Measuring Stellar Nurseries Near and Far: How and Where do Stars Form in Galaxies?

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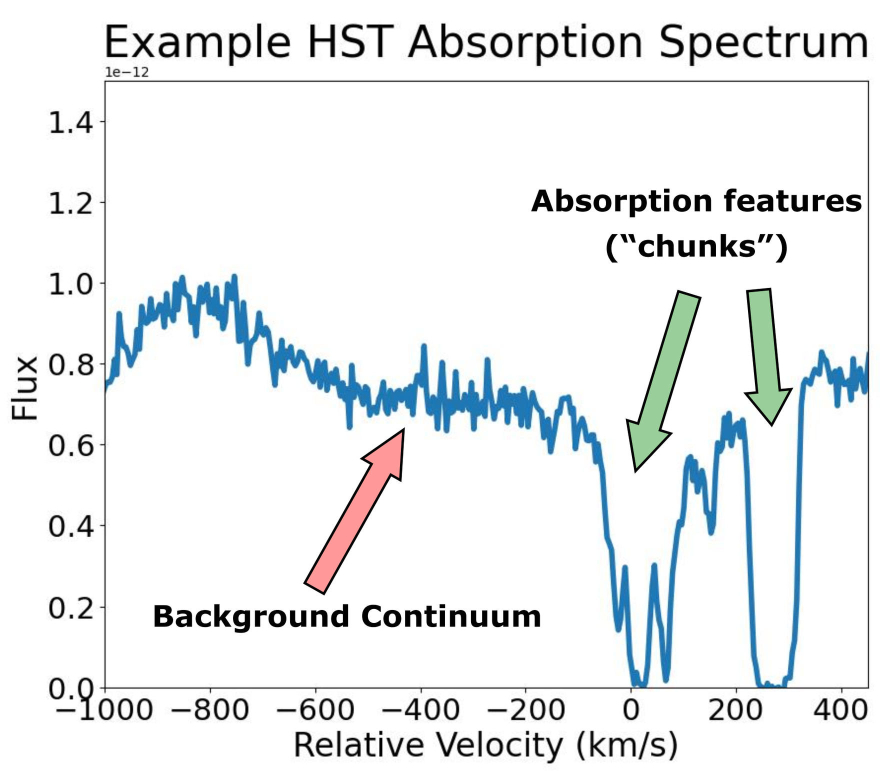
1. Background: The Galactic Gas Cycle

Galaxies, like our Milky Way, harbor stars and planets that are made out of gas. Lighter elements are fused into heavier elements in stellar cores throughout the lifetime of a star. Eventually, stars burn through their lighter fuel and die, leaving behind material that is more metal-rich than before. These remains of stars eventually cycle back into new star formation within the galaxy.

In our research, we will study the interiors of galaxies using high-resolution spectroscopic observations from the MaNGA survey. These spectra tell us about the star formation within the galaxy. We can then compare these results with observations from the Hubble Space Telescope to examine the environments of these galaxies. This research will give us a better understanding of what the environments of healthy, star-forming galaxies look like.

2. Observations

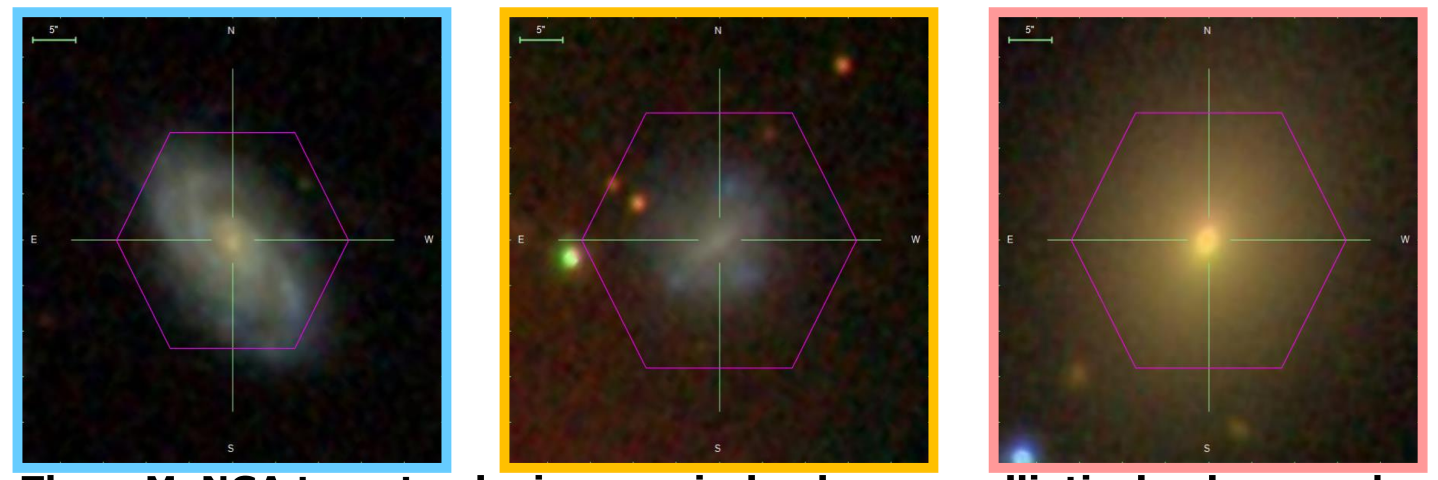
The data we will use comes from the Hubble Space Telescope (HST) and is primarily *absorption spectra*. With absorption spectroscopy, our target absorbs light that is emitted from some background light source. The absorption occurs only at specific wavelengths dictated by the composition of the target. These observations require a background light source with a continuous spectra. The light that is absorbed by our target appears as "chunks" taken out of the continuum.



