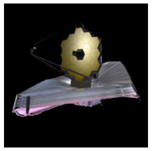

10417 - COHORTS: COsmic HORseshoe Transient Survey -- observing lensed stars at the cosmic noon under galaxy-galaxy strong lensing

Cycle: 5, Proposal Category: GO

INVESTIGATORS

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OBSERVATIONS

Folder	*Observation*	*Label*	*Observing Template*	*Science Target*
Observation 1				
	1	Cosmic Horseshoe (visit 1)	NIRCam Imaging	(1) SDSS-J114833.14+193003.2
	2	Cosmic Horseshoe (visit 2)	NIRCam Imaging	(1) SDSS-J114833.14+193003.2

ABSTRACT

Transient lensed stars are distant, bright stars in strongly lensed background galaxies that are temporarily detectable owing to stellar microlensing, and are now regularly found in JWST galaxy cluster observations. We propose to observe the Cosmic Horseshoe (source redshift of 2.4) and search for lensed stars for the first time in galaxy-galaxy strong lensing system. Among the most well-modelled gravitational lenses, the Horseshoe is a massive (stellar mass of ~3 billion solar masses), starburst (recent star formation rate of ~30 solar mass per year) galaxy at the cosmic noon. The extremely high recent star formation rate is expected to produce a lot of young, bright stars that are detectable via microlensing. Our proposed two deep visits cadenced by 30 days are expected to detect an abundant amount of transients in the Horseshoe, and

(i) <Measure the stellar initial mass function at cosmic noon>

Transient lensed stars have been demonstrated to be able to constrain the stellar initial mass function in z ~ 1 galaxies. Previous galaxy cluster observations have found almost no lensed stars at z ~ 2 -- observing the Horseshoe would generate a unique dataset to measure the stellar initial mass function at cosmic noon.

(ii) <Test the nature of dark matter>

The two prevailing candidates for cold dark matter -- whether comprising weakly interacting massive particles, or ultra-light axions -- predict

fundamentally different smaller-scale substructures in dark matter haloes. They produce an opposite trend in the spatial distribution of lensed stars with respect to the macroscopic critical curve, which allows for distinguishing the two models.

OBSERVING DESCRIPTION

This program observes a gravitationally lensed starburst galaxy at redshift 2.4, known as the ``Cosmic Horseshoe". The extreme star formation in the Horseshoe is expected to generate hundreds of lensed star transients -- individual luminous stars in the strongly lensed background galaxy that are made detectable temporarily due to stellar microlensing -- upon our proposed two deep (~2 hours per filter) visits separated by 28-30 days (range for flexibility). The data will enable us to: (i) measure the stellar initial mass function at cosmic noon, based on the lensed star detection rate; (ii) and provide a very powerful test of whether dark matter comprises entities that behave on macroscopic scales as either classical particles or waves by analyzing the spatial distribution of lensed stars, which is sensitive to the underlying small-scale substructures predicted assuming different dark matter candidates.

To discover transient lensed stars, our proposed observation consists of two visits separated by 30 days -- the maximum duration allowed for NIRCAM to observe the Horseshoe at the same rolling angle, avoiding apparent time variations in light intensity owing to the rotating point-spread-function. The characteristic brightening time scale of lensed stars is expected to be ~2-3 weeks -- the longer the cadence, the more likely the stars detected in the first epoch would have faded away in the second epoch and thus be identified as transients. The 30 days cadence, alongside the deep exposures, would hence maximize the detection rate and thus reduce the Poisson uncertainty for inferring both objectives (i) and (ii). The subtraction of the two epochs of images would allow us to remove the background lensed galaxy and identify transients with dedicated point-spread-function searching algorithms.

The Horseshoe is observable twice during Cycle 5. We chose the observation window between 24th April 2027 and 17th June 2027 which is within the meteorite avoidance zone. To enable flexibility in scheduling, the first observation can be carried out any time from 24th April 2027, to no later than 19th May 2027 to allow for a second visit cadenced 28-30 days later. The NIRCAM rolling angle would be fixed at 124.5 degrees for observations beginning on 24th April 2027 (2nd pointing on 24th May 2027), gradually decreasing to 116.3 degrees for observations beginning on 19th May 2027 (the latest date to begin the 1st pointing, with 2nd pointing on 17th June 2027), depending on the possible common rolling angle across the ~30-day cadence.

