2113 - Exploring the morning and evening limbs of a transiting exoplanet

Cycle: 1, Proposal Category: GO

INVESTIGATORS

<table>
<thead>
<tr>
<th>Name</th>
<th>Institution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dr. Nestor Espinoza (PI)</td>
<td>Space Telescope Science Institute</td>
</tr>
<tr>
<td>Dr. Ludmila Carone (CoI) (ESA Member)</td>
<td>Space Research Institute, Austrian Academy of Sciences</td>
</tr>
<tr>
<td>Dr. Paul Molliere (CoI) (ESA Member)</td>
<td>Max Planck Institute for Astronomy</td>
</tr>
<tr>
<td>Robin Baeyens (CoI) (ESA Member)</td>
<td>Universiteit van Amsterdam</td>
</tr>
<tr>
<td>Prof. Lars A. Buchhave (Col) (ESA Member)</td>
<td>Technical University of Denmark-DTU Space</td>
</tr>
<tr>
<td>Dr. Jens Hoeijmakers (CoI) (ESA Member)</td>
<td>Lund University</td>
</tr>
<tr>
<td>Dr. Mercedes Lopez-Morales (Col)</td>
<td>Smithsonian Institution Astrophysical Observatory</td>
</tr>
<tr>
<td>Dr. Joao Manuel Mendonca (CoI) (ESA Member)</td>
<td>Technical University of Denmark-DTU Space</td>
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<tr>
<td>Aaron Bello-Arufe (Col)</td>
<td>Jet Propulsion Laboratory</td>
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<tr>
<td>Dr. Hannah Diamond-Lowe (Col) (ESA Member)</td>
<td>Technical University of Denmark-DTU Space</td>
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<tr>
<td>Dr. Neale Gibson (Col) (ESA Member)</td>
<td>University of Dublin, Trinity College</td>
</tr>
<tr>
<td>Alexander Rathcke (Col) (ESA Member)</td>
<td>DTU-Space</td>
</tr>
<tr>
<td>Andrea Guzman Mesa (Col) (ESA Member)</td>
<td>University of Bern</td>
</tr>
<tr>
<td>Dr. Daniel Kitzmann (Col) (ESA Member)</td>
<td>University of Bern</td>
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<tr>
<td>Dr. Matthew Hooton (Col) (ESA Member)</td>
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<td>Brett M. Morris (Col)</td>
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<td>Chloe Fisher (Col) (ESA Member)</td>
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<td>Prof. Adam J. Burgasser (Col)</td>
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<td>Thea Kozakis (CoI) (ESA Member)</td>
<td>Technical University of Denmark-DTU Space</td>
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<tr>
<td>Prof. Kevin Heng (Col) (ESA Member)</td>
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OBSERVATIONS
In the past decade, transiting exoplanets have been one of the most successful in terms of the atmospheric characterization of exoplanets. The technique of transmission spectroscopy - the wavelength-dependent change in the planetary radii due to opacity sources in its atmosphere - in particular, has been one of the main workhorses of the field in terms of providing constraints on the atmospheric elemental abundances in gas giant exoplanets. To date, this technique relies on one simple, key assumption: the terminator region we observe during transit is homogeneous. Here, we aim at putting this assumption to the test by exploring transit lightcurve asymmetries indicative of inhomogeneities between the morning and evening limbs in one of the most promising targets to search for this effect. Due to the exquisite spectrophotometric precision enabled by the James Webb Space Telescope, our observations will be able to constrain wavelength-dependent morning-to-evening depth differences down to 50 ppm, and extract the very first near-infrared transmission spectrum of the morning and evening of an exoplanet. This unprecedented set of spectra will provide strong constraints on the temperature and/or cloudiness levels at the limbs, providing a benchmark dataset with which to put modelling techniques such as Global Circulation Models to the test.

OBSERVING DESCRIPTION
The Time-Series Observation (TSO) proposed in this work aims to target a primary transit of the exoplanet WASP-63b using NIRISS/SOSS with SUBSTRIP256, in order to capture both Order 1 and 2 spectra. The readout mode to use will be the NISRAPID mode. The exposure consists of a 1493-integration TSO exposure with 4 groups per integration using SUBSTRIP256 and the GR700XD grism, which is followed by a 15-integration TSO exposure with the same setup as before, but using the F277W filter, which we are requesting in order to isolate Order 1, which will be useful to inform spectral extraction algorithms. Given the periodic nature of the transits of WASP-63b, these observations have a phase-constraint with a 1-hour window; the ephemerides inputted in APT are the latest ones at the time of writing, and include ephemerides updated thanks to photometry from the Transiting Exoplanet Survey Satellite (TESS), which we estimate should have an uncertainty of only 2-3 minutes in the range from July 2022 to
July 2023. Furthermore, we have in addition constrained the set of possible Position Angles for our observations based on possible contaminating sources nearby our target. We request no parallel observations during our TSO exposures.

The TSO exposures mentioned above are preceded by a Target Acquisiton exposure which we have proposed to perform using the same science target (WASP-63). These will be obtained with the SOSSFAINT acquisition mode and the NISRAPID readout mode. According to our ETC estimates, using the NISRAPID readout pattern and a single integration composed of 19 groups, we should reach a signal-to-noise ratio of over 300, which is excellent for centroiding purposes.

