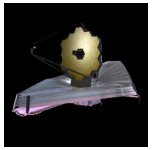

# 2667 - Good vibrations: Directly measuring Exoplanet aerosol compositions with MIRI spectroscopy

Cycle: 1, Proposal Category: GO

**INVESTIGATORS**

| *Name* | *Institution* |
|---|---|
| **Dr. Hannah Wakeford (PI) (ESA Member)** | **University of Bristol** |
| Lili Alderson (CoI) (ESA Member) | University of Bristol |
| Dr. Sarah E. Moran (CoI) | University of Arizona |
| Dr. Tiffany Kataria (CoI) (US Admin CoI) | Jet Propulsion Laboratory |
| Dr. Peter Gao (CoI) | Carnegie Institution of Washington |
| Dr. Mark S. Marley (CoI) | University of Arizona |
| Prof. David K. Sing (CoI) | The Johns Hopkins University |
| Dr. Nikole Lewis (CoI) | Cornell University |
| Dr. Kevin Stevenson (CoI) | The Johns Hopkins University Applied Physics Laboratory |
| Dr. Jeff A. Valenti (CoI) | Space Telescope Science Institute |
| Dr. Diana Powell (CoI) | University of Chicago |
| Dr. Natasha Batalha (CoI) | NASA Ames Research Center |

**OBSERVATIONS**

| *Folder* | *Observation* | *Label* | *Observing Template* | *Science Target* |
|---|---|---|---|---|
| Observation Folder | | | | |
| | 1 | HD209_MIRI_transit | MIRI Low Resolution Spectroscopy | (1) HD-209458 |
| | 51 | HD209_MIRI_transit | MIRI Low Resolution Spectroscopy | (1) HD-209458 |

**ABSTRACT**

Aerosols control the energy budget of an atmosphere and how much light is reflected, absorbed, and re-radiated. Aerosols in exoplanet atmospheres are commonly defined as either clouds (formed via condensation) or hazes (formed via photochemical reactions). The effect of aerosols as scattering in the UV-optical and muting of gas phase abundances in the near-IR has been observed in transmission spectra from giant hot Jupiters down to sub-Neptunes. However, aerosols are not all bad news for exoplanet spectra. The composition of aerosols directly measured in the IR, as condensate clouds or photochemical haze, will inform the temperature and pressure structure of the atmosphere. Without direct measurements of the aerosol composition, particle size, and abundance, we cannot fully account for the gas phase composition, the thermal structure, or the dynamical mixing in giant exoplanet atmospheres.

We will measure the first direct evidence of aerosols in the atmosphere of an exoplanet by observing the vibrational-mode absorption from sub-micron sized particles in the atmosphere of HD 209458b with MIRI LRS. With these observations, we will be able to constrain the particle size of the aerosols to less than an order of magnitude. This will enable us to constrain the magnitude of dynamical mixing in the atmosphere needed to produce such particle sizes, which in turn informs the role of mixing in the gas phase chemistry. In just a single transit, these high precision observations will not only distinguish between aerosols composed of cloud condensates and organic hazes, but also examine the role of aerosols in the radiative transfer, dynamics, and chemistry of exoplanet atmospheres

**OBSERVING DESCRIPTION**

We will use the MIRI instrument with LRS in Slitless Prism mode to measure the transit of the hot Jupiter HD 209458b. This is a time series observation and as such no parallel observation can be scheduled during the course of our observation. We will not conduct any dithers on our targer and will use FAST readout mode. Our target star is bright, K = 6.3, requiring an optimum number of 5 groups per integration with a total of 32165 integrations to cover our whole observing time. In total we will observe our target for 7.1 hours including readout times but excluding observatory overheads. This time includes needed stellar baseline measurements before and after transit as well as covering the entire transit duration to increase the precision of our measurements and ensure robust interpretation of the systematics and background. We additionally add an hour of observing time to account for a 60 minute window for the start of observations with JWST. The start window was calculated using the ExoCTK phase calculator and allows for a full hour for ease of scheduling.

**Fixed Targets**

| # | Name | Target Coordinates | Targ. Coord. Corrections | Miscellaneous |
|---|---|---|---|---|
| (1) | HD-209458 | RA: 22 03 10.8053 (330.7950221d)<br>Dec: +18 53 3.27 (18.88424d)<br>Equinox: J2000 | Proper Motion RA: 0.002084111884931303 sec of time/yr<br>Proper Motion Dec: -0.017889999958242697 arcsec/yr<br>Epoch of Position: 2015.5 | |

*Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.*
*Category=Star*
*Description=[Exoplanets]*

## Observation

**Proposal 2667, Observation 1: HD209_MIRI_transit**

Wed Jun 07 17:00:34 GMT 2023

**Diagnostic Status: Warning**

Observing Template: MIRI Low Resolution Spectroscopy

## Diagnostics

(HD209_MIRI_transit (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.

(HD209_MIRI_transit (Obs 1)) Warning (Form): Groups/Int cannot be 1, Groups/Int = 2 requires permission and Groups/Int of 3-4 is allowed but not recommended.

