Identification and Investigation of Interacting Galaxies Using Spatially Resolved Data

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Motivation:

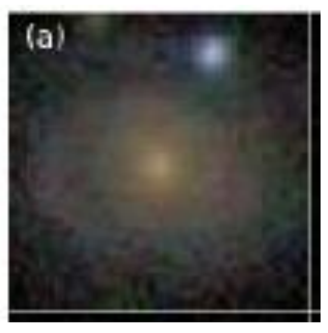
Galaxy interactions are a very fundamental process when discussing galaxy evolution, but many processes that occur during interactions are not fully understood, and quantitative studies are not trivial. Identifying interacting galaxies is also difficult, as analyzing images is not sufficient.

This work focuses on the star formation properties of interacting galaxies, so we can gain an understanding of how interaction affects galaxy evolution. From a galaxy evolution standpoint, the star formation activity of a galaxy can alter its spectral information, which tells us about properties such as stellar population and chemical composition. These alterations can be seen over a much longer timescale as opposed to optical images.

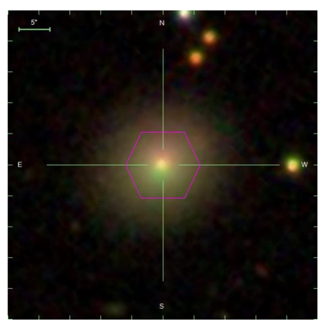
Spatially resolved star formation properties can tell us about where the star formation activity is occurring or has occurred, and show us if there is a relation to the location of interactions. Galaxy interactions can trigger star formation, but where does the star formation occur?

Identification:

Existing studies on identification of interacting galaxies are mostly done on optical images (e.g. SDSS). Popular methods of identification from optical images are by visual inspection (e.g. Galaxy Zoo Project (Darg et al. 2009)) and machine learning techniques (e.g. Ackermann et al. 2018). An issue with these methods is misclassifications, which can hinder the science of interacting galaxies. Visually based identification are susceptible to miss chance encounters or post-mergers. We suggest a more physically motivated identification method.



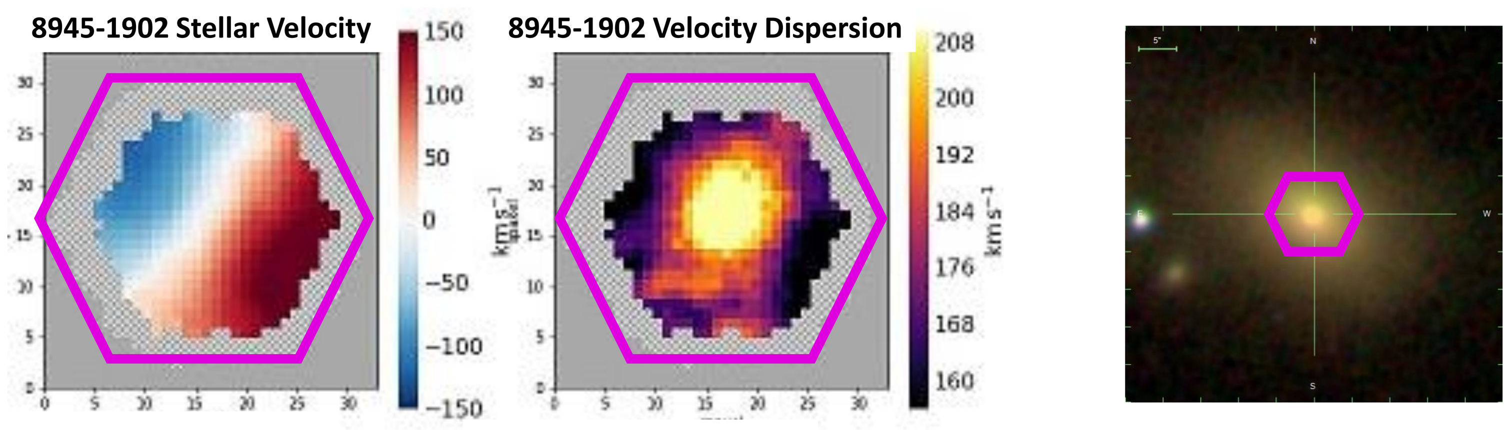
Chance encounter - Pearson et al. (2019)



