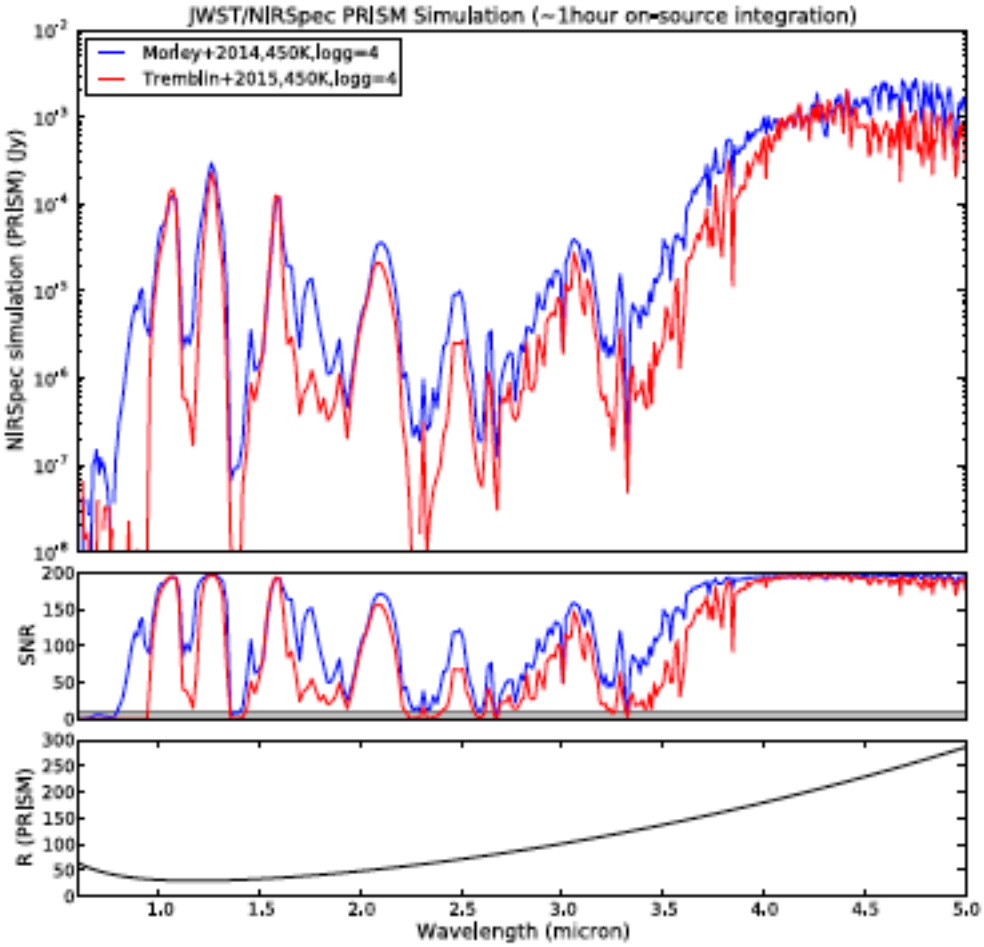
Infrared spectroscopy of Y dwarfs

1. Introduction

The goal is to obtain spectroscopic observations of a Y dwarf across the entire JWST NIRSpec and MIRI LRS wavelength ranges to understand whether these atmospheres are shaped by chemical disequilibrium driven by vertical transport or the formation of water clouds, and constrain the object's gravity, hence mass.

2.



Methodology

We will design slit spectroscopy observations to compare high-quality NIRSpec spectra in low (from 0.6 to 5.3 μm) and medium (from 2.87 to 5.27 μm) resolution, to models of cool atmospheres at different temperatures, gravity, degrees of turbulence, chemical equilibrium or disequilibrium driven by vertical transport, and clouds (see Figure 1). We will extend the study to MIRI LRS slit (5.0 to 12 μm) at low resolution.

Object type: Point-like source

Spectral configuration:

- NIRSpec/PRISM (0.6 to 5.3μm) and MIRI LRS (5.0 to 12 μm) data gives access to several diagnostics that can constrain models probing different:
  - temperatures
  - gravity
  - degrees of turbulence
  - in chemical equilibrium or with disequilibrium driven by vertical transport
  - water clouds coverage
- NIRSpec/G395M (2.87 to 5.27μm) data provides additional information in a region of the spectrum where the effect of water clouds is very pronounced and which contains the ammonia feature at 4.2 μm which is sensitive to temperature.