Example absorption spectrum from our HST data. This particular spectrum is of a neutral oxygen spectral line transformed into velocity space.

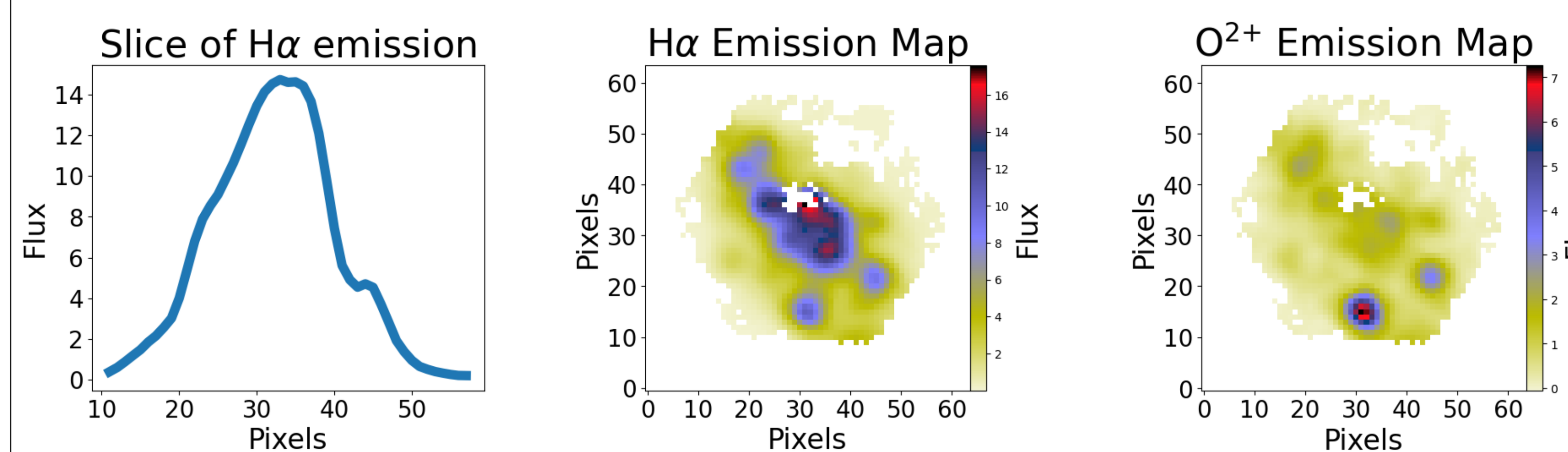
Stars are formed from gas, and they leave gas behind when they die. In order to better understand this how this gas cycle works in galaxies, we study the star formation activity of nearby galaxies by using high resolution observations of the galaxies' interiors. We combine these efforts with observations of galactic surroundings to determine what the environments of healthy galaxies look like, and how the gas surrounding a galaxy affects the star formation within.

