



5882 - Composition, Origin, and Fate of the Four Newborn Planets in the V1298

Tau System

Cycle: 3, Proposal Category: GO

INVESTIGATORS

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OBSERVATIONS

<i>Folder</i>	<i>Observation</i>	<i>Label</i>	<i>Observing Template</i>	<i>Science Target</i>
Observation Folder				
	2	V1298 Tau e	NIRSpec Bright Object Time Series	(1) V-V1298-Tau

ABSTRACT

NASA’s Kepler mission revealed that small planets between the size of Earth and Neptune are ubiquitous. Moreover, such planets are often found in tightly-packed multi-planet systems. The present-day patterns in the sizes and orbits of ‘compact multis’ are relics of the planet formation process. While the patterns are unambiguous, the physical processes that produce them remain mysterious. Fundamental questions about the formation of small planets remain unanswered. A key obstacle is the shortage of young planets with well-characterized bulk and atmospheric properties.

The best way to make progress is to characterize the progenitors of Kepler multis at young ages, at different stages in their formation. The planetary system around the 20–30 Myr star V1298Tau is such a progenitor. We propose to construct a homogenous library of NIR transmission spectra of all four planets in the V1298Tau system using NIRSpec/G395H. These spectra will reveal atmospheric carbon-to-oxygen ratio (C/O), mean metallicity

[Fe/H], envelope entropy, and cloud/haze properties. These measurements, in turn, will enable insights into where the planets formed in their disks, whether they experienced significant migration, the rate of cooling and the extent of envelope loss by 20–30 Myr. The homogeneous nature of this dataset enables planet-to-planet comparisons in the same system, which removes uncertainties from the modeling and interpretation and leads to a deeper understanding of the system.

OBSERVING DESCRIPTION

We propose to observe a single transit of V1298Tau d and e each using NIRSpec in the Bright Object Time Series (BOTS) mode. V1298Tau is too bright for target acquisition, so we will use the Wide Aperture Target Acquisition (WATA) mode on a nearby star Gaia DR3 51886331671984640. The acquisition star is $J = 14.8$, below the $J = 11.8$ WATA saturation limit, and $20''$ from the V1298tau. We will use the G395H/F290LP grism/filter combination, which provides $R \sim 600$ spectra over 2.8-5.2 microns. The transits themselves are 5.6 hours and 7.5 hours, respectively. Transit observations are differential measurements, and SNR per hour of telescope time is maximized when equal in- and out-of-transit photometry is collected. Thus, we request an equal amount of time out of transit. We used PandExo to compute the optimum number of groups per integration given the star's brightness and SED, while ensuring that no pixel exceeded 75% the saturation level. The optimum number was 8 groups per integration, which achieves a peak SNR of 217 per reduced pixel per 8 second integration. The achieved duty cycle is 78%. We used PandExo to compute the expected SNR of the transit spectrum used in the proposal. We determined we could measure the depth of V1298Tau d to ~ 25 ppm within a spectral channel of width $R = 40$. Observations of planets d and e must occur before, during, and after transits that take place every 12 and 48 days, respectively. Observing windows are centered on the forecasted transit midpoint based on our TTV model. The timing uncertainties are about 10 min, much smaller than the duration of observations.

Proposal 5882 - Targets - Composition, Origin, and Fate of the Four Newborn Planets in the V1298 Tau System

Fixed Targets	#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
	(1)	V-V1298-Tau	RA: 04 05 19.5910 (61.3316292d) Dec: +20 09 25.31 (20.15703d) Equinox: J2000	Proper Motion RA: 5.413 mas/yr Proper Motion Dec: -16.052000023591972 mas/yr Epoch of Position: 2015.5	
<i>Comments: Science target. This object was generated by the targetselector and retrieved from the SIMBAD database.</i>					
<i>Category=Star</i>					
<i>Description=[Exoplanets, K dwarfs, Young stellar objects]</i>					
<i>Extended=NO</i>					
(2)	Gaia-DR3-51886331671984640	RA: 04 05 18.6204 (61.3275850d) Dec: +20 09 11.10 (20.15308d) Equinox: J2000	Proper Motion RA: 20.101 mas/yr Proper Motion Dec: -12.851999963459093 mas/yr Epoch of Position: 2000		
<i>Comments: Acquisition target. This object was generated by the targetselector and retrieved from the SIMBAD database.</i>					
<i>Category=Star</i>					
<i>Description=[M dwarfs]</i>					
<i>Extended=NO</i>					

Proposal 5882 - Observation 2 - Composition, Origin, and Fate of the Four Newborn Planets in the V1298 Tau System

Tue Apr 02 23:00:57 GMT 2024

Observation	<p>Proposal 5882, Observation 2: V1298 Tau e</p> <p>Diagnostic Status: Warning</p> <p>Observing Template: NIRSpec Bright Object Time Series</p>																															
Diagnostics	<p>(V1298 Tau e (Obs 2)) Warning (Form): Exposure Duration exceeds the limit of 10000.0 seconds. Above this limit it is possible that a High Gain Antenna move may occur during the exposure.</p> <p>(Visit 2:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.</p>																															
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Template	<p>Subarray</p> <p>SUB2048</p>																															
Spectral Elements	<table border="1"> <thead> <tr> <th>#</th> <th>Grating/Filter</th> <th>Readout Pattern</th> <th>Groups/Int</th> <th>Integrations/Exp</th> <th>Exposures/Dith</th> <th>Total Dithers</th> <th>Total Integrations</th> <th>Total Exposure Time</th> <th>ETC Wkbk.Calc ID</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>G395H/F290LP</td> <td>NRSRAPID</td> <td>8</td> <td>6750</td> <td>1</td> <td>1</td> <td>6750</td> <td>54934.74</td> <td>175351.2</td> </tr> </tbody> </table>										#	Grating/Filter	Readout Pattern	Groups/Int	Integrations/Exp	Exposures/Dith	Total Dithers	Total Integrations	Total Exposure Time	ETC Wkbk.Calc ID	1	G395H/F290LP	NRSRAPID	8	6750	1	1	6750	54934.74	175351.2		
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Special Requirements	<p>Between Dates 29-AUG-2024:22:24:00 and 29-AUG-2024:23:24:00</p> <p>Between Dates 22-JAN-2025:22:56:00 and 22-JAN-2025:23:56:00</p> <p>Between Dates 23-SEP-2025:07:45:00 and 23-SEP-2025:08:45:00</p> <p>Between Dates 16-FEB-2026:08:14:00 and 16-FEB-2026:09:14:00</p> <p>Time Series Observation</p> <p>No Parallel Attachments</p>																															