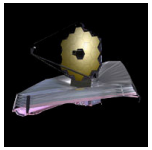

10674 - Comparative Planetology in Kepler-89: Mass-Loss, Disk Gaps, and Super-Puffs

Cycle: 5, Proposal Category: GO

INVESTIGATORS

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OBSERVATIONS

Folder	*Observation*	*Label*	*Observing Template*	*Science Target*
Kepler-89c				
	1	Kepler-89c	NIRSpec Bright Object Time Series	(1) Kepler-89
	2	Kepler-89c	NIRSpec Bright Object Time Series	(1) Kepler-89
	3	Kepler-89c	NIRSpec Bright Object Time Series	(1) Kepler-89
	4	Kepler-89c	NIRSpec Bright Object Time Series	(1) Kepler-89
Kepler-89d				

Folder	*Observation*	*Label*	*Observing Template*	*Science Target*
	5	Kepler-89d	NIRSpec Bright Object Time Series	(1) Kepler-89
Kepler-89e				
	6	Kepler-89e	NIRSpec Bright Object Time Series	(1) Kepler-89
	7	Kepler-89e	NIRSpec Bright Object Time Series	(1) Kepler-89

ABSTRACT

Multiplanet systems provide a natural laboratory for tracing how planets form and evolve within a shared environment, controlling for confounding factors like disk composition and mass. Kepler-89 is a one-of-a-kind multiplanet system; the mature, four-planet system is the only known transiting system to contain a Neptune-mass planet both interior and exterior to a giant planet, presenting a unique opportunity to address a number of questions related to planet formation and evolution.

We propose to measure the three gaseous planets in the system, Kepler-89c, d, and e. By comparing Kepler-89c's metallicity with the other planets in the system, as well as other Neptunes, we will reveal whether the planet underwent significant mass-loss. Next, we will constrain the presence of a disk gap that may have affected Kepler-89c's accretion by measuring differences in C/O between the planets. Lastly, we will determine why Kepler-89e has a low, "super-puff" density by measuring the metallicity of the atmosphere and constraining the presence of high-altitude hazes.

By revealing the story of the Kepler-89's formation and evolution, we will inform several areas of astrophysics from atmospheric escape to protoplanetary disk structure, all while providing the first atmospheric characterization of a Neptune-mass planet exterior to a giant planet-- a special orbital architecture shared with our own Solar System.

OBSERVING DESCRIPTION

We propose to obtain transmission spectra of the three gas-dominated planets of the Kepler-89 system with JWST/NIRSpec/PRISM (0.5-5.5 microns) to measure the abundance of H2O, CH4, CO, and CO2. The system is just dim enough for PRISM observations (J=11.22) without full saturation. We will observed four, one, and two transits of Kepler-89c, d, and e, respectively, in order to build adequate SNR to infer metallicity and C/O ratio to about 1/3 and 1/6 dex, respectively, as measured by state-of-the-art mock retrievals of data simulated with PandExo. Our observations will cover the transit duration, including an equal amount of out-of-transit baseline plus 30-minutes for systematics settling (Alderson et al. 2022). Observations are phase constrained around transit events for the ~10, 22, and 54 day period planets. Multiple transit opportunities exist for each planet. We include a wide orient to avoid a distant but associated companion (K=13).

Target acquistion setup achieves SNR>150. Saturation will occur in a single pixel- all other pixels won't be affect by saturation and TA should be successful.

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
(1)	Kepler-89	RA: 19 49 19.9343 (297.3330596d)	Proper Motion RA: 2.063 mas/yr	
		Dec: +41 53 28.01 (41.89111d)	Proper Motion Dec: 1.337 mas/yr	
		Equinox: J2000	Parallax: 0.0021069"	
			Epoch of Position: 2000	

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

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.
Category=Star
Description=[Exoplanet Systems, Exoplanets, F dwarfs, F stars]
Extended=NO

Observation

Proposal 10674, Observation 1: Kepler-89c

Wed May 20 22:00:18 GMT 2026

Diagnostic Status: Warning

Observing Template: NIRSpec Bright Object Time Series

Diagnostics

(Kepler-89c (Obs 1)) 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.