Detector configuration:

- NIRSpec: subarray, traditional readout mode
- MIRI LRS slit: FULL

Target acquisition:

- NIRSpec: Wide Aperture (WATA) with science object
- MIRI LRS: TA with science object

3. ETC

Goal

Hands-on creation of the ETC workbook for science and target acquisition for NIRSpec (MIRI LRS was demonstrated as part of the ETC hands-on).

Scenes and Sources

- Define a source using as target WISE J035000.32-565830.2
  - Name: WISE J035000.32-565830.2
  - Coordinates: RA=03:50:00.328 Dec=-56:58:30.23
  - Magnitudes (e.g.):
    - F140W= 22.30±0.20 mag (HST/WFC3)
    - W2=14.75±0.04 mag (WISE)
    - W3=12.33±0.28 mag (WISE)
  - Spectral type: Y1
  - Example model spectrum: morley_spec_ETC_noscale.txt, renormalized to the above measured F140W magnitude vegamag.
  - Shape: Point source
- Set up scene with the above defined point source

Calculations

1. NIRSpec Target Acquisition:

- Setup a representative background by using the target's coordinates and an example date for the observations derived using the target visibility tool to fall in The Cycle 1 window (2021-09-30 – 2022-09-30, e.g. Dec 1st 2021).
- In the instrument setup choose the WATA Acq mode.
- In the detector setup choose the NRSRAPID readout pattern.
- Determine a filter and subarray combination that gives the required SNR > 20.

Hints:

- NIRSpec TA Filters: F110W/F140X/CLEAR from narrower to wider bandpass.

- We use same readout pattern as the science, so as not to be charged extra time

2. NIRSpec Fixed-slit:
   - Set up the background the same as before.
   - In the instrument setup select the Prism/CLEAR grating and filter with the S200A1 Slit.
   - In the strategy set the wavelength to 1 μm .
   - In the detector setup use the SUBS200A1 subarray with the NRSRAPID readout pattern and use 3 exposures (dithers).
   - Modify the groups and integrations to achieve a SNR > 25.
   - Duplicate the calculation.
   - In the instrument setup change to the G395M/F290LP grating and filter. You'll get a warning about the wavelength so on the strategy set the wavelength to 4.7 μm.
   - Modify the groups and integrations to achieve a SNR > 100.

Hints:
   - For NIRSpec in general do not use integrations longer than ~3000 seconds, to avoid cosmic ray issues.
   - Note that when setting up the detector with subarrays, the only readout patterns available are NRS and NRSRAPID (only traditional mode).

3. MIRI Target Acquisition:
   - Set up the background the same as before.
   - For the instrument setup use the appropriate Acq Mode and the F560W filter.
   - For the detector setup use the appropriate subarray and the FASTGRPAVG readout pattern.
   - Determine the number of groups needed to obatin the required SNR > 20.

Hints:
   - The target acquisition and subarray only have one choice for MIRI LRS as indicated in the drop-down menues.

4. MIRI LRS slit:
   - Set up the background the same as before.
   - In the detector setup use the FAST readout pattern and 2 exposures per specification for the dither pattern (along-slid-nod).
   - In the strategy set the wavelength to 10 μm.
   - Determine the parameters needed to obatin a SNR > 50.

4. APT

Generate a JWST proposal using APT including NIRSpec and MIRI LRS observations using the ETC exposure times of the two NIRSpec and MIRI LRS workbooks, and the correspondent considered dither patterns.

- Target definition using the Fixed target resolver by position (SIMBAD):
  - Target name: WISE J035000.32-565830.2
  - Target coordinates: RA=03 50 00.328 Dec=-56 58 30.23
- Target category: Star
- Target description: Y dwarfs
- Target extended: NO
- APT Templates: NIRSpec fixed slit spectroscopy and MIRI low resolution spectroscopy

- Complete Target Acquisition pane using science object for both instruments

Hints:

- In order to have both PRISM and G395M done in the same observation (only one target acquisition needed) the dither pattern in APT needs to be the same for PRISM and G395M.
- For NIRSpec use the 3 primary dithers and set the sub-pixel dithers to None.
- For MIRI use the ALONG SLIT NOD dither (2 dither points).

Data Volume Considerations: Are the individual visits running into data volume issues? If so, what are the possible solutions?
Special Requirements: Do you need to impose some (scientifically justified) time constraint? For this case, we don't require PA constraints.
Aladdin Visualization: Use Aladdin to visualize instrument footprints/coverage/dithers. You can also play with the orientation.
Visit planner: Highlight the Observation folders and run the Visit Planner. Verify the schedulability of the program. Go to the visit planner menu and run smart accounting to remove potential unnecessary overheads.
Review the program: Do you have errors or warnings? If yes, are they expected? Can they be "fixed"?