Using the full subarray and the MEDIUM8 readout mode, we propose to have one integration with eight groups per exposure. 4 primary dithers and 2 subpixel positions in each visit would give rise to an exposure time of ~6700 seconds per filter per visit, and reaching depths between 28.8 - 29.5

ABmag, depending on the filter. This is expected to yield a large number of transients, and increase the constraining power of both objectives (i) and (ii).

We propose to observe in 6 filters in both epochs -- F090W, F150W, F200W, F277W, F356W, and F444W. F090W has the highest sensitivity towards blue supergiant stars, while the remaining filters allow one to characterize the surface temperature of red supergiants. F090W and F150W are expected to be the prime detection channels for the two classes of stars with their smaller point-spread functions. Stacking the two pointings would also give rise to a very deep image of the Horseshoe, revealing compact features in the lensed image and allowing for more stringent lens reconstruction (objective ii), as well as providing a high signal-to-noise spectral energy distribution measurement to infer stellar properties of the Horseshoe (objective i).

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
(1)	SDSS-J114833.14+193003.2	RA: 11 48 29.3614 (177.1223392d) Dec: +19 29 53.22 (19.49812d) Equinox: J2000	Epoch of Position: 2000	

Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.
Category=Galaxy
Description=[Einstein rings, Elliptical galaxies, Emission line galaxies, Starburst galaxies]
Extended=YES

Observation

Proposal 10417, Observation 1: Cosmic Horseshoe (visit 1)

Fri Mar 13 19:07:06 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.

(Cosmic Horseshoe (visit 1) (Obs 1)) Informational (Form): The Visit Planner and Spike may produce different schedulability results.

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
(1)	SDSS-J114833.14+193003.2	RA: 11 48 29.3614 (177.1223392d) Dec: +19 29 53.22 (19.49812d) Equinox: J2000	Epoch of Position: 2000	

Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.
Category=Galaxy
Description=[Einstein rings, Elliptical galaxies, Emission line galaxies, Starburst galaxies]
Extended=YES

Template

Module	Subarray
B	FULL

Dithers

#	Primary Dither Type	Primary Dithers	Subpixel Dither Type	Dither Size	Subpixel Positions
1	INTRAMODULEBOX	4	STANDARD		2

Spectral Elements

#	Short Filter	Long Filter	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Dithers	Total Exposure Time	Optional ETC ID
1	F090W	F444W	MEDIUM8	8	1	8	8	6699.744	273366
2	F150W	F356W	MEDIUM8	8	1	8	8	6699.744	273366
3	F200W	F277W	MEDIUM8	8	1	8	8	6699.744	273366

Special Requirements

Between Dates 24-APR-2027 and 16-MAY-2027
Aperture PA Range 116.6 to 124.4 Degrees (V3 116.54737309 to 124.34737309)

2 After 1 by 28 Days to 30 Days
Same Aperture PA 1, 2

Observation

Proposal 10417, Observation 2: Cosmic Horseshoe (visit 2)

Fri Mar 13 19:07:06 GMT 2026

Diagnostic Status: Warning

Observing Template: NIRCam Imaging

Diagnostics

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

(Cosmic Horseshoe (visit 2) (Obs 2)) Informational (Form): The Visit Planner and Spike may produce different schedulability results.

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
(1)	SDSS-J114833.14+193003.2	RA: 11 48 29.3614 (177.1223392d) Dec: +19 29 53.22 (19.49812d) Equinox: J2000	Epoch of Position: 2000	

Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.
Category=Galaxy
Description=[Einstein rings, Elliptical galaxies, Emission line galaxies, Starburst galaxies]
Extended=YES

Template

Module	Subarray
B	FULL

Dithers

#	Primary Dither Type	Primary Dithers	Subpixel Dither Type	Dither Size	Subpixel Positions
1	INTRAMODULEBOX	4	STANDARD		2

Spectral Elements

#	Short Filter	Long Filter	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Dithers	Total Exposure Time	Optional ETC ID
1	F090W	F444W	MEDIUM8	8	1	8	8	6699.744	273366
2	F150W	F356W	MEDIUM8	8	1	8	8	6699.744	273366
3	F200W	F277W	MEDIUM8	8	1	8	8	6699.744	273366

Special Requirements

Between Dates 26-MAY-2027 and 17-JUN-2027

2 After 1 by 28 Days to 30 Days
Same Aperture PA 1, 2