An Analysis of Planetary Nebulae and the Location of Their Turning Points

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Overview

- A new telescope has been built called the James Webb Space Telescope (JWST). It is due to be launched on 31 October this year.
- Its aim is to study the various phases of the Universe from the first glows after the Big Bang to the formation of stars and solar systems.

Aims

- Secure and apply knowledge of electromagnetic waves, advanced stellar physics, including spectroscopy and astronomy to real life, cutting-edge scientific research.
- Become familiar with how scientists and researchers work in academia and industry.
- Further our understanding of the spectra of planetary nebulae and how they can vary
- And finally, to help astronomers identify potential targets for the JWST.

Background Information

The James Webb Space Telescope, set to launch in 2021, aims to bring NASA closer to "discovering the secrets of the universe"(1). It has been designed as the successor to both the Hubble and Spitzer Space Telescopes and, with its increased sensitivity, will be able to see farther into space and with a higher resolution than we have before (2).

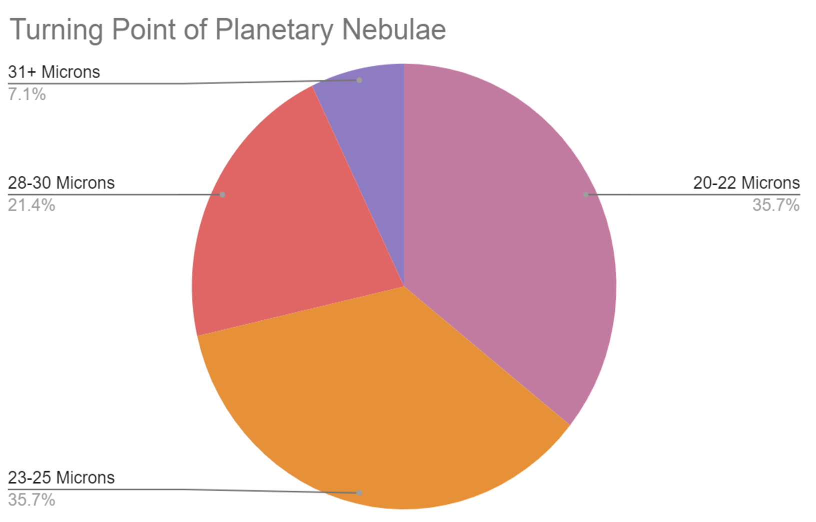
By analysing the data from the Spitzer telescope (intensity of different electromagnetic wavelengths emitted by an object given to us in a spectral graph format), we are able to classify objects, learn more about the make-up of stellar objects and find potential objects of interest for the JWST to explore further.

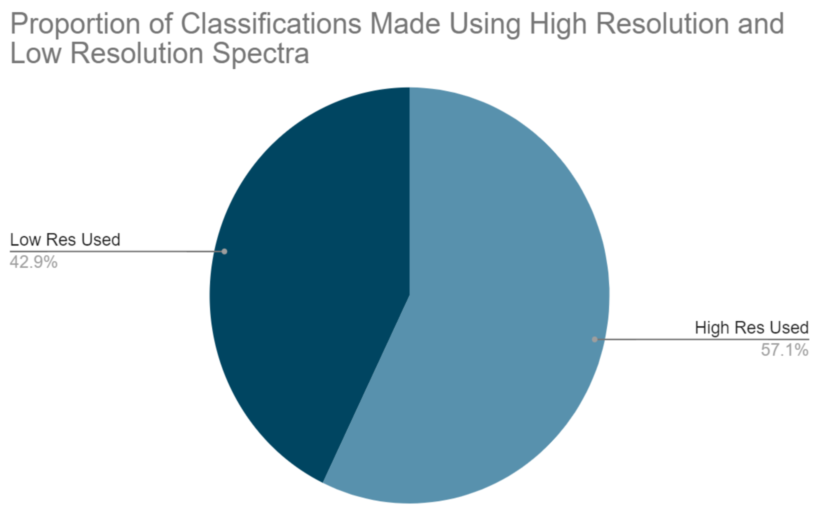
Key Features of a Planetary Nebula

The spectra of a planetary nebula (PN) can be described as a rising spectrum that flattens or dips in the region of 25-30 microns. Here are the key features we looked for when classifying planetary nebulae:

1. There will be an unknown redshift. If the object has a redshift, it is almost certainly a galaxy.
2. The continuum will be rising.
3. There will not be a stellar component.
4. A strong red excess.
5. It will not be rising above 25 microns.
6. Atomic emission lines, however these were not always consistent in our classifications.

Proportion of Different Turning Points





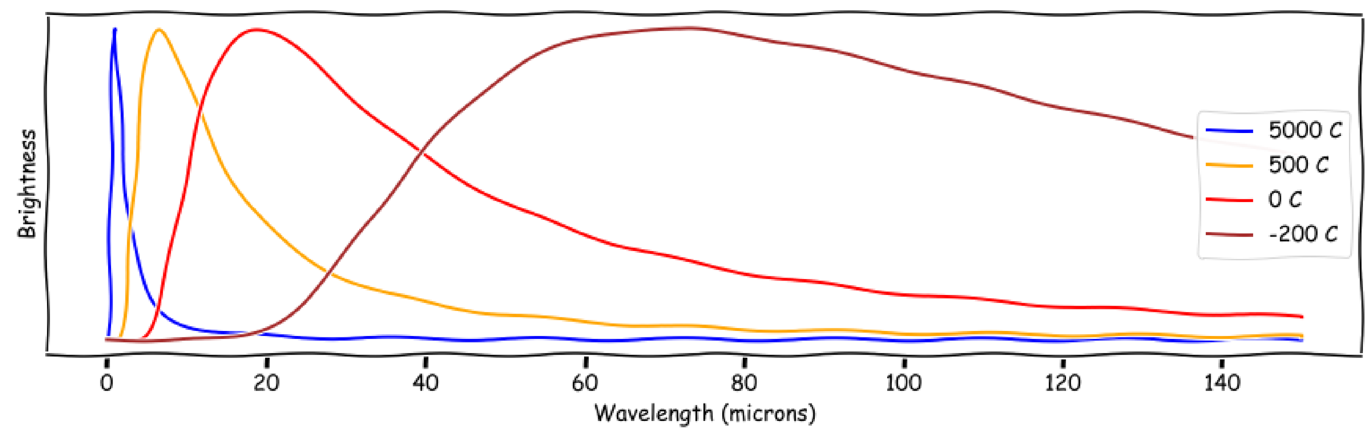
As shown in our pie charts, the majority of the 14 PNs we classified had a turning point of between 20 and 25 microns, with over 50% of the classifications being made with the use of the high resolution spectra. This was mainly due to the spectra being cut off between 12-15 microns, which therefore did not allow us to locate the turning points with the low resolution spectra. The high resolution spectra appear different to the low resolution, which could therefore impact the accuracy of our classifications.

Why Planetary Nebulae Have Different Turning Points

The peak on a spectra can give us a good indication of the temperature of that object. As an object gets hotter, its peak moves towards the shorter infra-red wavelengths.

Therefore the closer to the left of the spectra the peak is, the hotter the nebulae is. This could tell us two things:

- Age of nebula - More mature nebulae are likely to have condensed more and therefore become hotter.
- Density of nebula - More dense nebulae are likely to have higher temperatures (3).

