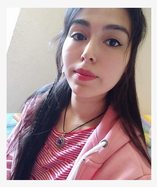
WHAN diagram as a technique for visualising spatially resolved nuclear activity in MaNGA galaxies



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Abstract: Emission-line diagnostic diagrams have proved to be a very useful resource to classify the type of nuclear activity or star-formation in emission line galaxies in the Sloan Digital Sky Survey[1,2]. In this case, the spectroscopic information mainly comes from the inner region of the galaxies, where emission is usually more intense than in outer galaxy regions. Now with the MaNGA[3] survey, the spectroscopic information can be obtained from all the observable area of the galaxy within its field of view, opening the possibility to explore the spatially resolved nuclear activity in galaxies. However, the most commonly used diagnostic diagrams, as the BPT[4,5] diagram, leaves unclassified a large fraction of the galaxies due to lack of quality some of the emission lines. In this regard, the $W_{H\alpha}$ versus $[N_{II}]/H_{\alpha}$ (WHAN[6]) diagram, which is able to analyse weak line galaxies, would provide a more complete view of the diverse activity at different regions of the MaNGA galaxies that could not be explored using the BPT diagram due to absent absorption lines. The main objective of this work is to develop a visualisation function, based on the WHAN diagnostic diagram, that would allow us to comprehensively explore the nuclear activity in MaNGA galaxies. Our function is designed to even explore the intermediate areas between adjoining WHAN categories, allowing us to investigate transition processes in the diverse stellar population among different regions of the galaxies. To do this, we use different colours to move gradually from one category to the other, according to their values of $W_{H\alpha}$ and/or $[N_{II}]/H_{\alpha}$, translating this information to a map of the galaxy. With this new technique we can study the spatially resolved nuclear activity in MaNGA galaxies, and it can be analysed in more detail than with previous methods. This function will allow us to explore the AGN/star-formation/quenching activity in the different galaxy components, which will help us to investigate, for instance, how the quenching process occurs in galaxies, if there is any relation between Active Galaxy Nuclei (AGN) activity or star-formation with the local environment in close pairs/mergers, whether nuclear activity is concentrate in the inner regions or it is more extended, etc. We aim to incorporate this function in Marvin[7], a tool specifically designed to visualise and analyse MaNGA data.

The existing BPT diagram in Marvin

Marvin has the capability of generating BPT diagrams for a particular galaxy. By default, a spaxel only becomes classified if it meets the criteria in all three diagrams. Even selecting the less strict criterion (based on the [OIII]/Hβ versus [NII]/Hα diagram), it depends on the emission in four lines, where [OIII] and Hβ might be weak, limiting the area where we could analyse the galaxy.

The BPT diagrams also limit the classification of the stellar activity to three categories: the star-formation type (SF), the Seyfert type, and LI(N)ERs type. This last category could also contain some kind of passive activity.

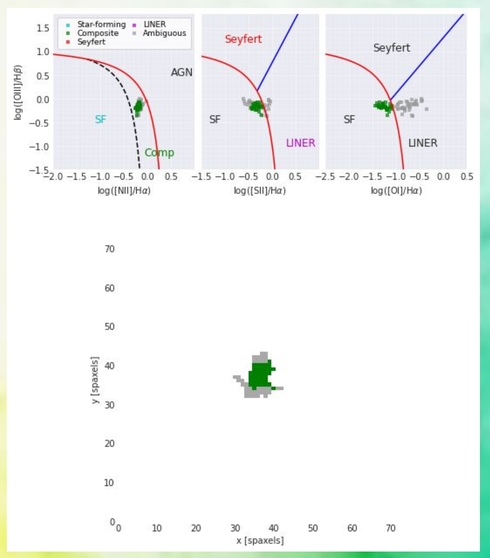

Figure 1: Marvin BPT diagram for MaNGA galaxy 9881-12704.

The existing WHAN diagram in Marvin

It is already possible to create a WHAN diagram for a particular galaxy with Marvin as a proposed Marvin Science Case Exercise (i.,e., it is not implemented as a functionality). Using only two emission lines (Hα and NII, which are easily observable in spectra), it is very useful for classifying regions with weak emission-lines that cannot be classified using BPT diagrams.

It also identifies weak AGN from fake AGN, named retired galaxies (RGs) from LI(N)ERs, allowing a more complete analysis of regions where the heating of their ionised gas is the result of old stars, rather than star formation or AGN activity.

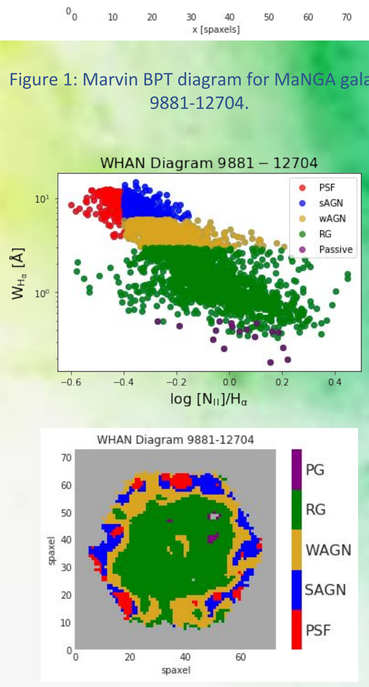

Figure 2: Marvin WHAN diagram for MaNGA galaxy 9881-12704.

