COSMIC MINING

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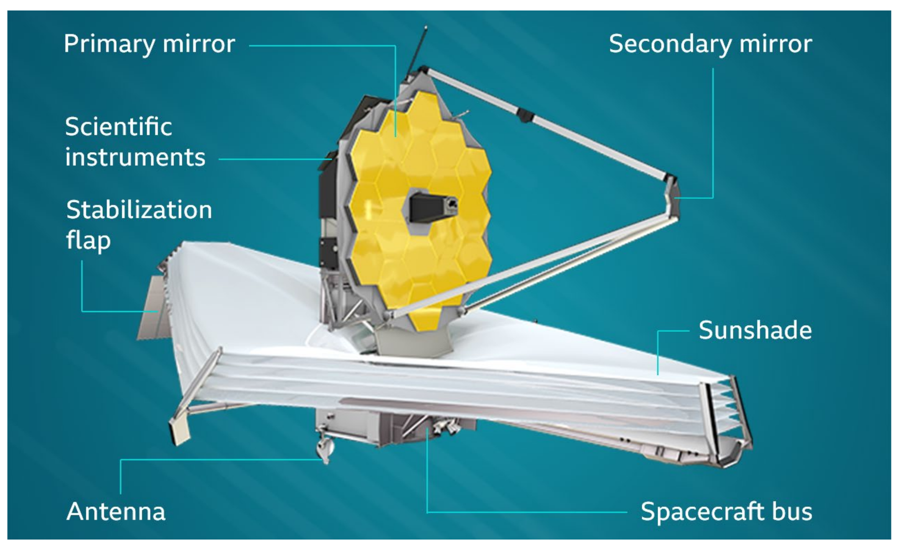
OVERVIEW

Throughout the project, we have been provided the opportunity to analyse spectra collected from the Spitzer Space Telescope, which are available through the CASSIS website. These spectra will have been classified as stellar objects such as O-Rich evolved stars or planetary nebula by looking at features such as emission and redshift. Certain spectra will be chosen as target points for the James Webb Telescope. Our findings from these spectra will assist the astronomers to find new discoveries and understand our universe more.