(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)	Kepler-89	RA: 19 49 19.9343 (297.3330596d)	Proper Motion RA: 2.063 mas/yr	
		Dec: +41 53 28.01 (41.89111d)	Proper Motion Dec: 1.337 mas/yr	
		Equinox: J2000	Parallax: 0.0021069"	
			Epoch of Position: 2000	

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

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.
Category=Star
Description=[Exoplanet Systems, Exoplanets, F dwarfs, F stars]
Extended=NO

Acquisition

#	Target	TA Method	Subarray	Filter	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Exposure Time	Optional ETC ID
1	SAME	WATA	SUB32	F110W	NRSRAPID	3	1	1	0.08	274737.4

Template

Subarray
SUB512

Spectral Elements

#	Grating/Filter	Readout Pattern	Groups/Int	Integrations/Exp	Exposures/Dith	Total Dithers	Total Integrations	Total Exposure Time	Optional ETC ID
1	PRISM/CLEAR	NRSRAPID	4	35800	1	1	35800	41215.824	274737.1

Special Requirements	
	Phase 0.9717 to 0.977 with period 10.4236774 Days and zero-phase 2454971.00904 HJD Time Series Observation No Parallel Attachments

Observation

Proposal 10674, Observation 2: Kepler-89c Wed May 20 22:00:18 GMT 2026

Diagnostic Status: Warning

Observing Template: NIRSpec Bright Object Time Series

Diagnostics

(Kepler-89c (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.

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

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
(1)	Kepler-89	RA: 19 49 19.9343 (297.3330596d)	Proper Motion RA: 2.063 mas/yr	
		Dec: +41 53 28.01 (41.89111d)	Proper Motion Dec: 1.337 mas/yr	
		Equinox: J2000	Parallax: 0.0021069"	
			Epoch of Position: 2000	

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

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.
Category=Star
Description=[Exoplanet Systems, Exoplanets, F dwarfs, F stars]
Extended=NO

Acquisition

#	Target	TA Method	Subarray	Filter	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Exposure Time	Optional ETC ID
1	SAME	WATA	SUB32	F110W	NRSRAPID	3	1	1	0.08	274737.4

Template

Subarray
SUB512

Spectral Elements

#	Grating/Filter	Readout Pattern	Groups/Int	Integrations/Exp	Exposures/Dith	Total Dithers	Total Integrations	Total Exposure Time	Optional ETC ID
1	PRISM/CLEAR	NRSRAPID	4	35800	1	1	35800	41215.824	274737.1

Special Requirements	
	Phase 0.9717 to 0.977 with period 10.4236774 Days and zero-phase 2454971.00904 HJD Time Series Observation No Parallel Attachments

Observation

Proposal 10674, Observation 3: Kepler-89c

Wed May 20 22:00:18 GMT 2026

Diagnostic Status: Warning

Observing Template: NIRSpec Bright Object Time Series

Diagnostics

(Kepler-89c (Obs 3)) 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.

(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)	Kepler-89	RA: 19 49 19.9343 (297.3330596d)	Proper Motion RA: 2.063 mas/yr	
		Dec: +41 53 28.01 (41.89111d)	Proper Motion Dec: 1.337 mas/yr	
		Equinox: J2000	Parallax: 0.0021069"	
			Epoch of Position: 2000	

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

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.
Category=Star
Description=[Exoplanet Systems, Exoplanets, F dwarfs, F stars]
Extended=NO

Acquisition

#	Target	TA Method	Subarray	Filter	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Exposure Time	Optional ETC ID
1	SAME	WATA	SUB32	F110W	NRSRAPID	3	1	1	0.08	274737.4

Template

Subarray
SUB512

Spectral Elements

#	Grating/Filter	Readout Pattern	Groups/Int	Integrations/Exp	Exposures/Dith	Total Dithers	Total Integrations	Total Exposure Time	Optional ETC ID
1	PRISM/CLEAR	NRSRAPID	4	35800	1	1	35800	41215.824	274737.1

Special Requirements	
	Phase 0.9717 to 0.977 with period 10.4236774 Days and zero-phase 2454971.00904 HJD Time Series Observation No Parallel Attachments

Observation

Proposal 10674, Observation 4: Kepler-89c

Wed May 20 22:00:18 GMT 2026

Diagnostic Status: Warning

Observing Template: NIRSpec Bright Object Time Series

Diagnostics

(Kepler-89c (Obs 4)) 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.

(Visit 4:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
(1)	Kepler-89	RA: 19 49 19.9343 (297.3330596d)	Proper Motion RA: 2.063 mas/yr	
		Dec: +41 53 28.01 (41.89111d)	Proper Motion Dec: 1.337 mas/yr	
		Equinox: J2000	Parallax: 0.0021069"	
			Epoch of Position: 2000	

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

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.
Category=Star
Description=[Exoplanet Systems, Exoplanets, F dwarfs, F stars]
Extended=NO

Acquisition

#	Target	TA Method	Subarray	Filter	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Exposure Time	Optional ETC ID
1	SAME	WATA	SUB32	F110W	NRSRAPID	3	1	1	0.08	274737.4

Template

Subarray
SUB512

Spectral Elements

#	Grating/Filter	Readout Pattern	Groups/Int	Integrations/Exp	Exposures/Dith	Total Dithers	Total Integrations	Total Exposure Time	Optional ETC ID
1	PRISM/CLEAR	NRSRAPID	4	35800	1	1	35800	41215.824	274737.1

Special Requirements	
	Phase 0.9717 to 0.977 with period 10.4236774 Days and zero-phase 2454971.00904 HJD Time Series Observation No Parallel Attachments

Observation

Proposal 10674, Observation 5: Kepler-89d

Wed May 20 22:00:18 GMT 2026

Diagnostic Status: Warning

Observing Template: NIRSpec Bright Object Time Series

Diagnostics

(Kepler-89d (Obs 5)) 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.

