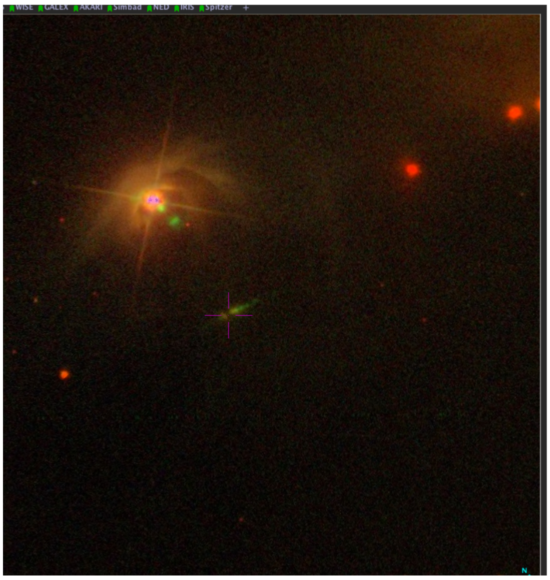
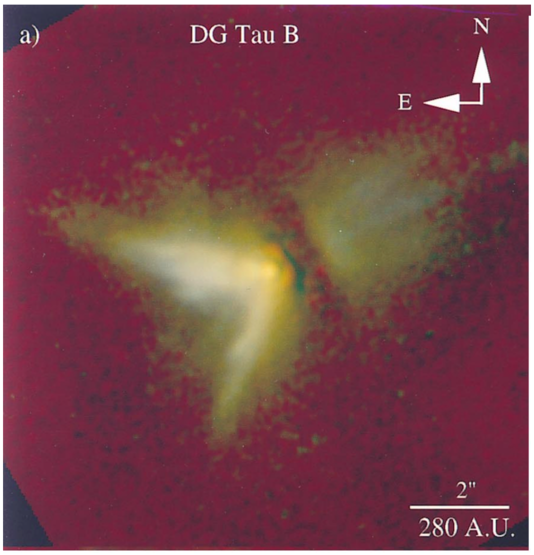
Tutorial : JWST MIRI-MRS DG Tau B source and outflows

Context :

DG Tau B is a class I target in the Taurus cloud driving a jet and massive CO outflow.
PA of the redshifted jet/CO outflow:

DG Tau B is located about 1 arcmin south-west of the bright T Tauri star DG Tau. It is highly obscured in the visible. A point source becomes visible at 2 micron and the source becomes very bright beyond





The image on the left shows the composite SDSS image of the field. The target DG Tau B is indicated by a red cross. The top left bright source is DG Tau. The image of the right shows a composite NICMOS/HST image.

Objectives of the proposal:

- Primary: map with MIRI-MRS (4-7.7" FOV) the inner regions of the outflows in the **H2 rotational transitions. Our main interest is on the (redshifted) North-Western lobe which is brighter in CO** but ideally we would like to map both lobes in the vicinity of the central source over a roughly 6 x 6 " FOV .

- Secondary: get a high SNR spectrum of the central protostar

Purpose of the tutorial :

- compute with the ETC the required parameters
- prepare the APT for this observation

1- ETC :

Login at https://jwst.etc.stsci.edu/ (anonymous if no MyST account).
create New Workbook => Load
rename Workbook => "DG Tau B MIRI-MRS"

Upload spectra: Upload mid-IR continuum spectrum of DG Tau B:
DGTauB_MKM_SLSHLH_bcd_mean_RSRF_fin_trunc_scale.txt

Scenes and Sources
(save button after each edition)

- Define Source 1 as continuum source: edit source 1 form
  - change ID to continuum source
  - upload DGTAUB_MKM.. as continuum file
  - renormalize to 1.88 Jy at 15 microns
  - define as point source centered at (0,0)

- Define Source 2 as H2 line emission region (=outflow)
  - create new source and change ID to H2 emission lines
  - no continuum
  - line tab: define the following list of lines:

	Wvl (microns)	FWHM (km/s)	Flux (erg/cm2/s)
H2 0-0 S(7)	5.51	15	1e-15
H2 0-0 S(5)	6.91	15	1e-15
H2 0-0 S(3)	9.66	15	1e-15
H2 0-0 S(2)	12.28	15	1e-15
H2 0-0 S(1)	17.03	15	1e-15

  - Define the shape of the line emission region: extended, flat distribution of extension 3 x 1.5 arcsec, normalized by surface brightness in arcsec^2.

- Define two scenes:
  - Scene 1 with Source 2 only (H2 outflow)
  - Scene 2 with Source 1 (point source continuum) and Source 2 (H2 outflow)

  both sources centered at (0,0) in both scenes.