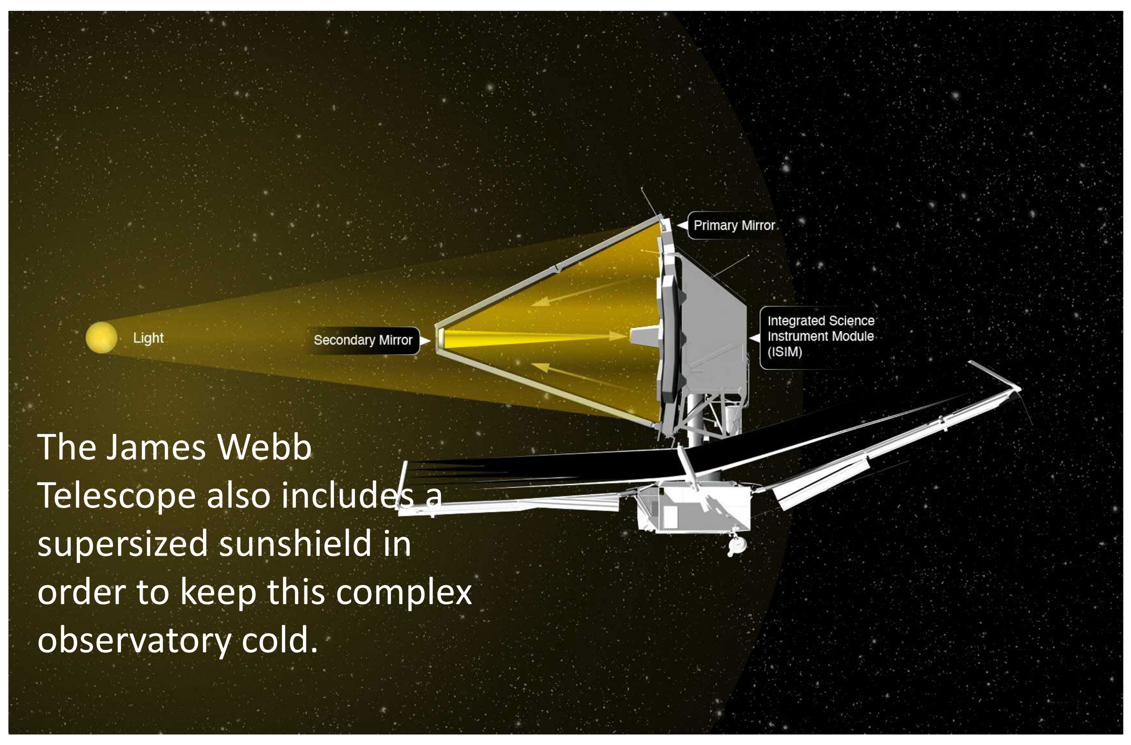


JAMES WEBB TELESCOPE

The James Webb Space Telescope, like the Spitzer Space Telescope, is an infrared observatory that was launched at the end of 2021 with increased clarity and higher sensitivity compared to the Spitzer Space Telescope. It is approximately 6200kg with 18 hexagonal primary mirrors. These mirrors are 705kg each and are made of beryllium with a coating of gold, which optimizes the reflection of infrared light of the mirrors. It also operates at a temperature of -223°C.

The PRIMARY MIRROR is an intercept for red and infrared light travelling through space. This light is the reflected onto the SECONDARY MIRROR, where light is directed to scientific instruments to be recorded. The size of the PRIMARY MIRROR (total area) is important as a large mirror can therefore detect dimmer or more distant objects (higher sensitivity) and provide high resolution images and spectra.

An innovative design using origami created the James Webb Telescope. The telescope is designed to neatly fold upon itself, therefore enabling maximum light to be collected and ensuring that the observatory is fully operational



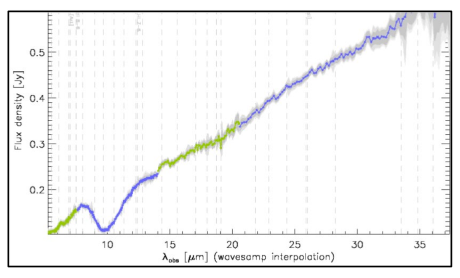
CLASSIFICATION PROCESS (Experimental Method)

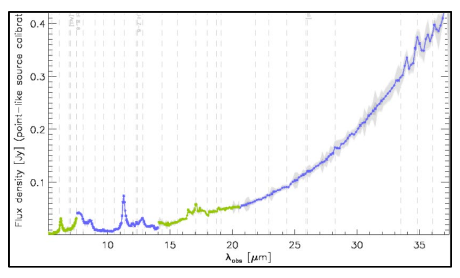
In order to classify an object, you must analyse five main sections on a results table: pre-classification checks, continuum, features, final classification and notes.

1. **Continuum:** The process of observing and identifying the overall pattern of the spectra and can be used to validate / disprove a previous classification. A table will be used in order to differentiate between the different types of star through factors, such as the stellar component for example that can be observed on the spectra graph.
2. **Features:** This section allows you to make more precise sub-classifications through analysing features such as emissions and absorptions. Although, analysing these features can be difficult as it is often hard to decide the original continuum and the overall trend; or absorption / emission features can often be very subtle.
3. **Final Classification:** This final stage uses the information gained in previous analysis to create a final classification. You must also rate how confident you are that the star you concluded is accurate to the graph. However, not every spectra can be classified into a specific group, these graphs would go under 'other'.

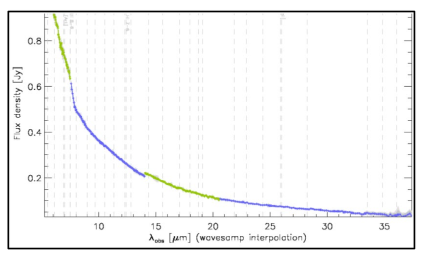
	0. Pre-classification checks	2.a. Continuum				2.b. Features				
Final classification	Redshift?	Continuum	Stellar Component?	Red Excess	Rising above 25 microns?	10 micron	Absorption at 13.7 microns	Absorption at 15 microns	18 micron	Atomic Emission Lines
Galaxy	Yes									
YSO (all)	Unknown	Rising	No	Strong	Yes					
YSO-1	Unknown	Rising	No	Strong	Yes	Absorption		Yes		
YSO-2	Unknown	Rising	No	Strong	Yes	Absorption		No		
Planetary nebula	Unknown	Rising	No	Strong	No					Yes
Star	Unknown	Falling	Yes	No		No	No	No	No	
O-rich evolved star	Unknown	Falling	Yes*	No		Emission or absorption			Emission or absorption	
C-rich evolved star	Unknown	Falling	Yes	No			Yes			