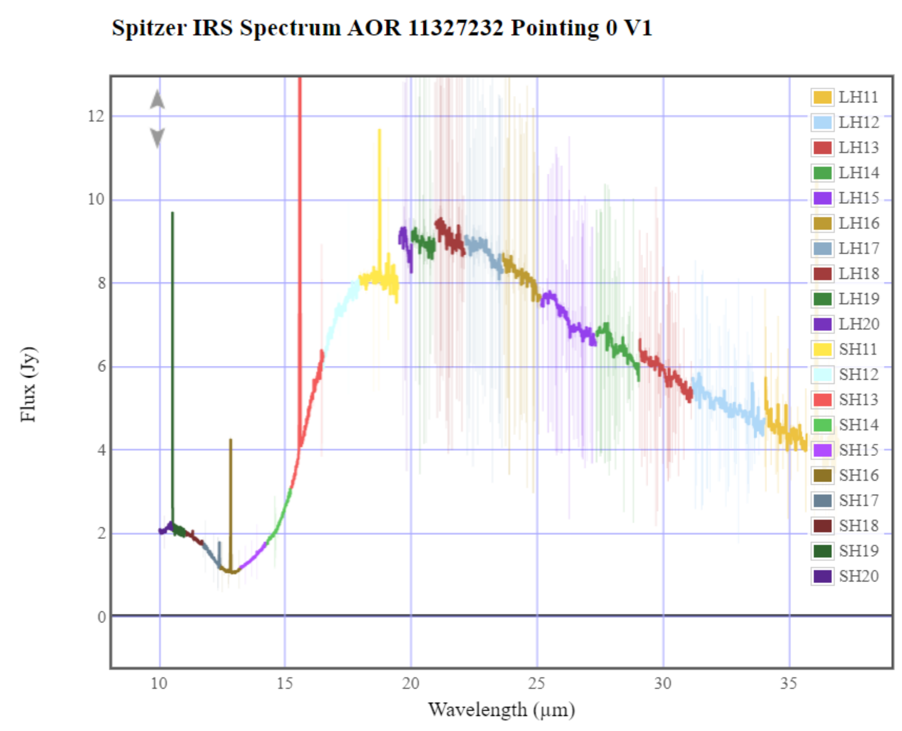


How Planetary Nebulae May Be Confused for Oxygen Rich Evolved Stars

There are many parts of an infrared spectrum which could indicate the presence of chemicals or minerals containing oxygen. PNs can have some of these features. For example:

- A broad emission or absorption feature at 8, 10, 18, 23, 28 and 33 microns indicate silicates are present (O and Si).
- A narrow emission feature at 25.91 microns ([O IV] Oxygen).
- A broad emission or absorption feature at 13.00 microns indicating aluminates are present (O and Al).

IRIS stated that oxygen-rich evolved stars without a stellar component indicate the presence of precious gems (such as Ruby, Spinel and Moissanite) and are therefore an object of interest to the JWST.



In this PN (AORkey: 11327232), there is a broad emission feature at 10.00 and 18.00 microns, indicating silicates are present, as well as a broad absorption at 13.00 microns which indicates aluminates are present. These are the most common indicators of an oxygen-rich evolved star. Its turnover point is much earlier than most PNs, meaning it could be mistaken for an o-rich evolved, however there are atomic emission lines present which are exclusive to planetary nebulae.

Conclusion

During the process, we have greatly improved our understanding of planetary nebulae and oxygen-rich evolved stars, which consequently advanced our ability to classify spectra and notice points of interest for the JWST. We look forward to the launch of the JWST and how the classifications submitted through IRIS will shape the telescope's mission. Given more time, we would classify more spectra to give us a better understanding of these turning points.

1. The Observatory [Internet]. WebbTelescope.org. [cited 2020 Dec 5]. Available from: https://www.webbtelescope.org/webb-science/the-observatory

2. The Technology behind the James Webb Space Telescope | Global Space Project [Internet]. James Webb Space Telescope. [cited 2020 Dec 5]. Available from: https://jwst.org.uk/the-technology/

3. Bone G, Chadha G, Saunders N. Objects in the Universe. In: A Level Physics for OCR A. Oxford: Oxford University Press; 2015.