Calculations

MIRI-MRS: select Scene 1 and target the H2 9.7 microns line

- Check that the right scene and sources are selected
- Use average background conditions
- Select the instrument set-up (channel, wavelength range) that covers the H2 line of interest
- Strategy tab: Define the strategy to compute the SNR
  - background subtraction: IFU on target + off target pointing: do you think the Nod in scene would work in this case ?
  - aperture radius: corresponding to MRS slide width (between 0.25 and 0.3”)
  - define position in scene to compute the SNR
  - wavelength of slice: wavelength of H2 line

  Note: this calculation will overestimate the SNR per spaxel.
  Look at the SNR map in the lower left corner of the window to estimate SNR per spaxel
  Aim for a SNR>= 10 per spaxel in the line emitting region.

- Detector set-up:
  select FULL and FASTR1 readout, TOTAL DITHERS = 4 (corresponding to the 4 dither positions), Integrations per exposure = 1

  → **find the number of groups that will give SNR >= 10 per spaxel (in the SNR map) in the line region.**

  → **Repeat the calculation with Scene2 (line + continuum)**
  Check that the continuum is not saturated on source
  Estimate the SNR achieved on source in the continuum (you will need to adapt the strategy).
  Compare the SNR estimates in the line region with the previous calculation.

Simultaneous MIRI imaging:
use F770W, F1000W and F2550W filters in scene 2
default read out mode for the imager is FAST
watch for significant saturation and consider using imaging subarrays if you run into issues.

→ what do you conclude about simultaneous imaging ?

Hints:

- with MIRI favour long single integrations over short multiple integrations. Having a low percentage of slightly saturated pixels should not be an issue; the calibration pipeline will use the unsaturated portion of the ramps to estimate a count rate value for the spaxel.

2- APT

Create New JWST proposal

- File -> New -> New JWST proposal
- Skip the proposal information for now
- Under the Targets Tab add a “fixed target” and search by name in SIMBAD
  [EM98] DG Tau B cRN
  RA=04 27 2.6046, DEC=+26 05 29.79
- fill in the information about the target . Pay attention to the ‘extended’ target field.
- Define a background target: define a suitable position from e.g. Aladin visualization tool.
- Go back to the DG Tau B target. Click on the box “Observation requires companion background observations”. Select the background target

Define Target Observations

- Under the observations tab, create a New Observation folder.
- Skip the observation summary
- Click on the observation and fill in the information: you will need one observation folder for the target and one for the background. In the MIRI-MRS configuration you will need three sets of exposures for the three MRS gratings allowing to cover the entire spectral range. If you plan simultaneous imaging you will also need to specify the three filters.
- Edit your observation and specify:
    - instrument, template (MIRI Medium Resolution Spectroscopy), target
    - go to edit observation
    - target acquisition method: chose no TA here but may depend on specific program.
    - MIRI imager subarray if required (same as used in the ETC)
    - Primary channels : all
    - Wavelength: Short/Medium/Long gratings should be split off into three separate sets of exposures to be able to use multiple filters for the simultaneous imaging
    - set number of dithers, readout mode and number of groups and integrations as defined previously with the ETC.
- Use the Aladin visualization tool to see the MIRI footprint

Define Background Observations

- The background observation folder can be created by duplicating the target observation folder and changing the target. Click on the observation and fill in the background target information.

- Consider your background strategy: do you need to dither ?
- Go to the Special requirements and add a Time Constraint Explicit requirement. Link the DG Tau B and the background observations to be executed in a non interruptible sequence. This is to ensure that data are taken under the same conditions.

Observation schedulability

- **Visit planner:** highlight the Observation folders and run the Visit Planner (click on Update Display if nothing happens). Verify the schedulability of the program. Go to the visit planner menu and run smart accounting to remove potential unnecessary overheads.
- Go back to **Form editor** and **check the total charged execution time** in the Proposal Information Tab.
- **Review the program**: do you have errors or warnings ? can you fix any ?

How many fields would be required to map both lobes of the outflow with MIRI-MRS and what would be the total time of such proposal ?

Useful Docs:

Instructions for filling out MIRI-MRS APT:
https://jwst-docs.stsci.edu/jwst-mid-infrared-instrument/miri-apt-templates/miri-mrs-apt-template#gsc.tab=0

Examples of publicly available APT files (accessible from within APT)
https://www.stsci.edu/jwst/science-execution/program-information?id=1947
https://jwst-docs.stsci.edu/jwst-mid-infrared-instrument/miri-example-science-programs/miri-mrs-and-nirspec-ifu-observations-of-cassiopeia-a#gsc.tab=0

Proposal Planning Video Tutorials:
https://jwst-docs.stsci.edu/proposal-planning-video-tutorials#gsc.tab=0