



11694 - Is PSR J2322-2650b really a carbon planet?

Cycle: 5, Proposal Category: GO

INVESTIGATORS

<i>Name</i>	<i>Institution</i>
Michael Zhang (PI)	University of Chicago
Prof. Roger Romani (CoI)	Stanford University
Brandon Park Coy (CoI)	University of Chicago
Dr. Hayley Beltz (CoI)	University of Kansas
Prof. Jacob L. Bean (CoI) (US Admin CoI)	University of Chicago
Dr. Matthew Conor Nixon (CoI)	Arizona State University
Maya Beleznyay (CoI)	Stanford University
Dr. Peter Gao (CoI)	Carnegie Institution of Washington
Prof. Alexander Philippov (CoI)	University of Maryland
Dr. Thaddeus Komacek (CoI) (ESA Member)	University of Oxford

OBSERVATIONS

<i>Folder</i>	<i>Observation</i>	<i>Label</i>	<i>Observing Template</i>	<i>Science Target</i>
G140H				
	1		NIRSpec Fixed Slit Spectroscopy	(1) PSR-J2322-2650
G395H				
	2		NIRSpec Fixed Slit Spectroscopy	(1) PSR-J2322-2650
	3		NIRSpec Fixed Slit Spectroscopy	(1) PSR-J2322-2650

ABSTRACT

Molecular carbon (C2 and C3) has recently been detected in JWST spectra of the "pulsar planet" PSR J2322-2650b. These observations have been used to argue that the planet is a unique and exotic object: helium-dominated but highly enriched in carbon, with a C/O ratio exceeding 100. Such a

composition would severely challenge all known formation mechanisms. However, the inference of helium dominance is based only on the planet's low density (which is comparable to that of a typical hot Jupiter) as well as the lack of hydrogen-bearing molecules, and the C/O constraint assumes equilibrium chemistry, which may not be valid given the high-energy irradiation from the pulsar host.

We propose to test the helium-dominated hypothesis by using NIRSpec/G140H to look for escaping helium in the 1083 nm metastable line. We also propose to test the C/O constraint using NIRSpec / G395H to look for CO at wavelengths where it is least likely to be obscured by C₂. Direct observational verification of these indirect inferences will bring us closer to understanding the true origin of this extreme and enigmatic object.

OBSERVING DESCRIPTION

With NIRSpec/G140H, we will observe the night side of the planet for two hours. With NIRSpec/G395H, we will observe the day side of the planet twice for two hours each. Taking into account the 1 h scheduling uncertainty, we will have at least 30 min of observations on either side of conjunction for all visits.

For all visits, we opt to use the narrowest slit (0.2") to minimize the risk of contaminating sources in the background. The G140H observations should be nodded, with 5 nod positions and 2 integrations of 461 groups at each position. For the G395H observations, we use fewer groups per integration and forgo nodding because stability and time resolution are more important than avoiding a few bad pixels.

Proposal 11694 - Targets - Is PSR J2322-2650b really a carbon planet?

#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
(1)	PSR-J2322-2650	RA: 23 22 34.6384 (350.6443267d) Dec: -26 50 58.40 (-26.84956d) Equinox: J2000	Proper Motion RA: -2.26 mas/yr Proper Motion Dec: -8.31 mas/yr Parallax: 0.00159" Epoch of Position: 2022.4	
<p><i>Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.</i></p> <p><i>SIMBAD listed proper motion for this target. When retrieving targets with PM from SIMBAD, APT requests the coordinates be calculated with an epoch of the year 2000. Do not modify this epoch. Always review coordinates using the Target Confirmation tool, which graphically displays the PM.</i></p> <p><i>Category=Star</i> <i>Description=[Pulsars]</i> <i>Extended=NO</i></p>				
(2)	acq_star	RA: 23 22 36.2857 (350.6511904d) Dec: -26 51 23.86 (-26.85663d) Equinox: J2000	Proper Motion RA: 6.5503 mas/yr Proper Motion Dec: -4.7632 mas/yr Parallax: 0.001885" Epoch of Position: 2016	
<p><i>Comments:</i> <i>Category=Star</i> <i>Description=[K dwarfs]</i> <i>Extended=NO</i></p>				

Proposal 11694 - Observation 1 - Is PSR J2322-2650b really a carbon planet?