Our proposal: the improved WHAN scheme

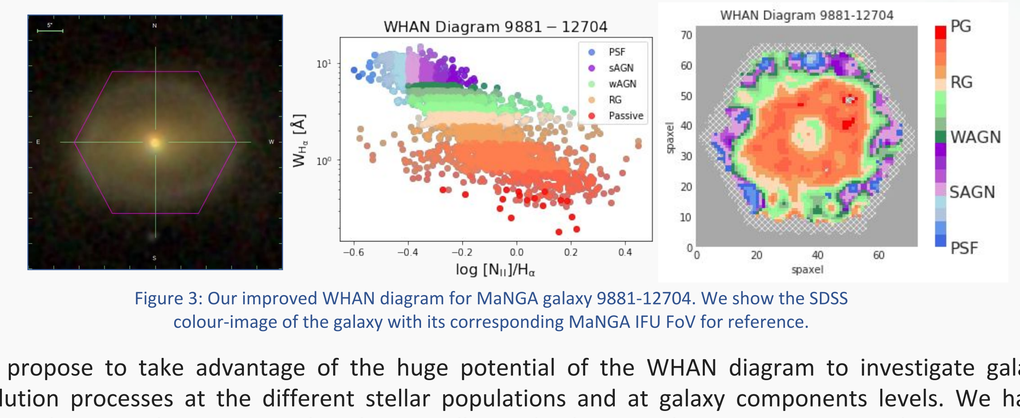

Figure 3: Our improved WHAN diagram for MaNGA galaxy 9881-12704. We show the SDSS colour-image of the galaxy with its corresponding MaNGA IFU FoV for reference.

We propose to take advantage of the huge potential of the WHAN diagram to investigate galaxy evolution processes at the different stellar populations and at galaxy components levels. We have designed a new scheme to visualise the spatially resolved WHAN diagram in MaNGA galaxies. Besides providing a more complete picture of the emission activity, we combine colors schemes and subcategories definition to explore the transition within a same category or between two adjacent categories in a very flexible way. The colors gradients were selected to visualise a gradual transition within or between categories or galaxy regions, without the necessity of the limits imposed by each category. We are building this scheme as a function that could be integrated in Marvin.

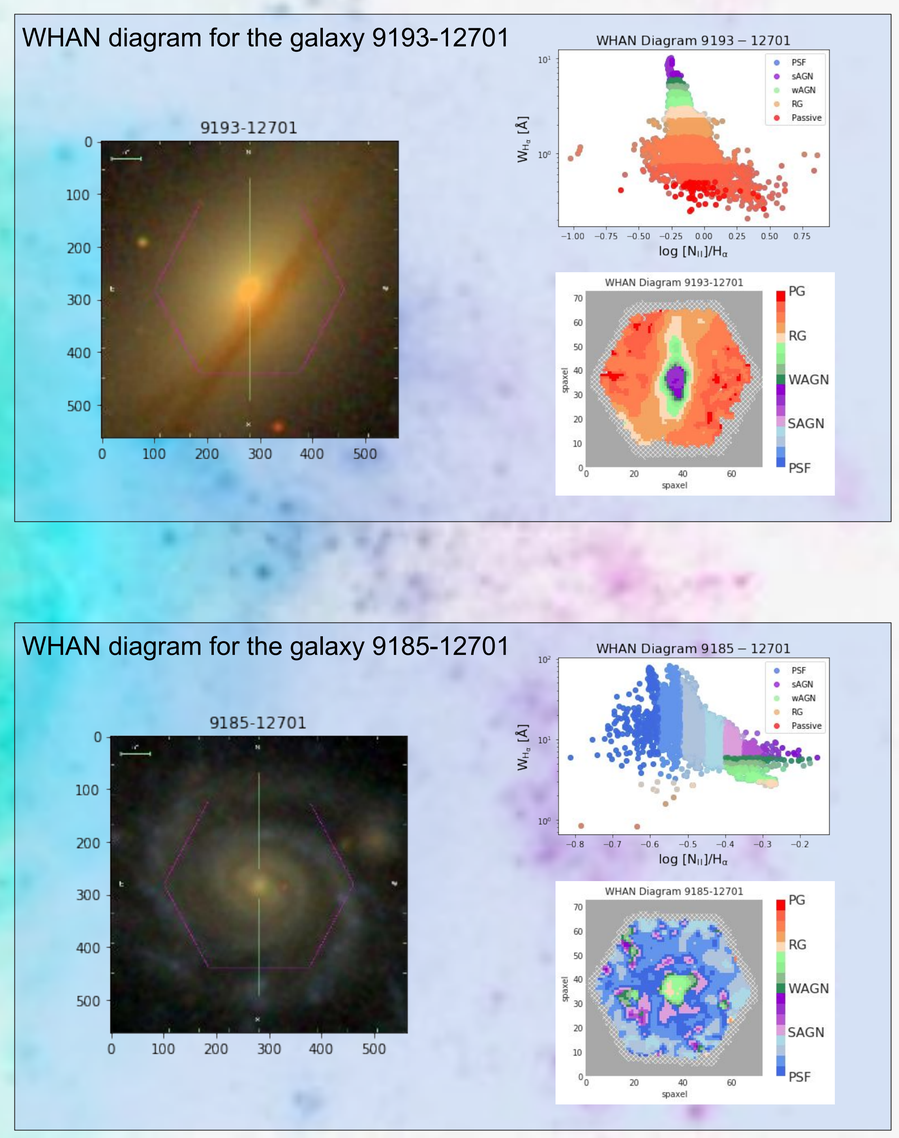

Figure 4: Examples of our improved WHAN diagram for MaNGA galaxies 9193-12703 (upper panels), 9185-127-01 (middle panels), and 8082-12702 (lower panels). We show the SDSS colour-image for each galaxy with its corresponding MaNGA IFU FoV for reference.

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