Identifying spectral lines in MIRI JWST data

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In this project, you will analyse the MIRI spectral cubes for the source NGC 7469.

Basic Exploration I

Identify the Object:

- Use **NED** and **Simbad** to find the basic properties of the given object.
- What are the **sky coordinates (RA and Dec)** of the object?
- What is the **distance** to the object?
- What is its **redshift (z)** value?
- What is the **category** of the object?
  (Example: Galaxy, AGN, quasar, star, planet etc.)
- What is the **sub-category** (if available)?

Read and Summarise:

- Briefly read about the **category** of your object.
- What does this category typically mean in the context of extragalactic astronomy? (Hint: Look into the **Unified Model** of AGNs or similar frameworks, if relevant)

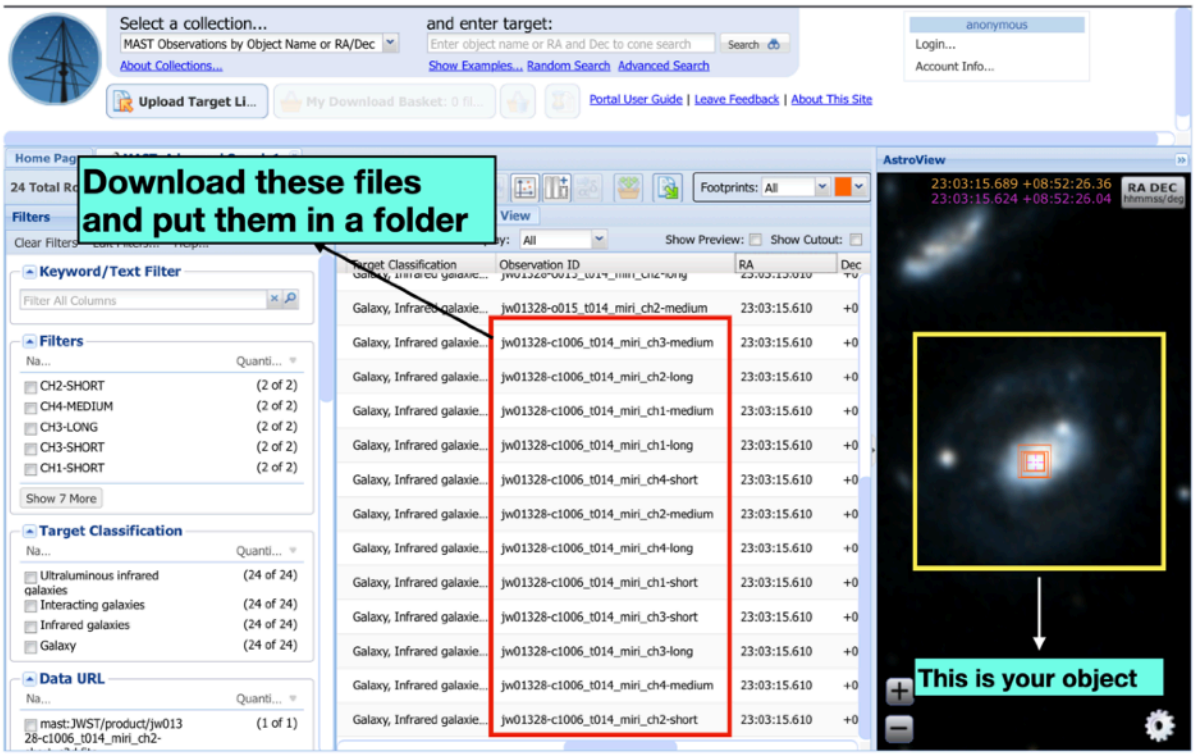
Understand the Role of MIR:

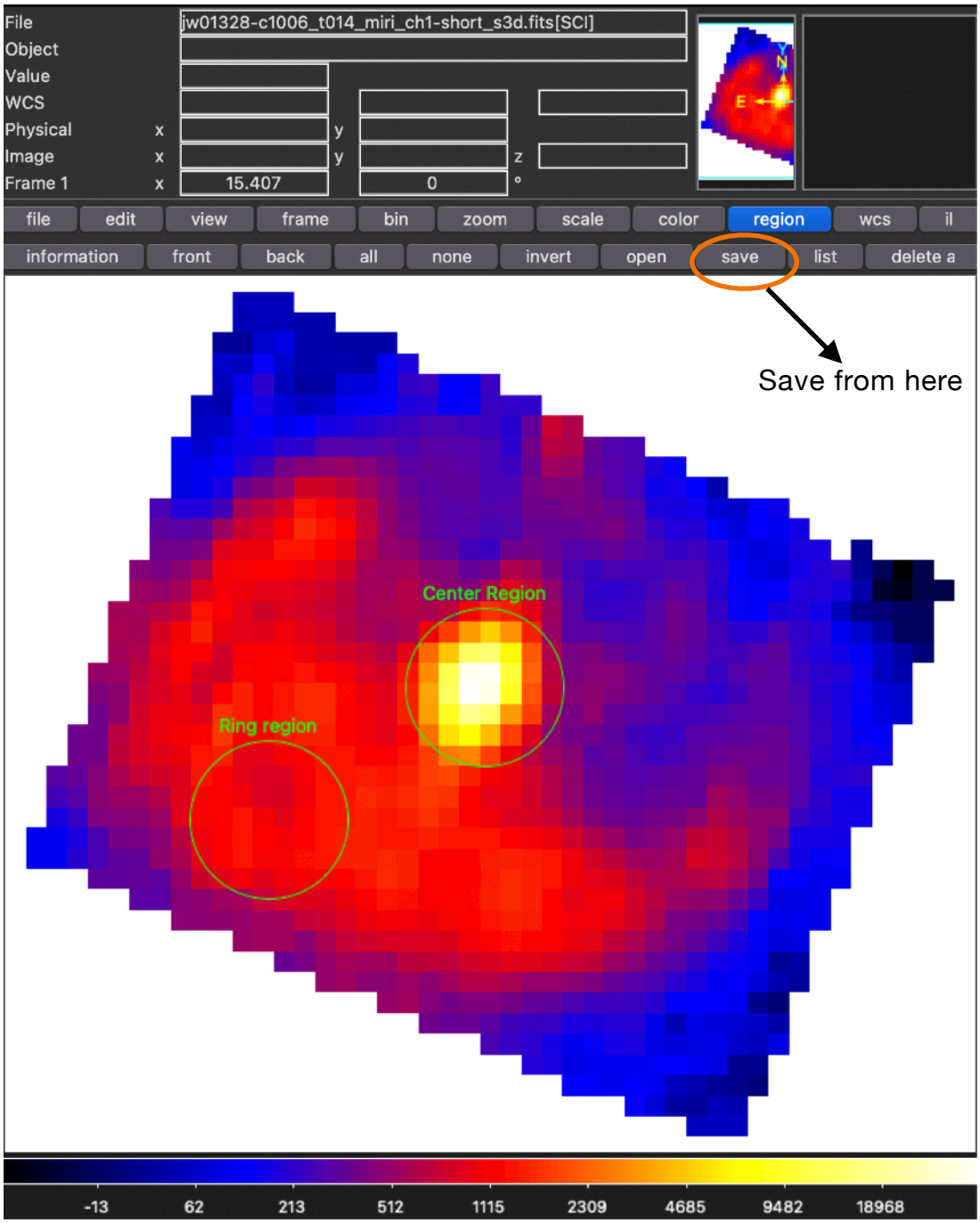
- Why is **Mid-Infrared (MIR) imaging** critical for studying objects like this and helps reveal hidden structures that Optical/NIR cannot?

Steps about how to download data

First go to the MAST portal. Then go to advanced search. There, give the following input:

1. Object Name: NGC 7469
2. Observation Type: science


Select a collection...
MAST Observations by Object Name or RA/Dec
and enter target:
Enter object name or RA and Dec to cone search
Search
About Collections...
Show Examples... Random Search Advanced Search
anonymous
Login...
Account Info...
Upload Target Li...
Portal User Guide | Leave Feedback | About This Site
Download these files and put them in a folder
Filters
Keyword/Text Filter
Filter All Columns
CH2-SHORT (2 of 2)
CH4-MEDIUM (2 of 2)
CH3-LONG (2 of 2)
CH3-SHORT (2 of 2)
CH1-SHORT (2 of 2)
Show 7 More
Target Classification
Ultraluminous infrared galaxies (24 of 24)
Interacting galaxies (24 of 24)
Infrared galaxies (24 of 24)
Galaxy (24 of 24)
Data URL
mast:JWST/product/jw01328-c1006_t014_miri_ch2- (1 of 1)
Footprints: All
Show Preview: Show Cutout:
Target Classification
Observation ID
RA
Dec
Galaxy, Infrared galaxie... jw01328-o015_t014_miri_ch2-medium 23:03:15.610 +0
Galaxy, Infrared galaxie... jw01328-c1006_t014_miri_ch3-medium 23:03:15.610 +0
Galaxy, Infrared galaxie... jw01328-c1006_t014_miri_ch2-long 23:03:15.610 +0
Galaxy, Infrared galaxie... jw01328-c1006_t014_miri_ch1-medium 23:03:15.610 +0
Galaxy, Infrared galaxie... jw01328-c1006_t014_miri_ch1-long 23:03:15.610 +0
Galaxy, Infrared galaxie... jw01328-c1006_t014_miri_ch4-short 23:03:15.610 +0
Galaxy, Infrared galaxie... jw01328-c1006_t014_miri_ch2-medium 23:03:15.610 +0
Galaxy, Infrared galaxie... jw01328-c1006_t014_miri_ch4-long 23:03:15.610 +0
Galaxy, Infrared galaxie... jw01328-c1006_t014_miri_ch1-short 23:03:15.610 +0
Galaxy, Infrared galaxie... jw01328-c1006_t014_miri_ch3-short 23:03:15.610 +0
Galaxy, Infrared galaxie... jw01328-c1006_t014_miri_ch3-long 23:03:15.610 +0
Galaxy, Infrared galaxie... jw01328-c1006_t014_miri_ch4-medium 23:03:15.610 +0
Galaxy, Infrared galaxie... jw01328-c1006_t014_miri_ch2-short 23:03:15.610 +0
AstroView
23:03:15.689 +08:52:26.36
23:03:15.624 +08:52:26.04
RA DEC
This is your object


File jw01328-c1006_t014_miri_ch1-short_s3d.fits[SCI]
Object
Value
WCS
Physical x y
Image x y z
Frame 1 x 15.407 0 °
file edit view frame bin zoom scale color region wcs il
information front back all none invert open save list delete a
Save from here
Center Region
Ring region
-13 62 213 512 1115 2309 4685 9482 18968

3. Mission: JWST

4. Instrument: MIRI/IFU

5. Product Type: cube

It will take some time and at top left it will show the records found: 24. There, you click 'search' and it should open it something like as shown in first figure.

Download the following files -c1006_ is mentioned in their name. These are calibrated files. And save them in a single folder where your code is kept or give the suitable path for each file. Then open the ch1 short and make the regions as shown in the second figure with radius = 0.5 arcsec. Save the region file as .reg file with format ‘ds9’ and coordinate system as ‘icrs’ respectively.

Basic Exploration II

Calculate Pixel Scale in Parsecs:

- Open the **SCI extension header** from the FITS file (DS9 or python).
- What is the **pixel scale (CDELT1 or CDELT2)** in arcseconds?
- Convert this value to **parsecs per pixel** using the astropy module.
- Repeat the above exercise for all fits files.
- Based on the typical pixel scale you computed for all channels, what **physical size on the object** does one pixel cover? Which region of the object are we trying to study here?

Analyse and answer the questions

Extract and Save Region Spectra:

- Can you use the code provided in Session 5 as your base, change the file names of the regions, and extract the spectra for each?
  (Hint: Iterate over region files, extract spectra, and save them.)

- Can you save the extracted spectra to a data-frame in pandas and optionally write it to a CSV file? (Optional)
  (Explore this if you haven’t tried it before.)

Compare Spectra Between Regions:

- After plotting the spectra for both regions, do you notice any vertical shift in the spectra?
  (Hint: If yes, this is likely due to a calibration issue — ignore this for now.)

- Apart from any vertical shift, do you see any differences in the spectral features between these two regions?
  List all the differences you can find.

- What could be the possible physical or astrophysical reasons behind these differences?
  (Hint: The relative strength of multiple ionisation lines of the same atom can tell us about conditions like density, temperature, or ionisation source. Also, for easy analysis, broad features are PAHs, narrow ones are atomic line features.)

Inspect Channel-wise Variations:

- As you move from Channel 1 to Channel 4 and towards longer wavelengths, do you notice any change in the spectral features (Number of features, error/ oscilations)?

- Is this change likely to be due to an instrumental effect or a real astrophysical property? Take a reasoned guess and explain your reasoning.

Reason the Region Selection:

- Based on your analysis so far, why do you think I selected these two particular regions for you to analyse? Can you take an educated guess?

Identify and Tabulate Emission Features:

- By opening each FITS file using Cubeviz (online or offline), can you identify all the emission lines and features visible in the spectra?

- Can you make a table listing:

    - Line Name (full name with atomic/molecular transition)

    - Wavelength (in rest-frame, microns)

    - Astrophysical significance (what it traces or indicates in the system)

- If required you can add another column to specify the region out of two it is stronger, or is visible only in one but not the other etc for each line.