Fri Mar 13 21:09:36 GMT 2026

Observation	Proposal 11694, Observation 1 Diagnostic Status: Warning Observing Template: NIRSpec Fixed Slit Spectroscopy																																	
	(Observation 1) Warning (Form): The slew between the acquisition exposure and the farthest science exposure is 46.543 Arcsec (larger than the recommended limit of 38.000 Arcsec) and may result in reduced or no schedulability. See more information in the diagnostic browser. (Visit 1:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.																																	
Diagnostics																																		
Fixed Targets	<table border="1"> <thead> <tr> <th>#</th> <th>Name</th> <th>Target Coordinates</th> <th colspan="4">Targ. Coord. Corrections</th> <th colspan="4">Miscellaneous</th> </tr> </thead> <tbody> <tr> <td>(1)</td> <td>PSR-J2322-2650</td> <td>RA: 23 22 34.6384 (350.6443267d) Dec: -26 50 58.40 (-26.84956d) Equinox: J2000</td> <td colspan="4">Proper Motion RA: -2.26 mas/yr Proper Motion Dec: -8.31 mas/yr Parallax: 0.00159" Epoch of Position: 2022.4</td> <td colspan="4"></td> </tr> </tbody> </table> <p><i>Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.</i></p> <p><i>SIMBAD listed proper motion for this target. When retrieving targets with PM from SIMBAD, APT requests the coordinates be calculated with an epoch of the year 2000. Do not modify this epoch. Always review coordinates using the Target Confirmation tool, which graphically displays the PM.</i></p> <p><i>Category=Star</i> <i>Description=[Pulsars]</i> <i>Extended=NO</i></p>											#	Name	Target Coordinates	Targ. Coord. Corrections				Miscellaneous				(1)	PSR-J2322-2650	RA: 23 22 34.6384 (350.6443267d) Dec: -26 50 58.40 (-26.84956d) Equinox: J2000	Proper Motion RA: -2.26 mas/yr Proper Motion Dec: -8.31 mas/yr Parallax: 0.00159" Epoch of Position: 2022.4								
	#	Name	Target Coordinates	Targ. Coord. Corrections				Miscellaneous																										
(1)	PSR-J2322-2650	RA: 23 22 34.6384 (350.6443267d) Dec: -26 50 58.40 (-26.84956d) Equinox: J2000	Proper Motion RA: -2.26 mas/yr Proper Motion Dec: -8.31 mas/yr Parallax: 0.00159" Epoch of Position: 2022.4																															
Acquisition	<table border="1"> <thead> <tr> <th>#</th> <th>Target</th> <th>TA Method</th> <th>Subarray</th> <th>Filter</th> <th>Readout Pattern</th> <th>Groups/Int</th> <th>Integrations/Exp</th> <th>Total Integrations</th> <th>Total Exposure Time</th> <th>Optional ETC ID</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>2 acq_star</td> <td>WATA</td> <td>SUB32</td> <td>CLEAR</td> <td>NRSRAPID</td> <td>3</td> <td>1</td> <td>1</td> <td>0.08</td> <td>165648</td> </tr> </tbody> </table>											#	Target	TA Method	Subarray	Filter	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Exposure Time	Optional ETC ID	1	2 acq_star	WATA	SUB32	CLEAR	NRSRAPID	3	1	1	0.08	165648	
	#	Target	TA Method	Subarray	Filter	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Exposure Time	Optional ETC ID																							
1	2 acq_star	WATA	SUB32	CLEAR	NRSRAPID	3	1	1	0.08	165648																								
Template	<table border="1"> <thead> <tr> <th>HFF Readout Mode</th> <th>Slit</th> <th>Subarray</th> </tr> </thead> <tbody> <tr> <td>false</td> <td>S200A1</td> <td>SUBS200A1</td> </tr> </tbody> </table>											HFF Readout Mode	Slit	Subarray	false	S200A1	SUBS200A1																	
	HFF Readout Mode	Slit	Subarray																															
false	S200A1	SUBS200A1																																
Dithers	<table border="1"> <thead> <tr> <th>#</th> <th>Primary Dither Positions</th> <th>Sub-Pixel Pattern</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>5</td> <td>NONE</td> </tr> </tbody> </table>											#	Primary Dither Positions	Sub-Pixel Pattern	1	5	NONE																	
	#	Primary Dither Positions	Sub-Pixel Pattern																															
1	5	NONE																																
Spectral Elements	<table border="1"> <thead> <tr> <th>#</th> <th>Grating/Filter</th> <th>Slit</th> <th>Readout Pattern</th> <th>Groups/Int</th> <th>Integrations/Exp #</th> <th>Autocal</th> <th>Total Dithers</th> <th>Total Integrations</th> <th>Total Exposure Time</th> <th>Optional ETC ID</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>G140H/F100LP</td> <td>S200A1</td> <td>NRSRAPID</td> <td>461</td> <td>2</td> <td>1</td> <td>NONE</td> <td>5</td> <td>10</td> <td>7198.165</td> <td>262575</td> </tr> </tbody> </table>											#	Grating/Filter	Slit	Readout Pattern	Groups/Int	Integrations/Exp #	Autocal	Total Dithers	Total Integrations	Total Exposure Time	Optional ETC ID	1	G140H/F100LP	S200A1	NRSRAPID	461	2	1	NONE	5	10	7198.165	262575
	#	Grating/Filter	Slit	Readout Pattern	Groups/Int	Integrations/Exp #	Autocal	Total Dithers	Total Integrations	Total Exposure Time	Optional ETC ID																							
1	G140H/F100LP	S200A1	NRSRAPID	461	2	1	NONE	5	10	7198.165	262575																							