(Visit 5:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
(1)	Kepler-89	RA: 19 49 19.9343 (297.3330596d) Dec: +41 53 28.01 (41.89111d) Equinox: J2000	Proper Motion RA: 2.063 mas/yr Proper Motion Dec: 1.337 mas/yr Parallax: 0.0021069" Epoch of Position: 2000	

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

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.
Category=Star
Description=[Exoplanet Systems, Exoplanets, F dwarfs, F stars]
Extended=NO

Acquisition

#	Target	TA Method	Subarray	Filter	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Exposure Time	Optional ETC ID
1	SAME	WATA	SUB32	F110W	NRSRAPID	3	1	1	0.08	274737.4

Template

Subarray
SUB512

Spectral Elements

#	Grating/Filter	Readout Pattern	Groups/Int	Integrations/Exp	Exposures/Dith	Total Dithers	Total Integrations	Total Exposure Time	Optional ETC ID
1	PRISM/CLEAR	NRSRAPID	4	43500	1	1	43500	50080.68	274737.2

Special Requirements	
	Phase 0.9842 to 0.987 with period 22.3429648 Days and zero-phase 2454965.74164 HJD Time Series Observation No Parallel Attachments

Observation

Proposal 10674, Observation 6: Kepler-89e

Wed May 20 22:00:18 GMT 2026

Diagnostic Status: Warning

Observing Template: NIRSpec Bright Object Time Series

Diagnostics

(Kepler-89e (Obs 6)) 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.

(Visit 6:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
(1)	Kepler-89	RA: 19 49 19.9343 (297.3330596d) Dec: +41 53 28.01 (41.89111d) Equinox: J2000	Proper Motion RA: 2.063 mas/yr Proper Motion Dec: 1.337 mas/yr Parallax: 0.0021069" Epoch of Position: 2000	

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

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.
Category=Star
Description=[Exoplanet Systems, Exoplanets, F dwarfs, F stars]
Extended=NO

Acquisition

#	Target	TA Method	Subarray	Filter	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Exposure Time	Optional ETC ID
1	SAME	WATA	SUB32	F110W	NRSRAPID	3	1	1	0.08	274737.4

Template

Subarray
SUB512

Spectral Elements

#	Grating/Filter	Readout Pattern	Groups/Int	Integrations/Exp	Exposures/Dith	Total Dithers	Total Integrations	Total Exposure Time	Optional ETC ID
1	PRISM/CLEAR	NRSRAPID	4	27625	2	1	55250	63608.22	274737.3

Special Requirements	
	Phase 0.9918 to 0.9932 with period 54.319962 Days and zero-phase 2454994.23987 HJD Time Series Observation No Parallel Attachments

Observation

Proposal 10674, Observation 7: Kepler-89e

Wed May 20 22:00:18 GMT 2026

Diagnostic Status: Warning

Observing Template: NIRSpec Bright Object Time Series

Diagnostics

(Kepler-89e (Obs 7)) 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.

(Visit 7:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.

Fixed Targets

#	Name	Target Coordinates	Targ. Coord. Corrections	Miscellaneous
(1)	Kepler-89	RA: 19 49 19.9343 (297.3330596d)	Proper Motion RA: 2.063 mas/yr	
		Dec: +41 53 28.01 (41.89111d)	Proper Motion Dec: 1.337 mas/yr	
		Equinox: J2000	Parallax: 0.0021069"	
			Epoch of Position: 2000	

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

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.
Category=Star
Description=[Exoplanet Systems, Exoplanets, F dwarfs, F stars]
Extended=NO

Acquisition

#	Target	TA Method	Subarray	Filter	Readout Pattern	Groups/Int	Integrations/Exp	Total Integrations	Total Exposure Time	Optional ETC ID
1	SAME	WATA	SUB32	F110W	NRSRAPID	3	1	1	0.08	274737.4

Template

Subarray
SUB512

Spectral Elements

#	Grating/Filter	Readout Pattern	Groups/Int	Integrations/Exp	Exposures/Dith	Total Dithers	Total Integrations	Total Exposure Time	Optional ETC ID
1	PRISM/CLEAR	NRSRAPID	4	27625	2	1	55250	63608.22	274737.3

Special Requirements	
	Phase 0.9918 to 0.9932 with period 54.319962 Days and zero-phase 2454994.23987 HJD Time Series Observation No Parallel Attachments