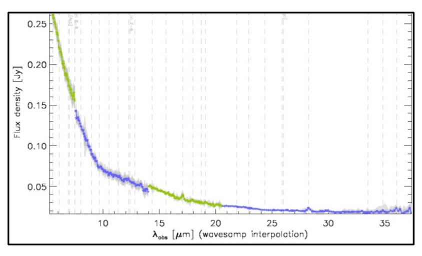
FORMING STARS: the gradient of the line spectrum continues to increase above 30 microns
(overall rising trend)
- **YSO-1 Stars** are really cold objects, with lots of dust present, that have absorption features at 10 and 15 microns
- **YSO-1 Stars** have narrow absorption feature at 10 microns



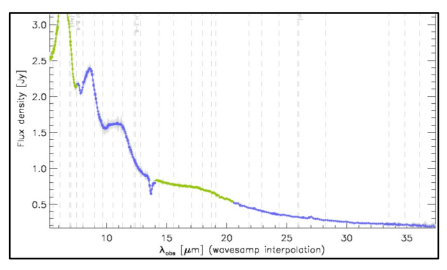


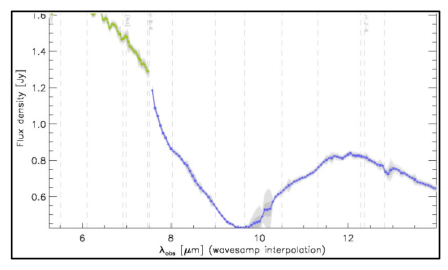
ORDINARY STARS: spectrum without large emission or absorption features
(overall decreasing trend)



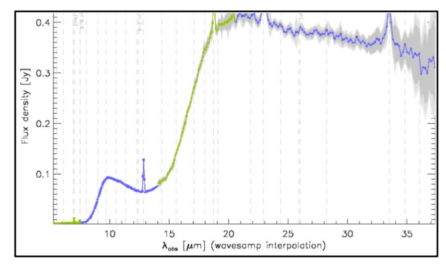


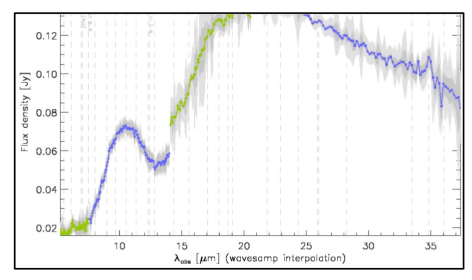
EVOLVED STARS: there is dip between 6 and 8 microns hence different from ordinary star
(overall decreasing trend)
- **O-Rich Evolved Stars** have broad emission features at 10 and 18 microns (oxygen)
- **C-Rich Evolved Stars** have an absorption feature at 13,7 microns (carbon)





