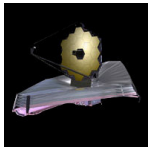

6095 - Where is the Antimatter? Identifying the Galactic Positron Engines

Cycle: 3, Proposal Category: GO

INVESTIGATORS

Name	*Institution*
Prof. Jeremy Darling (PI)	**University of Colorado at Boulder**

OBSERVATIONS

Folder	*Observation*	*Label*	*Observing Template*	*Science Target*
Observation Folder				
	1	Sgr A*	NIRSpec IFU Spectroscopy	(1) SgrA
	3	Sgr A*	NIRSpec IFU Spectroscopy	(1) SgrA
	2	GA	NIRSpec IFU Spectroscopy	(2) Great-Annihilator

ABSTRACT

The existence of antimatter in the form of positrons has been observed in the Galaxy via 511 keV annihilation photons for half a century, but the astrophysical engines producing the positrons have yet to be identified. Numerous plausible sources of positrons have been proposed, some of which are distributed and some of which are pointlike such as Sgr A*, stellar-mass black holes, and compact X-ray binaries. If the Galactic matter-antimatter annihilation is dominated by point sources, then JWST is the only facility that can detect them. Studies of the annihilation gamma-ray spectrum show that nearly all annihilation events are preceded by the formation of an electron-positron bound state called Positronium (Ps), a hydrogen-like "atom" where the proton is replaced by the positron. Positronium has quantum transitions with half the energy of hydrogen: its Lyman alpha line has a wavelength 243 nm, H-alpha is 1.31 microns, and Paschen alpha is 3.75 microns. There will therefore be Ps "recombination" emission lines that precede annihilation. These are faint but within the reach of JWST, and ground-based observations have thus far been unable to adequately remove terrestrial atmospheric spectral features, despite custom-built spectrometers. We propose to address the mystery of the sources of Galactic antimatter by observing two likely Ps engines in the Pa-alpha transition: Sgr A* and the Great Annihilator. Both detection and lack of detection will provide important insight into positron production mechanisms and the general physics of high-energy phenomena. Theory alone has

so far been unable to identify the dominant mechanism for antimatter production.

OBSERVING DESCRIPTION

We propose to obtain NIRSpec G395H/F290LP IFU spectra of the region around Sgr A* and the Great Annihilator to search for the Paschen alpha "recombination" emission line of positronium at 3.75 microns. This transition is expected to be the brightest as observed due to the high dust extinction for Lyman alpha and Balmer alpha transitions. IFU observations will use a 4-point nod to minimize backgrounds and maximize S/N. The spectral resolution may slightly resolve the emission line, so spectral smoothing can be used to enhance S/N. The emission line is expected to be faint but detectable with S/N~20 in 10 ks if the source of electron-positron annihilation not diffuse. If the source of Galactic 511 keV emission is from several dominant point sources, the S/N will be reduced correspondingly, but detection should still be possible. Following previous JWST observations of the Sgr A* vicinity using the NIRSpec IFU in program 1939 that did not include the positronium line, we use 25 groups per integration and 9 integrations per exposure with NRSRAPID readout. Nearby and in-IFU dither pattern sources will not saturate the detector.

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
(1)	SgrA	RA: 17 45 40.0383 (266.4168262d) Dec: -29 00 28.07 (-29.00780d) Equinox: J2000	Epoch of Position: 2000	
Comments: This object was generated by the targetselector and retrieved from the SIMBAD database. *The target is the region centered on Sgr A*.* *Coordinates were checked; these represent the VLA coordinates used by the calibration library.* *Category=ISM* *Description=[Emission nebulae, Plasma clouds]* *Extended=YES*				
(2)	Great-Annihilator	RA: 17 43 54.8300 (265.9784583d) Dec: -29 44 42.60 (-29.74517d) Equinox: J2000	Epoch of Position: 2000	
Comments: This object was generated by the targetselector and retrieved from the SIMBAD database. *Coordinates were checked: these represent the VLA coordinates.* *Category=Star* *Description=[Black holes, X-ray binary stars]*				

Observation

Proposal 6095, Observation 1: Sgr A*

Mon Sep 30 18:00:18 GMT 2024

Diagnostic Status: Warning

Observing Template: NIRSpec IFU Spectroscopy

Comments: We employ the 4-point nod here but used the 2-point nod in the ETC with twice the integration time because the ETC does not offer a 4-point nod mode.

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)	SgrA	RA: 17 45 40.0383 (266.4168262d) Dec: -29 00 28.07 (-29.00780d) Equinox: J2000	Epoch of Position: 2000	

Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.

The target is the region centered on Sgr A.*

Coordinates were checked; these represent the VLA coordinates used by the calibration library.
Category=ISM
Description=[Emission nebulae, Plasma clouds]
Extended=YES

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	G395H/F290LP	NRSIRS2	10	2	false	true	NONE	4	8	5952.267	210001
2	G395H/F290LP	NRSIRS2	10	2	true	true	NONE	4	8	5952.267	210001

Special Requirements

MSA Scheduled Aperture PA 227.8100 to 227.8100 Degrees (V3 88.83837 to 88.83837)

Observation

Proposal 6095, Observation 3: Sgr A*

Mon Sep 30 18:00:18 GMT 2024

Diagnostic Status: Warning

Observing Template: NIRSpec IFU Spectroscopy

Comments: We employ the 4-point nod here but used the 2-point nod in the ETC with twice the integration time because the ETC does not offer a 4-point nod mode.

WOPR repeat of visit 1:1

Diagnostics

(Visit 3:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
(1)	SgrA	RA: 17 45 40.0383 (266.4168262d) Dec: -29 00 28.07 (-29.00780d) Equinox: J2000	Epoch of Position: 2000	

Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.

The target is the region centered on Sgr A.*

Coordinates were checked; these represent the VLA coordinates used by the calibration library.
Category=ISM
Description=[Emission nebulae, Plasma clouds]
Extended=YES

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	G395H/F290LP	NRSIRS2	10	2	false	true	NONE	4	8	5952.267	210001
2	G395H/F290LP	NRSIRS2	10	2	true	true	NONE	4	8	5952.267	210001

Observation

Proposal 6095, Observation 2: GA Mon Sep 30 18:00:18 GMT 2024

Diagnostic Status: Warning

Observing Template: NIRSpec IFU Spectroscopy

Comments: We employ the 4-point nod here but used the 2-point nod in the ETC with twice the integration time because the ETC does not offer a 4-point nod mode.

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)	Great-Annihilator	RA: 17 43 54.8300 (265.9784583d) Dec: -29 44 42.60 (-29.74517d) Equinox: J2000	Epoch of Position: 2000	

Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.

Coordinates were checked: these represent the VLA coordinates.
Category=Star
Description=[Black holes, X-ray binary stars]

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	G395H/F290LP	NRSIRS2	9	2	false	true	NONE	4	8	5368.712	210001
2	G395H/F290LP	NRSIRS2	9	2	true	true	NONE	4	8	5368.712	210001

Special Requirements

MSA Scheduled Aperture PA 228.2479 to 228.2479 Degrees (V3 89.27623 to 89.27623)