

Studying the ionization mechanism in a nearby starburst galaxy

Title of the project: Studying the ionization mechanism in a nearby starburst galaxy

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Level: Honours

Background:

One of the questions in galaxy evolution that remains under investigation is why, in some galaxies, star formation is quenched but in others it continues or is even enhanced. Processes such as active galactic nucleus (AGN) and star-formation feedback could possibly remove gas from the galaxy or heat the existing gas, resulting in the quenching of star formation (Somerville & Davé, 2015; Morganti, 2017). Understanding the dominant ionization mechanism in a galaxy can provide valuable information about the ultimate fate of the galaxy, as well as galaxy evolution as a whole. Nearby starburst galaxies provide extreme, nearby environments to study these processes with resolved observations.

The ionization mechanism can be studied with the Baldwin, Phillips, and Terlevich (BPT; Baldwin et al., 1981) diagram. The BPT diagram differentiates between star-forming, composite and AGN regions of galaxies based on the relative strength of certain emission lines, including [OIII], [NII], H β and H α (see, for example, Fig. 1a). Falling in the star-forming region of the BPT diagram indicates that star formation is the main power source, falling in the AGN region indicates that an AGN is the power source, and the composite region shows a combination of star formation, shocks and low-luminosity AGN/LINER activity.

In many studies, the integrated properties of the galaxies are studied, however the ionization mechanism can be different across the galaxy. The integrated properties allow us to differentiate between AGN-dominated galaxies and star-formation-dominated galaxies; however, for example, an AGN might be dominant in the nucleus and star formation in the spiral arms. This can only be differentiated by using resolved observations. In a recent paper (Mullaney et al., 2026), the dominant power source across Seyfert galaxy NGC 1365 was studied with the Multi Unit Spectroscopic Explorer (MUSE; Bacon et al., 2010) instrument on the Very Large Telescope (VLT). Because of the high spatial resolution, the authors were able to differentiate between the different regions of the galaxy and found an “AGN-like” region in the spiral arms that is not due to an AGN but due to shock regions increasing the ionization.

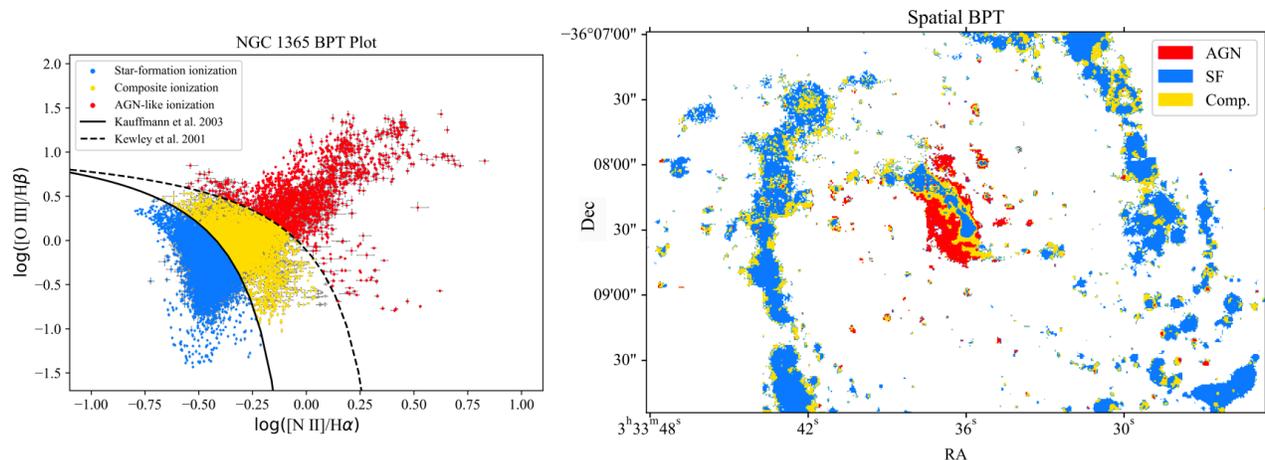


Figure 1: BPT diagram (left) for each spaxel of galaxy NGC 1365, differentiating between the AGN (red), star-forming (blue) and composite region (yellow). In the plot on the right, the spatial map of the galaxy is shown, colour-coded according to the dominant ionization mechanism.

What do we aim to do?

The aim would be to study one nearby starburst galaxy with integral field unit (IFU) data from SALT or with archival data from MUSE to understand the ionization mechanism in the galaxy. This will require modelling of the emission lines to calculate the ratios needed for the BPT diagram. The exact galaxy will be chosen with the student based on the availability of data. The ultimate goal is to end up with a similar plot to Fig. 1 for the galaxy we have chosen and understand what the dominant ionization mechanism is for the specific galaxy.

What is needed from you?

Basic Python skills are required. Knowledge of fitting emission/absorption lines is beneficial but not required.

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References:

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