PLANETARY NEBULAE: a rising spectrum which flattens/dips after 30 microns

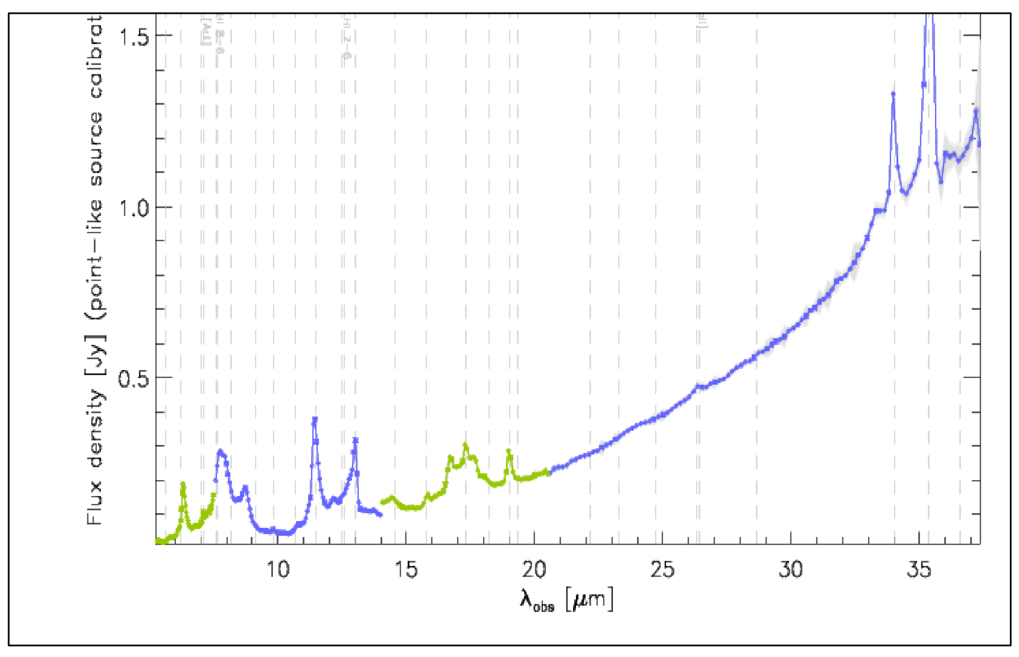


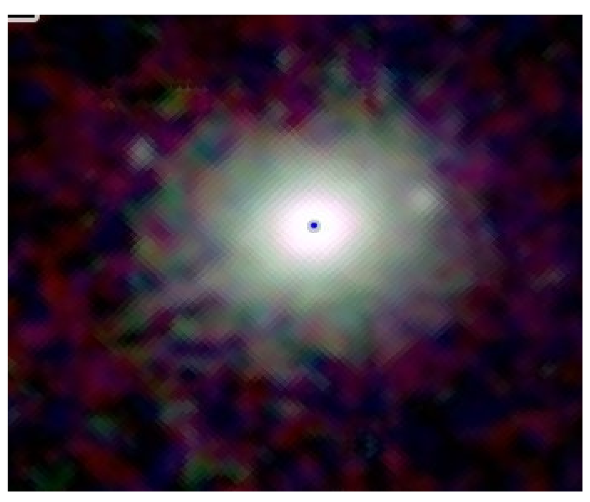


ANALYSIS of AORKEY 9074688

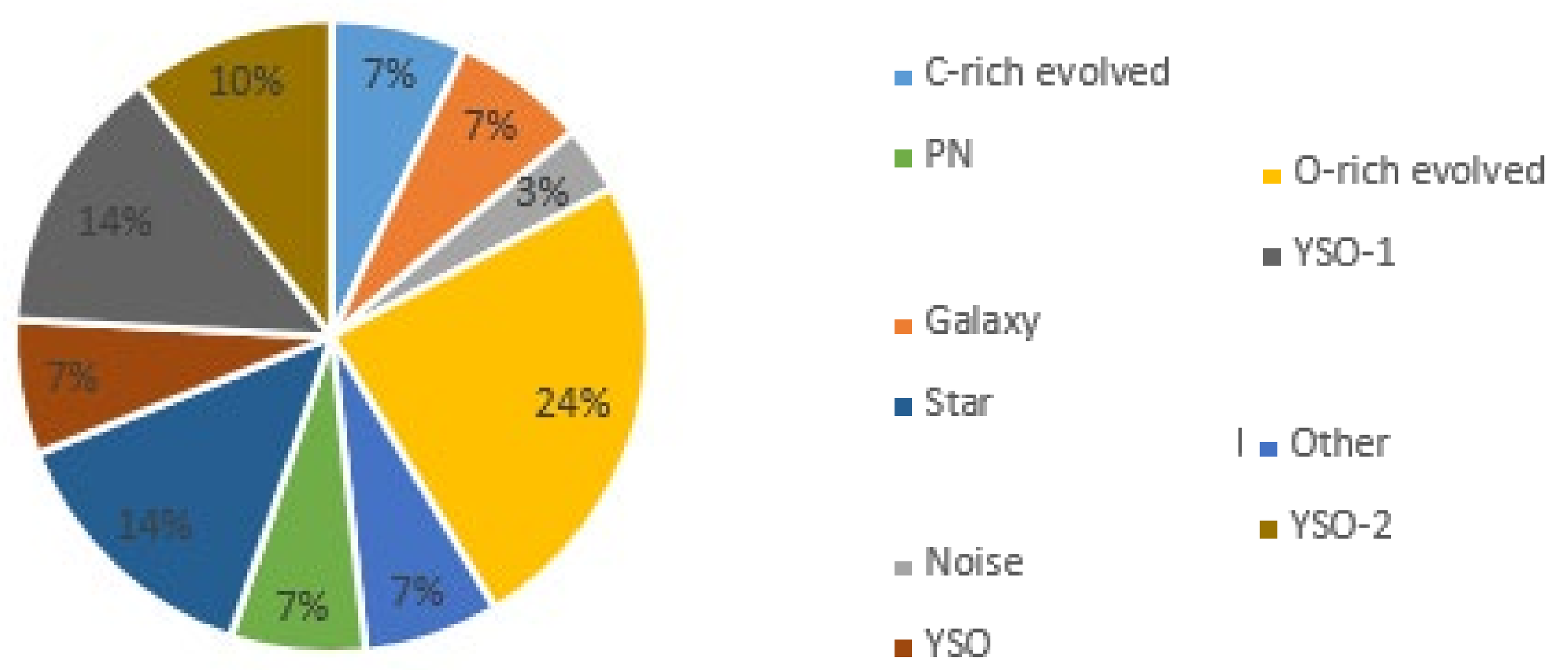
The spectrum AORKEY 9074688 in our dataset was concluded to be a Galaxy due to its spectrum possessing a redshift of 0.015984, and no easily distinguishable features of emission or absorption.