Proposal 11694 - Observation 1 - Is PSR J2322-2650b really a carbon planet?

Special Requirements

Phase 0.055 to 0.185 with period 0.322963997 Days and zero-phase 2456130.85411 HJD

Proposal 11694 - Observation 2 - Is PSR J2322-2650b really a carbon planet?

Fri Mar 13 21:09:36 GMT 2026

Observation	<p>Proposal 11694, Observation 2</p> <p>Diagnostic Status: Warning</p> <p>Observing Template: NIRSpec Fixed Slit Spectroscopy</p>																																	
	<p>(Observation 2) Warning (Form): The slew between the acquisition exposure and the farthest science exposure is 45.718 Arcsec (larger than the recommended limit of 38.000 Arcsec) and may result in reduced or no schedulability. See more information in the diagnostic browser.</p> <p>(Visit 2:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.</p>																																	
Diagnostics																																		
Fixed Targets	<table border="1"> <thead> <tr> <th>#</th> <th>Name</th> <th>Target Coordinates</th> <th colspan="4">Targ. Coord. Corrections</th> <th colspan="4">Miscellaneous</th> </tr> </thead> <tbody> <tr> <td>(1)</td> <td>PSR-J2322-2650</td> <td>RA: 23 22 34.6384 (350.6443267d) Dec: -26 50 58.40 (-26.84956d) Equinox: J2000</td> <td colspan="4">Proper Motion RA: -2.26 mas/yr Proper Motion Dec: -8.31 mas/yr Parallax: 0.00159" Epoch of Position: 2022.4</td> <td colspan="4"></td> </tr> </tbody> </table> <p><i>Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.</i></p> <p><i>SIMBAD listed proper motion for this target. When retrieving targets with PM from SIMBAD, APT requests the coordinates be calculated with an epoch of the year 2000. Do not modify this epoch. Always review coordinates using the Target Confirmation tool, which graphically displays the PM.</i></p> <p><i>Category=Star</i> <i>Description=[Pulsars]</i> <i>Extended=NO</i></p>											#	Name	Target Coordinates	Targ. Coord. Corrections				Miscellaneous				(1)	PSR-J2322-2650	RA: 23 22 34.6384 (350.6443267d) Dec: -26 50 58.40 (-26.84956d) Equinox: J2000	Proper Motion RA: -2.26 mas/yr Proper Motion Dec: -8.31 mas/yr Parallax: 0.00159" Epoch of Position: 2022.4								
	#	Name	Target Coordinates	Targ. Coord. Corrections				Miscellaneous																										
(1)	PSR-J2322-2650	RA: 23 22 34.6384 (350.6443267d) Dec: -26 50 58.40 (-26.84956d) Equinox: J2000	Proper Motion RA: -2.26 mas/yr Proper Motion Dec: -8.31 mas/yr Parallax: 0.00159" Epoch of Position: 2022.4																															
Acquisition	<table border="1"> <thead> <tr> <th>#</th> <th>Target</th> <th>TA Method</th> <th>Subarray</th> <th>Filter</th> <th>Readout Pattern</th> <th>Groups/Int</th> <th>Integrations/Exp</th> <th>Total Integrations</th> <th>Total Exposure Time</th> <th>Optional ETC ID</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>2 acq_star</td> <td>WATA</td> <td>SUB32</td> <td>CLEAR</td> <td>NRSRAPID</td> <td>3</td> <td>1</td> <td>1</td> <td>0.08</td> <td>165648</td> </tr> </tbody> </table>											#	Target	TA Method	Subarray	Filter	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Exposure Time	Optional ETC ID	1	2 acq_star	WATA	SUB32	CLEAR	NRSRAPID	3	1	1	0.08	165648	
	#	Target	TA Method	Subarray	Filter	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Exposure Time	Optional ETC ID																							
1	2 acq_star	WATA	SUB32	CLEAR	NRSRAPID	3	1	1	0.08	165648																								
Template	<table border="1"> <thead> <tr> <th>HFF Readout Mode</th> <th>Slit</th> <th>Subarray</th> </tr> </thead> <tbody> <tr> <td>false</td> <td>S200A1</td> <td>SUBS200A1</td> </tr> </tbody> </table>											HFF Readout Mode	Slit	Subarray	false	S200A1	SUBS200A1																	
	HFF Readout Mode	Slit	Subarray																															
false	S200A1	SUBS200A1																																
Dithers	<table border="1"> <thead> <tr> <th>#</th> <th>Primary Dither Positions</th> <th>Sub-Pixel Pattern</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>NONE</td> <td>NONE</td> </tr> </tbody> </table>											#	Primary Dither Positions	Sub-Pixel Pattern	1	NONE	NONE																	
	#	Primary Dither Positions	Sub-Pixel Pattern																															
1	NONE	NONE																																
Spectral Elements	<table border="1"> <thead> <tr> <th>#</th> <th>Grating/Filter</th> <th>Slit</th> <th>Readout Pattern</th> <th>Groups/Int</th> <th>Integrations/Exp #</th> <th>Autocal</th> <th>Total Dithers</th> <th>Total Integrations</th> <th>Total Exposure Time</th> <th>Optional ETC ID</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>G395H/F290LP</td> <td>S200A1</td> <td>NRSRAPID</td> <td>184</td> <td>25</td> <td>1</td> <td>NONE</td> <td>1</td> <td>25</td> <td>7206.262</td> <td>262575</td> </tr> </tbody> </table>											#	Grating/Filter	Slit	Readout Pattern	Groups/Int	Integrations/Exp #	Autocal	Total Dithers	Total Integrations	Total Exposure Time	Optional ETC ID	1	G395H/F290LP	S200A1	NRSRAPID	184	25	1	NONE	1	25	7206.262	262575
	#	Grating/Filter	Slit	Readout Pattern	Groups/Int	Integrations/Exp #	Autocal	Total Dithers	Total Integrations	Total Exposure Time	Optional ETC ID																							
1	G395H/F290LP	S200A1	NRSRAPID	184	25	1	NONE	1	25	7206.262	262575																							

