Identifying spectral lines in MIRI JWST data

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

NGC 7469

- Using NED and SIMBAD, Here are some basic properties of NGC 7469.

Sky Coordinates :

RA - 345.815059
Dec - 8.873917

Distance – 195+65.6 Mly

Redshift(z) - 0.016268 ± 7.00e-6

Categary – intermediate spiral Galaxy

Seyfert 1 Galaxy :

- A type of Active Galactic Nuclei
- Seyfert galaxies are one of the two largest groups of active Galaxies.
- Type 1 means it has both narrow and broad emission lines indicating the presence of high-velocity gas near the black hole.
- In NGC 7469, **both AGN activity and starburst regions coexist**, making it an excellent laboratory to study the interplay between black holes and star formation.

Type : (R')SAB(rs)a

Mid-Infrared (MIR) imaging

- MIRI's wavelengths(5–28 microns) can pass/see through thick clouds of gas and dust around AGNs and star-forming regions.
- So it can observe those dusty region around AGN and other Structures hidden behind or within dusty region.
- It traces **both AGN and star formation activity.**
- It provides key **diagnostic emission lines and PAH features** that help us understand the physical conditions in the galaxy.

Basic Exploration II

Calculating pixel scale for all fits files of all channels

Average pixel scale: 57.09274707239006

Based on the calculated pixel scales, one pixel in the MIRI IFU cubes covers approximately **44 to 68 parsecs** depending on the channel.

I attached code in jupyter file part
we are likely studying the circumnuclear star-forming ring and the inner regions around the AGN in NGC 7469. Which also includes Inner dusty regions and possibly parts of the AGN torus.

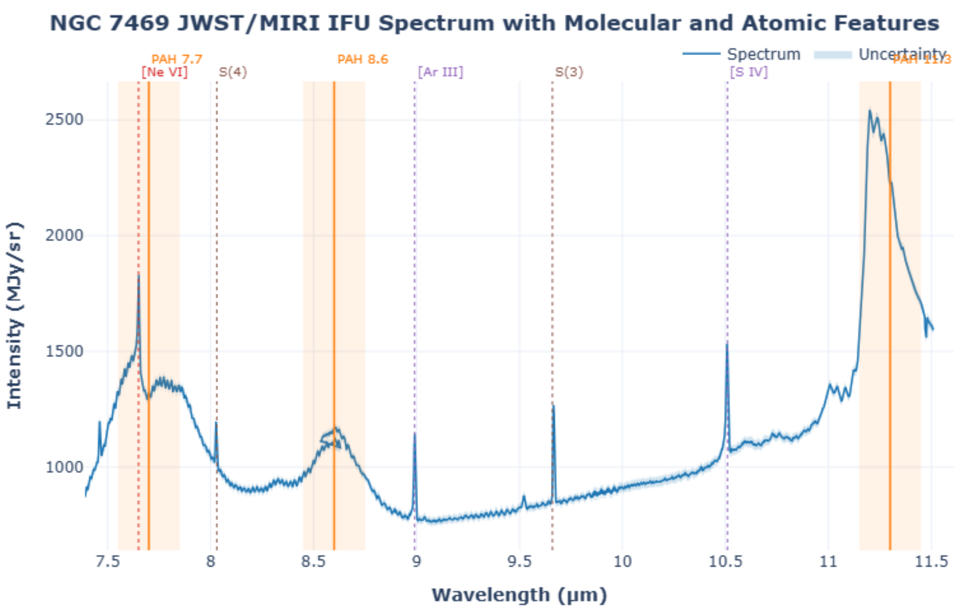
Extract and Save Region Spectra:

Using code from session 5 as a base, i extracted spectra of different region for channel 2.

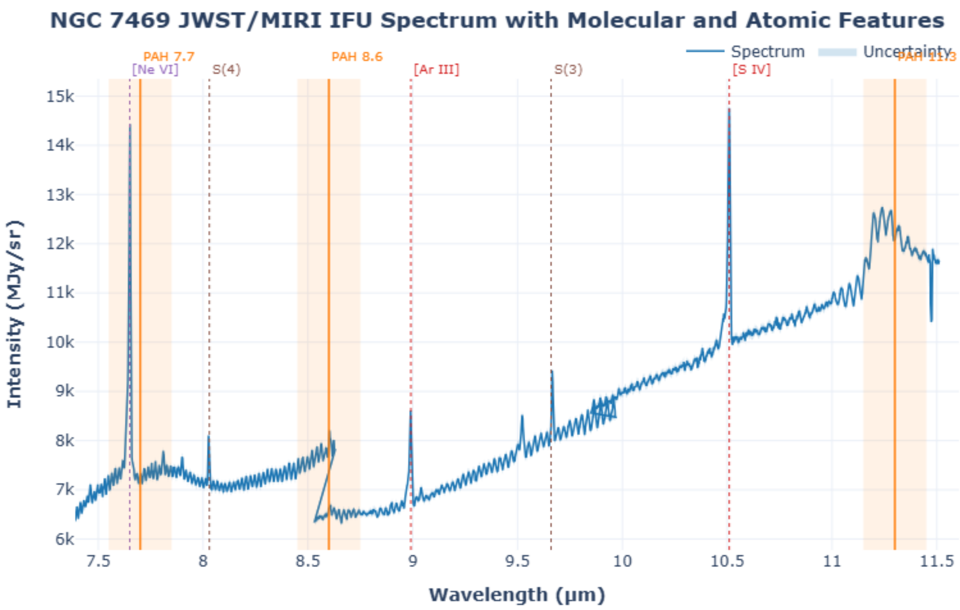
Compare Spectra Between Regions:

After plotting the spectra for both regions, do you notice any vertical shift in the spectra?
Ans: yes.