3. MaNGA Galaxies



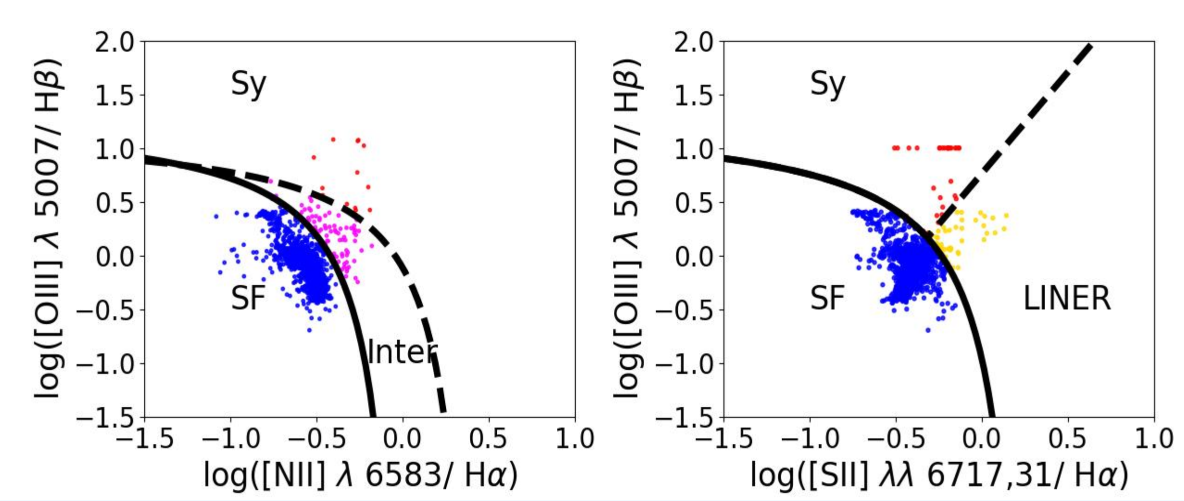
Three MaNGA target galaxies: a spiral galaxy, an elliptical galaxy, and an irregular galaxy, from left to right.

The data we utilize from MaNGA is *emission spectra*. Hot, energetic gases emit light of particular colors that are dictated by their composition.



From left to right: A slice of Hα emission from the spiral galaxy, a spatially resolved emission map of Hα for the same galaxy, and a spatially resolved map of O^{2+} emission.

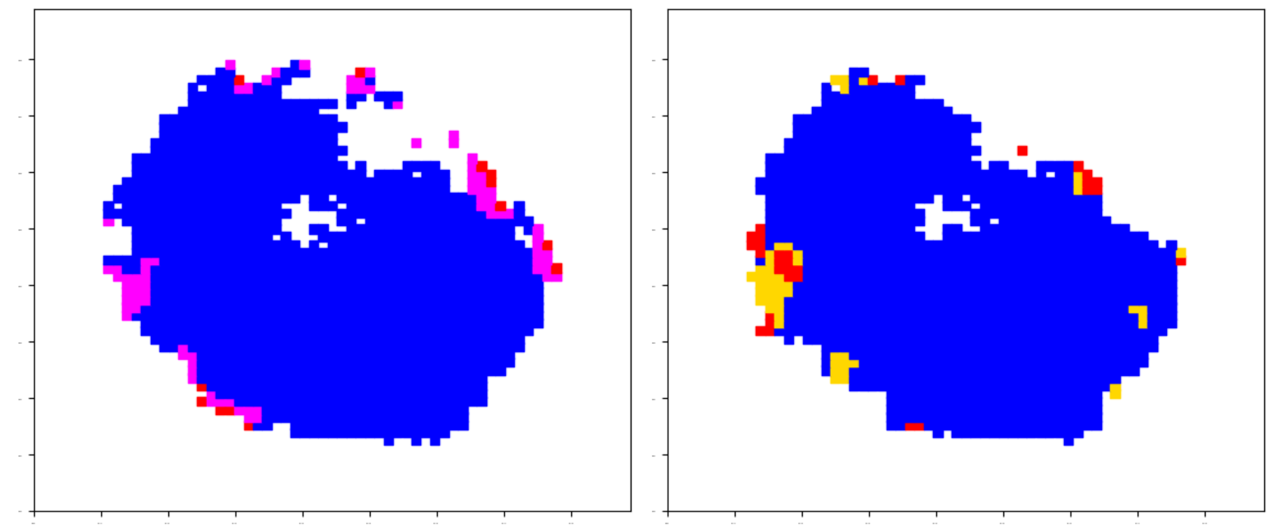
We use the ratios of different spectral lines to determine what is happening in the galaxy using a graphical diagnostic tool called a BPT Diagram (Baldwin, Phillips, & Terlevich 1981). Hα emission (the n=3 to n=2 transition) acts as a tracer of ionized hydrogen, and O^{2+} emission acts as a tracer of ionized oxygen. We examine the ratios of these lines to determine if the ionization we observe is consistent with an active star-formation region or if it looks like a Seyfert or LINER active galactic nucleus (AGN). We then plot these points on a spatially resolved map of the galaxy.



