arcsec^2) is suited to map the extension of the target galaxies.

To minimize the contamination due to the MSA leakage, we selected the PA of the NIRSpec in such a way that no bright objects fall within the region covered by the NIRSpec MSA.

We have used hydrodynamical simulations of barred galaxies to ensure the spatial resolution and spectral resolution of the proposed instrumental setup is suited to determine the bar pattern speed of galaxies at z>1 (see Technical Justification for more details about the feasibility study).

Proposal 5766 - Targets - Probing the bar slowing down across cosmic time

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
(1)	EGS-24154	RA: 14 19 29.8385 (214.8743271d) Dec: +52 53 13.02 (52.88695d) Equinox: J2000		
Comments: *Category=Galaxy* *Description=[Disk galaxies]*				
(2)	EGS-12823	RA: 14 19 31.8933 (214.8828888d) Dec: +52 50 9.79 (52.83605d) Equinox: J2000		
Comments: *Category=Galaxy* *Description=[Disk galaxies]*				

Observation

Proposal 5766, Observation 1: gal EGS-24154

Fri Mar 01 16:01:15 GMT 2024

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)	EGS-24154	RA: 14 19 29.8385 (214.8743271d) Dec: +52 53 13.02 (52.88695d) Equinox: J2000		

Comments:
Category=Galaxy
Description=[Disk galaxies]

Template

TA Method
NONE

Dithers

#	Dither Type	Size	Starting Point	Number of Points	Points
1	CYCLING	MEDIUM	1	8	

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	G140M/F070LP	NRSIRS2	62	1	false	true	NONE	8	8	36297.158	

Observation

Proposal 5766, Observation 2: gal EGS-12823

Fri Mar 01 16:01:15 GMT 2024

Diagnostic Status: Warning

Observing Template: NIRSpec IFU Spectroscopy

Diagnostics

(Visit 2:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
(2)	EGS-12823	RA: 14 19 31.8933 (214.8828888d) Dec: +52 50 9.79 (52.83605d) Equinox: J2000		

Comments:
Category=Galaxy
Description=[Disk galaxies]

Template

TA Method
NONE

Dithers

#	Dither Type	Size	Starting Point	Number of Points	Points
1	CYCLING	MEDIUM	1	8	

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	G140M/F070LP	NRSIRS2	62	1	false	true	NONE	8	8	36297.158	