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.
Ans:
In session 5 :



Different region of same channel:



As seen in both pictures,there are few differences in both plots.
Such as,

- Emission line ha more intensity value and are stronger in second plot.
- PAHs regions also has higher intensity values and is stronger.
- Shape differences can also be seen.
- There is also a obvious difference in PAH 8.6 region.

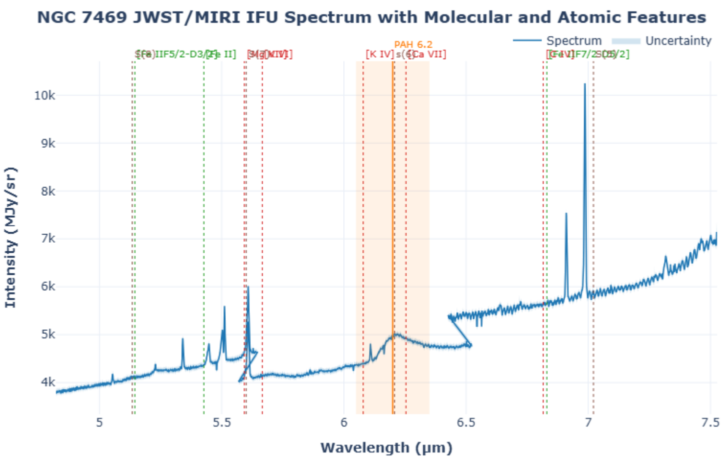
What could be the possible physical or astrophysical reasons behind these differences?
Ans:

- Stronger emission lines are because of more denser area and very strong radiation.
- Stronger PAH feature is indicating strong star formation than AGN.
- This differences can also be because of dusty area or high density gas area.
- Also because of not being clearly In sight.

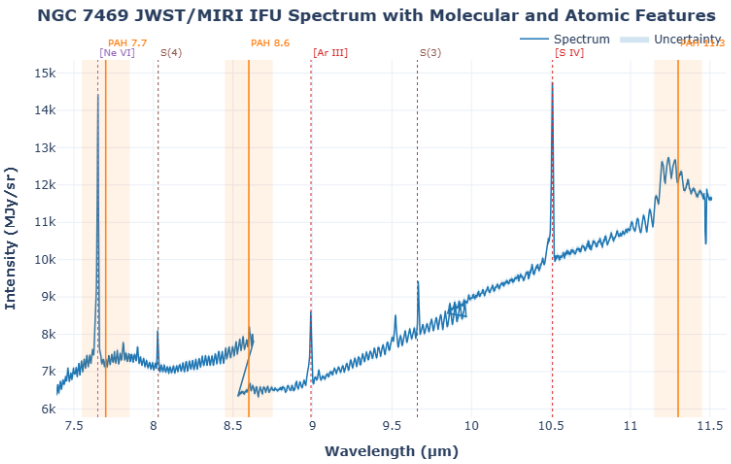
Inspect Channel-wise Variations:

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/ oscillations)?
Ans.
As we move to channel 1 to channel 4 it goes from small wavelength to longer wavelength ,the noticeable changes are,
Increase in intensity values, decrease in no. of feature(specially decrease in hydrogen lines),increase in noise,uncertainity in shapes and possibly more.