Updates on August 9, 2023:

- Modified RA, DEC and proper motions from Gaia DR3.
- Removed and modified some PA's, updated with new contamination overlap models; still consistent with the current planned window in September.
- Because background scaling has been an issue for some NIRISS/SOSS programs, we have decided to add background observations to our program (Observations 1-4). Each background exposure is a 4 group, 10-integration exposure in FULL. No TA is taken in this exposure; they are made non-interruptible and linked through sequences with the TSO. This charges an extra 1.2-hours to the program.
- We decreased the number of integrations of the TSO from 1629 to 1493. This reduced the time-on-target from 12.44 hours to 11.4 hours --- matching the difference to account for the extra background observations in the total charged time to the program. This still leaves us with plenty of time pre and post-transit. The duration of the transit event is 5.34 hours, so this new time-on-target would account for 3.03 hours pre transit and 3.03 hours post transit if the event is properly centered (i.e., total of 6.06 hours out-of-transit baseline).
- The TSO period and time-of-transit center have been updated to those published by Patel & Espinoza (2022AJ....163..228P). This has an uncertainty at 1-sigma of 49.5 seconds for September 29, 2023. In addition, the phase constraints have been updated on the TSO to match the new pre-mid transit time expected on target (11.4 / 2 = 5.7 hours) using the ExoCTK phase-constraint tool.
### Fixed Targets

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<th>Name</th>
<th>Target Coordinates</th>
<th>Targ. Coord. Corrections</th>
<th>Miscellaneous</th>
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<td>Proper Motion RA: -17.468 mas/yr</td>
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<tr>
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<td>Proper Motion Dec: -27.2924 mas/yr</td>
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Comments: RA, DEC, proper motions and parallax all obtained from GAIA DR3 (Source ID 5574766468155514752).
Category=Star 
Description=[G stars] 
Extended=NO
## Proposal 2113 - Observation 1 - Exploring the morning and evening limbs of a transiting exoplanet

**Proposal 2113, Observation 1: Background observation 1, 40 arcsec offset**

**Diagnostics Status:** Warning

Observing Template: NIRISS Single-Object Slitless Spectroscopy

---

### Diagnostic Warning

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

---

### Fixed Targets

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*Comments: RA, DEC, proper motions and parallax all obtained from GAIA DR3 (Source ID 5574766468155514752), Category=Star, Description=[G stars], Extended=NO*

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### Template Subarray

**Include F277W Exposure?**

FULL

false

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### Spectral Elements

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### Special Requirements

Offset 0.0 arcsec, 40.0 arcsec

Time Series Observation

No Parallel Attachments

Sequence Observations 1, 2, 3, 4, 5, Non-interruptible
Proposal 2113 - Observation 2 - Exploring the morning and evening limbs of a transiting exoplanet

**Observation**

Proposal 2113, Observation 2: Background observation 2, 20 arcsec offset

**Diagnostic Status:** Warning

Observing Template: NIRISS Single-Object Slitless Spectroscopy

---

**Diagnostics**

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

**Fixed Targets**

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**Template**

Subarray: FULL

Include F277W Exposure?: false

**Spectral Elements**

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**Special Requirements**

Offset 0.0 arcsec, 20.0 arcsec

Time Series Observation

No Parallel Attachments

Sequence Observations 1, 2, 3, 4, 5, Non-interruptible
Proposal 2113 - Observation 3 - Exploring the morning and evening limbs of a transiting exoplanet

Diagnostics

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

Fixed Targets

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Comments: RA, DEC, proper motions and parallax all obtained from GAIA DR3 (Source ID 5574766468155514752), Category=Star
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Acquisition

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Special Requirements

Offset 0.0 arcsec, -20.0 arcsec
Time Series Observation
No Parallel Attachments
Sequence Observations 1, 2, 3, 4, 5, Non-interruptible
Proposal 2113 - Observation 4 - Exploring the morning and evening limbs of a transiting exoplanet

Observation

Proposal 2113, Observation 4: Background observation 4, -40 arcsec offset

Diagnostic Status: Warning

Observing Template: NIRISS Single-Object Slitless Spectroscopy

Diagnostics

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

Fixed Targets

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Acquisition

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Special Requirements

Offset 0.0 arcsec, -40.0 arcsec
Time Series Observation
No Parallel Attachments
Sequence Observations 1, 2, 3, 4, 5, Non-interruptible
### Proposal 2113 - Observation 5 - Exploring the morning and evening limbs of a transiting exoplanet

#### Observing Template: NIRISS Single-Object Slitless Spectroscopy

- **Diagnostic Status:** Warning

---

#### Fast Text

(WASP-63 transit (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.

(Exposure) 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.

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#### Fixed Targets

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*Comments: RA, DEC, proper motions and parallax all obtained from GAIA DR3 (Source ID 5574766468155514752).*

*Category=Star*

*Description=[G stars]*

*Extended=NO*

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#### Acquisition

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#### Special Requirements

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- Aperture PA Range 0 to 10 Degrees (V3 359.43873283 to 0.43873283)
- Aperture PA Range 45 to 62 Degrees (V3 44.43873283 to 61.43873283)
- Aperture PA Range 265 to 290 Degrees (V3 264.43873283 to 289.43873283)
- Aperture PA Range 331 to 339 Degrees (V3 330.43873283 to 338.43873283)
- Aperture PA Range 79.4 to 93.5 Degrees (V3 78.83873283 to 92.93873283)
- Time Series Observation
- Sequence Observations 1, 2, 3, 4, 5, Non-interruptible

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Fri Aug 11 15:01:36 GMT 2023

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