(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) | HD-209458 | RA: 22 03 10.8053 (330.7950221d)<br>Dec: +18 53 3.27 (18.88424d)<br>Equinox: J2000 | Proper Motion RA: 0.002084111884931303 sec of time/yr<br>Proper Motion Dec: -0.017889999958242697 arcsec/yr<br>Epoch of Position: 2015.5 | |

*Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.*
*Category=Star*
*Description=[Exoplanets]*

## Acquisition

| # | Target | Filter | Readout Pattern | Groups/Int | Integrations/Exp | Total Integrations | Total Exposure Time | ETC Wkbk.Calc ID |
|---|---|---|---|---|---|---|---|---|
| 1 | 1 HD-209458 | F1000W | FAST | 4 | 1 | 1 | 0.636 | 61628 |

## Template

| Subarray | Obtain Verification Image? |
|---|---|
| SLITLESSPRISM | true |

## Dithers

| # | Dither Type | No. Spectral Steps | Spectral Step Offset | No. Spatial Steps | Spatial Step Offset |
|---|---|---|---|---|---|
| 1 | NONE | | | | |

## Pointing Verification

| # | PV Readout Pattern | PV Groups/Int | PV Integrations/Exp | PV Total Integrations | PV Exposures/Dith | PV Total Dithers | PV Total Exposure Time | PV ETC Wkbk.Calc ID | Filter |
|---|---|---|---|---|---|---|---|---|---|
| 1 | FASTR1 | 4 | 1 | 1 | 1 | 1 | 0.636 | | F1000W |

**Spectral Elements**

| # | Readout Pattern | Groups/Int | Integrations/Exp | Total Integrations | Exposures/Dith | Total Dithers | Total Exposure Time | ETC Wkbk.Calc ID |
|---|---|---|---|---|---|---|---|---|
| 1 | FASTR1 | 7 | 20191 | 20191 | 1 | 1 | 25689.254 | 61628 |

**Special Requirements**

Phase 0.9030663728282162 to 0.9148875468735558 with period 3.5247486 Days and zero-phase 2451659.93742 HJD
Time Series Observation
No Parallel Attachments
No Parallel Attachments

## Observation

**Proposal 2667, Observation 51: HD209_MIRI_transit**

Wed Jun 07 17:00:34 GMT 2023

**Diagnostic Status: Warning**

Observing Template: MIRI Low Resolution Spectroscopy

## Diagnostics

(HD209_MIRI_transit (Obs 51)) 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.

(HD209_MIRI_transit (Obs 51)) Warning (Form): Groups/Int cannot be 1, Groups/Int = 2 requires permission and Groups/Int of 3-4 is allowed but not recommended.

(Visit 51:1) Warning (Form): Overheads are provisional until the Visit Planner has been run.

## Fixed Targets

| # | Name | Target Coordinates | Targ. Coord. Corrections | Miscellaneous |
|---|---|---|---|---|
| (1) | HD-209458 | RA: 22 03 10.8053 (330.7950221d)<br>Dec: +18 53 3.27 (18.88424d)<br>Equinox: J2000 | Proper Motion RA: 0.002084111884931303 sec of time/yr<br>Proper Motion Dec: -0.017889999958242697 arcsec/yr<br>Epoch of Position: 2015.5 | |

*Comments: This object was generated by the targetselector and retrieved from the SIMBAD database.*
*Category=Star*
*Description=[Exoplanets]*

## Acquisition

| # | Target | Filter | Readout Pattern | Groups/Int | Integrations/Exp | Total Integrations | Total Exposure Time | ETC Wkbk.Calc ID |
|---|---|---|---|---|---|---|---|---|
| 1 | 1 HD-209458 | F1000W | FAST | 4 | 1 | 1 | 0.636 | 61628 |

## Template

| Subarray | Obtain Verification Image? |
|---|---|
| SLITLESSPRISM | true |

## Dithers

| # | Dither Type | No. Spectral Steps | Spectral Step Offset | No. Spatial Steps | Spatial Step Offset |
|---|---|---|---|---|---|
| 1 | NONE | | | | |

## Pointing Verification

| # | PV Readout Pattern | PV Groups/Int | PV Integrations/Exp | PV Total Integrations | PV Exposures/Dith | PV Total Dithers | PV Total Exposure Time | PV ETC Wkbk.Calc ID | Filter |
|---|---|---|---|---|---|---|---|---|---|
| 1 | FASTR1 | 4 | 1 | 1 | 1 | 1 | 0.636 | | F1000W |

**Spectral Elements**

| # | Readout Pattern | Groups/Int | Integrations/Exp | Total Integrations | Exposures/Dith | Total Dithers | Total Exposure Time | ETC Wkbk.Calc ID |
|---|---|---|---|---|---|---|---|---|
| 1 | FASTR1 | 7 | 20191 | 20191 | 1 | 1 | 25689.254 | 61628 |

**Special Requirements**

Phase 0.9030663728282162 to 0.9148875468735558 with period 3.5247486 Days and zero-phase 2451659.93742 HJD
Time Series Observation
No Parallel Attachments
No Parallel Attachments