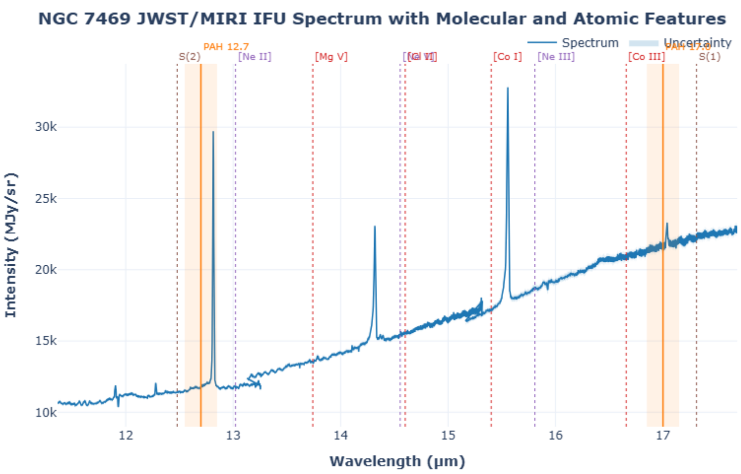
Channel 1



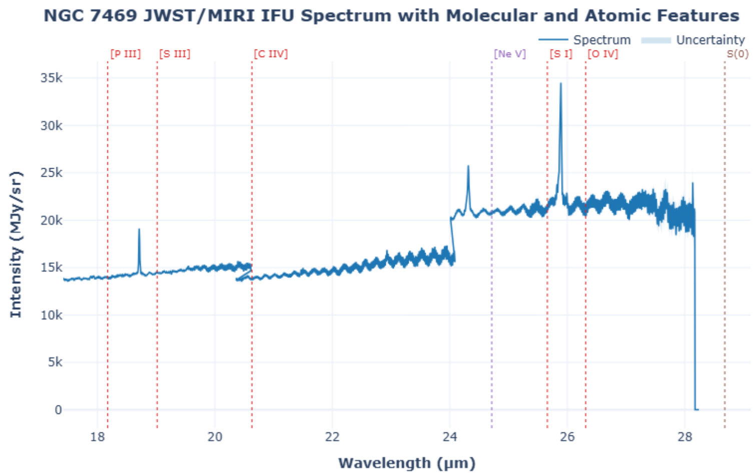
Channel 2



Channel 3



Channel 4



Is this change likely to be due to an instrumental effect or a real astrophysical property? Take a reasoned guess and explain your reasoning.
Ans.
It may be due to both instrumental effect and real astrophysical property,but largly due to instrumental effect because of larger wavelengths,or some error noise,or some uncertainities.

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?
Ans.

- May be to understand the changes and variation through out the data cube or any one channel.
- To understand change in intensity,shape and radiation, to learn analyse spectral lines better.
- Why and how its changing!!!

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.

Line Name	Wavelength (µm)	Astrophysical Significance
H_2 S(8)	5.1341	Traces hot molecular hydrogen, often heated by shocks or UV radiation.
H_2 S(7)	5.6006	Traces warm/hot molecular gas; indicates energetic processes like shocks or intense UV fields.
H_2 S(6)	6.2073	Traces warm molecular hydrogen; sensitive to UV heating and shocks.
H_2 S(5)	7.0214	Traces moderately warm molecular gas in photodissociation regions or shock fronts.
H_2 S(4)	8.030	Traces warm molecular gas; can indicate shock heating or strong star-forming activity.
H_2 S(3)	9.660	Traces warm molecular gas; strong in star-forming regions and shocks.
H_2 S(2)	12.470	Traces warm molecular gas; used to study excitation conditions in the ISM.
H_2 S(1)	17.312	Traces warm molecular hydrogen; sensitive to UV heating, shocks, and X-ray dominated regions.
H_2 S(0)	28.680	Traces cold to warm molecular hydrogen; indicates star formation fuel and large gas reservoirs.
Fe IIF5/2-D3/2	5.144	Traces ionised gas; can indicate shock excitation or supernova remnants.
Fe II 4/2-6/2	5.420	Traces low-ionisation gas, often in star-forming regions or outflows.
Fe II 7/2	6.830	Traces ionised gas in regions influenced by shocks or supernovae.
Mg VII	5.590	High-ionisation line; traces AGN activity or extremely hot gas.
K VI	5.660	High-ionisation line; typically associated with AGN or highly ionised regions.
K IV	6.070	Moderate ionisation line; can trace warm ionised gas or star-forming regions.
Ca VII	6.250	High-ionisation line; indicates AGN influence or very hot ionised gas.
C IV	6.810	High-ionisation carbon line; commonly associated with AGNs, shocks, or energetic winds.
Ne VI	7.650	Very high-ionisation line; strong indicator of AGN radiation fields.
Ar III	8.991	Traces ionised gas in star-forming regions; sensitive to stellar UV fields.
S IV	10.510	Traces ionised gas; present in HII regions and AGN environments.
Ne II	13.020	Low-ionisation line; classic tracer of HII regions and star-forming activity.
Mg V	13.740	Traces highly ionised gas; can indicate AGN photoionisation or shocks.
Ne V	14.550	Very high-ionisation line; strong AGN diagnostic.
Cl II	14.600	Traces moderately ionised gas; found in star-forming regions.

Co I	15.400	Traces neutral or low-ionisation gas; less common, but can be associated with cold gas regions.
Ne III	15.800	Traces intermediate-ionisation gas; sensitive to both stellar and AGN radiation.
Co III	16.650	Traces ionised gas; possible indicator of energetic stellar or AGN environments.
P III	18.170	Traces ionised gas in HII regions or evolved stars.
S III	19.017	Classic tracer of HII regions; strong in star-forming environments.
C IIV	20.630	High-ionisation line; typically associated with AGN activity or fast outflows.
Ne V	24.710	Very high-ionisation line; strong AGN tracer.
S I	25.650	Traces neutral sulfur; associated with cold gas or photodissociation regions.
O IV	26.311	High-ionisation line; commonly used to trace AGN or energetic stellar winds.