Molecular Feature Analysis of the Orion Nebula Comparing Image and Spectral Data

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ABSTRACT

A. Background

The Orion Nebula has historically been a region of high interest in the astronomy community. This is because the Orion Nebula is a star forming region, i.e. a stellar nursery, that is oriented such that a unique transition region is visible from Earth. This transition region is dubbed the Orion Bar, and it is a segment of the Orion Nebula which marks the boundary between a region of ionized hydrogen (where stars are forming) and a region of molecular hydrogen (where future stars will form). Studies of this region have been conducted using both spectral and image data to determine the propagation of ultraviolet radiation within the nebula. Ultraviolet radiation plays a key role in star formation because the radiation ionizes and heats gas which impacts how atoms and molecules interact. Also, as the radiation expands it pushes away regions of less dense gas and compresses regions of more dense gas potentially creating catalysts for future star formation. My work on this region has been focused on polycyclic aromatic hydrocarbon (PAH) molecules; these emit infrared radiation when struck by ultraviolet light, so they can be used to trace the ultraviolet radiation field.

B. Data Used

For my research I dealt with both spectra and images, and I made comparisons of the data obtained by the two. The spectral data used for this research has both positional data and wavelength data. Essentially, the data can be used to examine how the brightness of a given wavelength changes with spatial progression from ionized hydrogen to molecular hydrogen. The data is structured such that one represents wavelength, the other axis represents the spatial location, and the brightness of each pixel represents the amount of light detected at a given position and wavelength. Fig. 1 shows an example of the image data used in this research. Both the x-axis and the y-axis represent

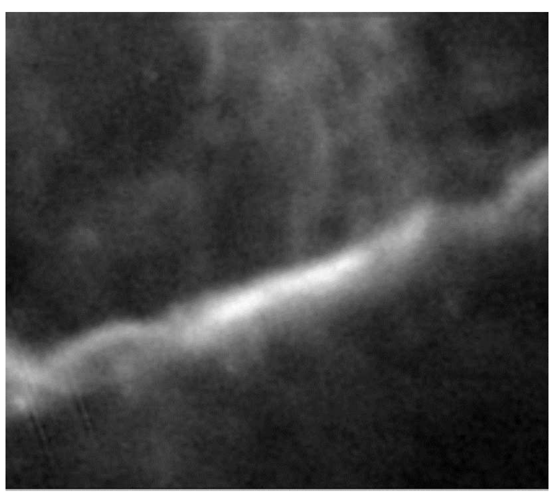

FIG. 1.

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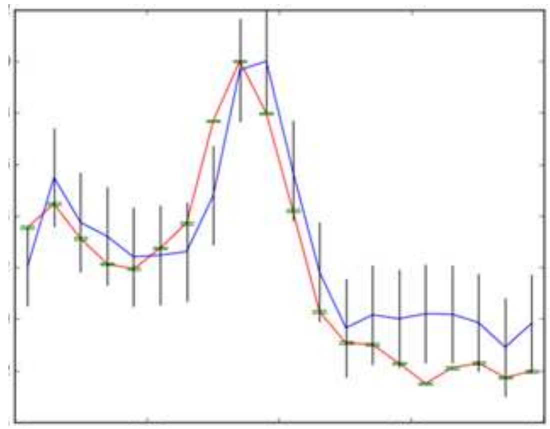

FIG. 2.

spatial position, and the brightness of the pixel is again representative of the amount of light detected. The data was gathered with the Stratospheric Observatory For Infrared Astronomy. The spectra were taken so as to cover the wavelength of three different PAH emissions. The images were taken through filters which only let in light over a small wavelength range which encompassed the PAH emissions. Image data and spectral data vary in that spectra have more wavelength resolution but less spatial resolution than do images.

C. Analysis Techniques

The data gathered were analyzed through generation of flux profiles. A flux profile is a data type used to examine how radiation changes as a function of spatial position. Essentially, the wavelength range of the PAH emissions were identified in the images, this was summed, and then averaged over several spatial pixels. The image data was averaged over the corresponding spatial locations. This effectively gives brightness of the feature as a function of position in the sky for several positions. Fig. 2 shows an example flux profile where the x-axis is spatial position and the y-axis is average brightness. The red line on the figure is the spectral data and the blue line is the image data. The flux profiles are normalized so comparisons of the image and spectra flux profiles can be made to determine whether they exhibit similar behavior.

D. Conclusion

This goal of this research was to map out the ultraviolet radiation field in a star forming region by using infrared emissions of PAH molecules. This was accomplished in part by creation of flux profiles. This confirmed that spectra and image data can convey the same information for this project. Looking at Fig. 2, one can see that both the spectral flux profile and the image flux profile follow the same basic shape. Thus, data analysis can be done with both spectral data and image data! This is an incredible conclusion to draw because spectra are much more time consuming to take than images, provide data of a much smaller region of space, and are much more expensive to take. The image data used for this research has a low signal to noise ratio, so analysis can only be done on a portion of the data, but future imaging observations can take slightly more time and result in data encompassing a larger swath of space that is relatively inexpensive to obtain.