Proposal 11694 - Observation 2 - Is PSR J2322-2650b really a carbon planet?

Special Requirements

Phase 0.555 to 0.685 with period 0.322963997 Days and zero-phase 2456130.85411 HJD

Proposal 11694 - Observation 3 - Is PSR J2322-2650b really a carbon planet?

Fri Mar 13 21:09:36 GMT 2026

Observation	<p>Proposal 11694, Observation 3</p> <p>Diagnostic Status: Warning</p> <p>Observing Template: NIRSpec Fixed Slit Spectroscopy</p>																																	
	<p>(Observation 3) Warning (Form): The slew between the acquisition exposure and the farthest science exposure is 45.718 Arcsec (larger than the recommended limit of 38.000 Arcsec) and may result in reduced or no schedulability. See more information in the diagnostic browser.</p> <p>(Visit 3:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.</p>																																	
Diagnostics																																		
Fixed Targets	<table border="1"> <thead> <tr> <th>#</th> <th>Name</th> <th>Target Coordinates</th> <th>Targ. Coord. Corrections</th> <th>Miscellaneous</th> </tr> </thead> <tbody> <tr> <td>(1)</td> <td>PSR-J2322-2650</td> <td>RA: 23 22 34.6384 (350.6443267d) Dec: -26 50 58.40 (-26.84956d) Equinox: J2000</td> <td>Proper Motion RA: -2.26 mas/yr Proper Motion Dec: -8.31 mas/yr Parallax: 0.00159" Epoch of Position: 2022.4</td> <td></td> </tr> </tbody> </table> <p><i>Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.</i></p> <p><i>SIMBAD listed proper motion for this target. When retrieving targets with PM from SIMBAD, APT requests the coordinates be calculated with an epoch of the year 2000. Do not modify this epoch. Always review coordinates using the Target Confirmation tool, which graphically displays the PM.</i></p> <p><i>Category=Star</i> <i>Description=[Pulsars]</i> <i>Extended=NO</i></p>											#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous	(1)	PSR-J2322-2650	RA: 23 22 34.6384 (350.6443267d) Dec: -26 50 58.40 (-26.84956d) Equinox: J2000	Proper Motion RA: -2.26 mas/yr Proper Motion Dec: -8.31 mas/yr Parallax: 0.00159" Epoch of Position: 2022.4														
	#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous																													
(1)	PSR-J2322-2650	RA: 23 22 34.6384 (350.6443267d) Dec: -26 50 58.40 (-26.84956d) Equinox: J2000	Proper Motion RA: -2.26 mas/yr Proper Motion Dec: -8.31 mas/yr Parallax: 0.00159" Epoch of Position: 2022.4																															