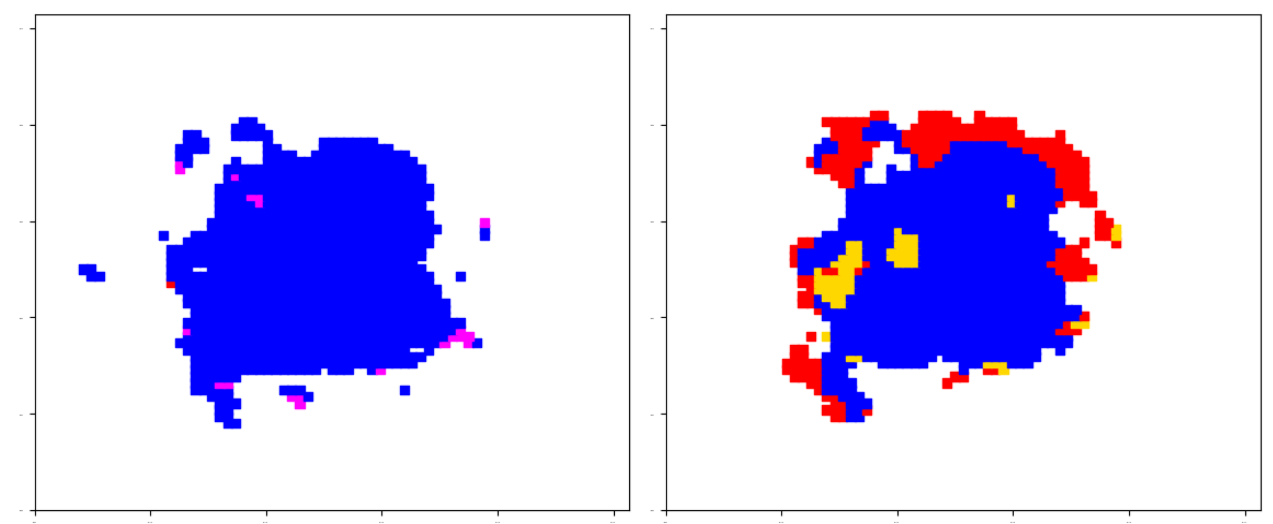
BPT Diagram for the spiral galaxy using N^{+} and S^{+} diagnostic criteria from Kewley et al. 2006. Ionization is largely consistent with star formation.

Flux units for all MaNGA plots are 10^{-17} erg s^{-1} cm^{-2} $spaxel^{-1}$.

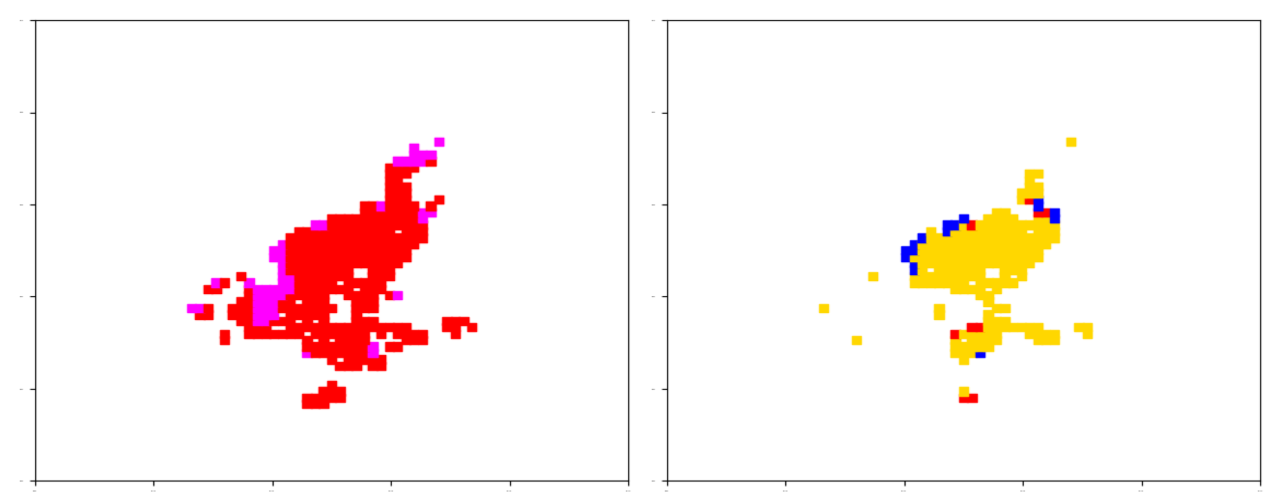
4. BPT Diagrams



Spatially resolved BPT Diagrams of the spiral galaxy. As indicated by the blue color, this galaxy's ionization indicates large regions of active star formation.



Spatially resolved BPT Diagrams of the elliptical galaxy. Again, we see a lot of star-forming regions



Spatially resolved BPT Diagrams of the irregular galaxy. Very few points are consistent across both classification diagrams, but gas ionization is consistent with AGN behavior.

5. Future Research

Our research into this topic is still in its beginning stages. In the near future, we expect to make significant progress in this study into galaxies and their environments. Our next steps are to gain a better understanding of the interiors of star-forming galaxies using MaNGA data. Then, we will utilize HST observations to study the material surrounding these galaxies. This study will help contribute to our understanding of the galactic gas cycle.