Source Properties	
Detection level	40 (sigma)
Object (NED, SIMBAD)	NGC 7252, NGC 7252 (multiple)
Redshift	0.015984
Estimated extent	~ 4.3 " (plot)



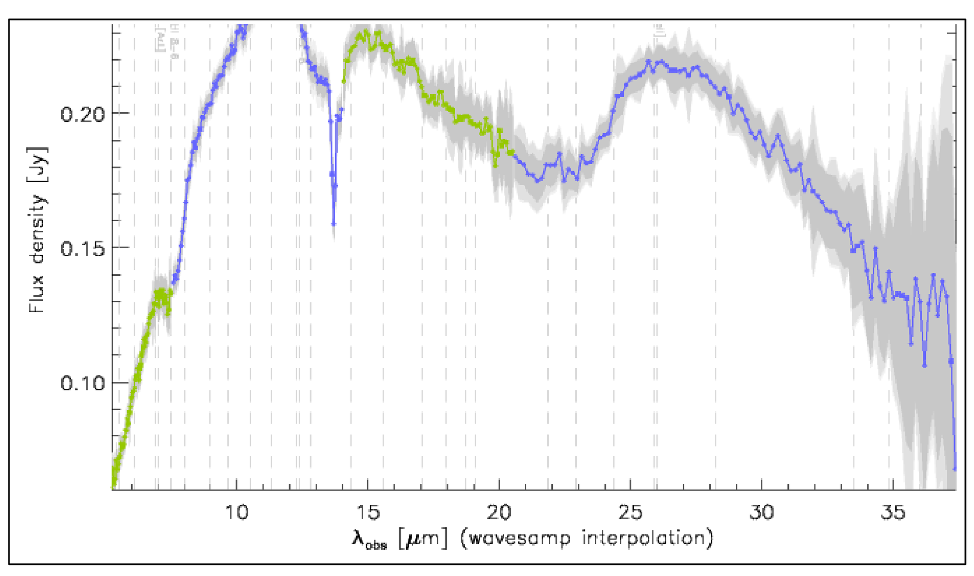


RESULTS



CONCLUSIONS

We have successfully analysed 50 spectra that were collected from the Spitzer Space Telescope. The greater part of our results has been classified as stars, and the majority of these stars are O-Rich evolved stars. Whilst we were mostly confident with our classifications, there were some spectra, such as the one below, which had many emission/absorption features and noise, which was difficult for us to decide. However, we worked together and by peer review, we had confidently classified the spectra. Had we had more time, we would have shared our results with people outside our group and encouraged more peer review.



AORkey: 24319232

There are also a few spectra that have been classified as Other, which will now be of interest to the astronomers. They can then also analyse these spectra and hopefully the James Webb Telescope will be focused on this point, which may discover a new spectral body as it focuses on infrared light instead of ultraviolet.

GALAXIES
- Galaxies are vast collections of dust, stars, and interstellar objects, such as black holes; galaxies like our Milky Way containing an estimated 100-400 billion stars. Other galaxies can have numbers closer to the trillions.
- Central to every galaxy there are supermassive black holes which can possess masses billions of times that of our Sun. Sagittarius A* (A-star) is the supermassive black hole at the centre of our galaxy and has a mass of 4.3 million Solar Masses.
- The distances between galaxies are so immense that light is warped as the doppler effect forces "Redshift" of the light from the expansion of the universe.
  - "Satellite galaxies" surround the Milky Way, ranging from as close as 200,000 light-years to over 1 million light-years. Even at this distance, the light from them would have been emitted before the evolution of *Homo sapiens*. While our nearest true galaxy, Andromeda, is 2.5 million light-years away from us and on course to collide with the Milky-Way 4 billion years from now.
  - The light from the most distant galaxies represents little more than snapshots of the early universe. GN-z11 is one of the farthest galaxies confirmed, at a redshift value of 11.09, and is almost 32 billion light-years away. The light of this galaxy was emitted 13.4 billion years ago. It is through observations such as these that the expansion of the universe is visualised.

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