Acquisition	<table border="1"> <thead> <tr> <th>#</th> <th>Target</th> <th>TA Method</th> <th>Subarray</th> <th>Filter</th> <th>Readout Pattern</th> <th>Groups/Int</th> <th>Integrations/Exp</th> <th>Total Integrations</th> <th>Total Exposure Time</th> <th>Optional ETC ID</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>2 acq_star</td> <td>WATA</td> <td>SUB32</td> <td>CLEAR</td> <td>NRSRAPID</td> <td>3</td> <td>1</td> <td>1</td> <td>0.08</td> <td>165648</td> </tr> </tbody> </table>											#	Target	TA Method	Subarray	Filter	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Exposure Time	Optional ETC ID	1	2 acq_star	WATA	SUB32	CLEAR	NRSRAPID	3	1	1	0.08	165648	
	#	Target	TA Method	Subarray	Filter	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Exposure Time	Optional ETC ID																							
1	2 acq_star	WATA	SUB32	CLEAR	NRSRAPID	3	1	1	0.08	165648																								
Template	<table border="1"> <thead> <tr> <th>HFF Readout Mode</th> <th>Slit</th> <th>Subarray</th> </tr> </thead> <tbody> <tr> <td>false</td> <td>S200A1</td> <td>SUBS200A1</td> </tr> </tbody> </table>											HFF Readout Mode	Slit	Subarray	false	S200A1	SUBS200A1																	
	HFF Readout Mode	Slit	Subarray																															
false	S200A1	SUBS200A1																																
Dithers	<table border="1"> <thead> <tr> <th>#</th> <th>Primary Dither Positions</th> <th>Sub-Pixel Pattern</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>NONE</td> <td>NONE</td> </tr> </tbody> </table>											#	Primary Dither Positions	Sub-Pixel Pattern	1	NONE	NONE																	
	#	Primary Dither Positions	Sub-Pixel Pattern																															
1	NONE	NONE																																
Spectral Elements	<table border="1"> <thead> <tr> <th>#</th> <th>Grating/Filter</th> <th>Slit</th> <th>Readout Pattern</th> <th>Groups/Int</th> <th>Integrations/Exp #</th> <th>Autocal</th> <th>Total Dithers</th> <th>Total Integrations</th> <th>Total Exposure Time</th> <th>Optional ETC ID</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>G395H/F290LP</td> <td>S200A1</td> <td>NRSRAPID</td> <td>184</td> <td>25</td> <td>1</td> <td>NONE</td> <td>1</td> <td>25</td> <td>7206.262</td> <td>262575</td> </tr> </tbody> </table>											#	Grating/Filter	Slit	Readout Pattern	Groups/Int	Integrations/Exp #	Autocal	Total Dithers	Total Integrations	Total Exposure Time	Optional ETC ID	1	G395H/F290LP	S200A1	NRSRAPID	184	25	1	NONE	1	25	7206.262	262575
	#	Grating/Filter	Slit	Readout Pattern	Groups/Int	Integrations/Exp #	Autocal	Total Dithers	Total Integrations	Total Exposure Time	Optional ETC ID																							
1	G395H/F290LP	S200A1	NRSRAPID	184	25	1	NONE	1	25	7206.262	262575																							

Proposal 11694 - Observation 3 - Is PSR J2322-2650b really a carbon planet?

Special Requirements

Phase 0.555 to 0.685 with period 0.322963997 Days and zero-phase 2456130.85411 HJD