MaNGA Post-Merger

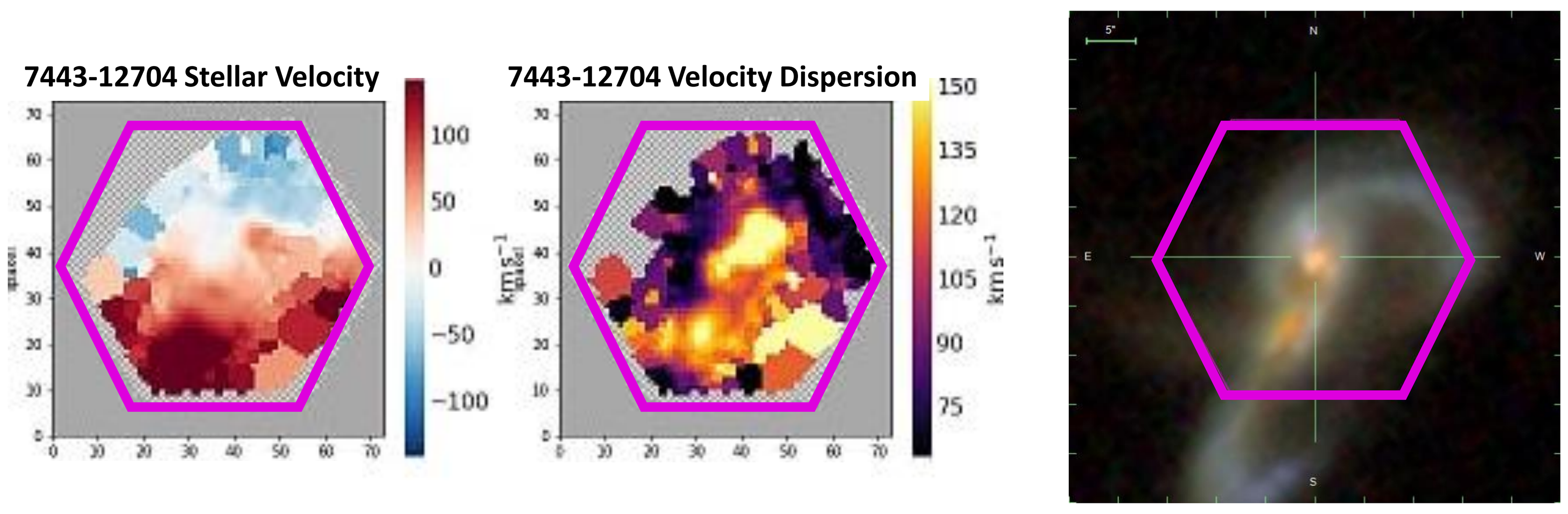
We have spatially resolved data that may possibly help us develop a good indicator of interaction. For this study, we have conducted identification of galaxies in the MaNGA Catalogue (Bundy et al. 2014) and classified them based on spatially resolved stellar dynamics, looking at MaNGA stellar velocity and stellar velocity dispersion two-dimensional maps.

A)



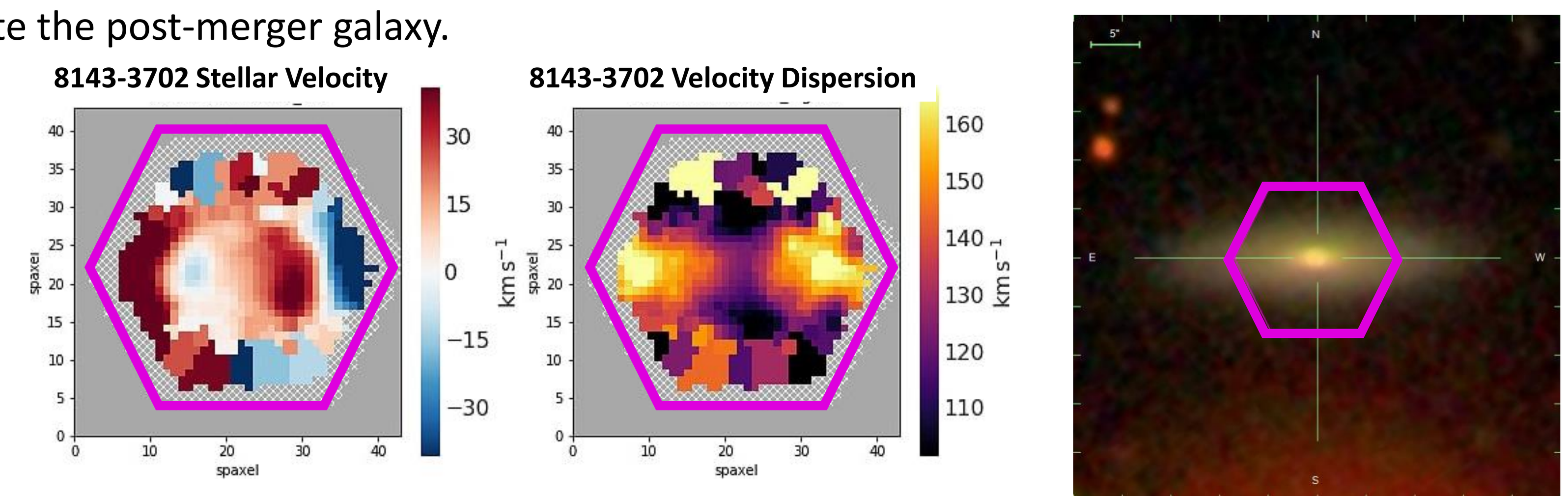
We identified interacting galaxies by searching for asymmetries and distortions in the stellar velocity maps. The stellar velocity dispersion maps showed increased values in a) the cores of the galaxies, b) locations of interaction and c) merger indicators such as tidal tails.

B)



Post-merger galaxies, like written above, are a common cause of misclassification, as their optical images look like single galaxies. However, their stellar dynamic maps show disturbances. A characteristic that has been observed in post-merging systems is "counterrotation", as noted in studies such as Johnston et al. (2018). The stellar velocity dispersion maps of such galaxies showed two cores, perhaps an indication of remnants of the two galaxies that merged to create the post-merger galaxy.

C)

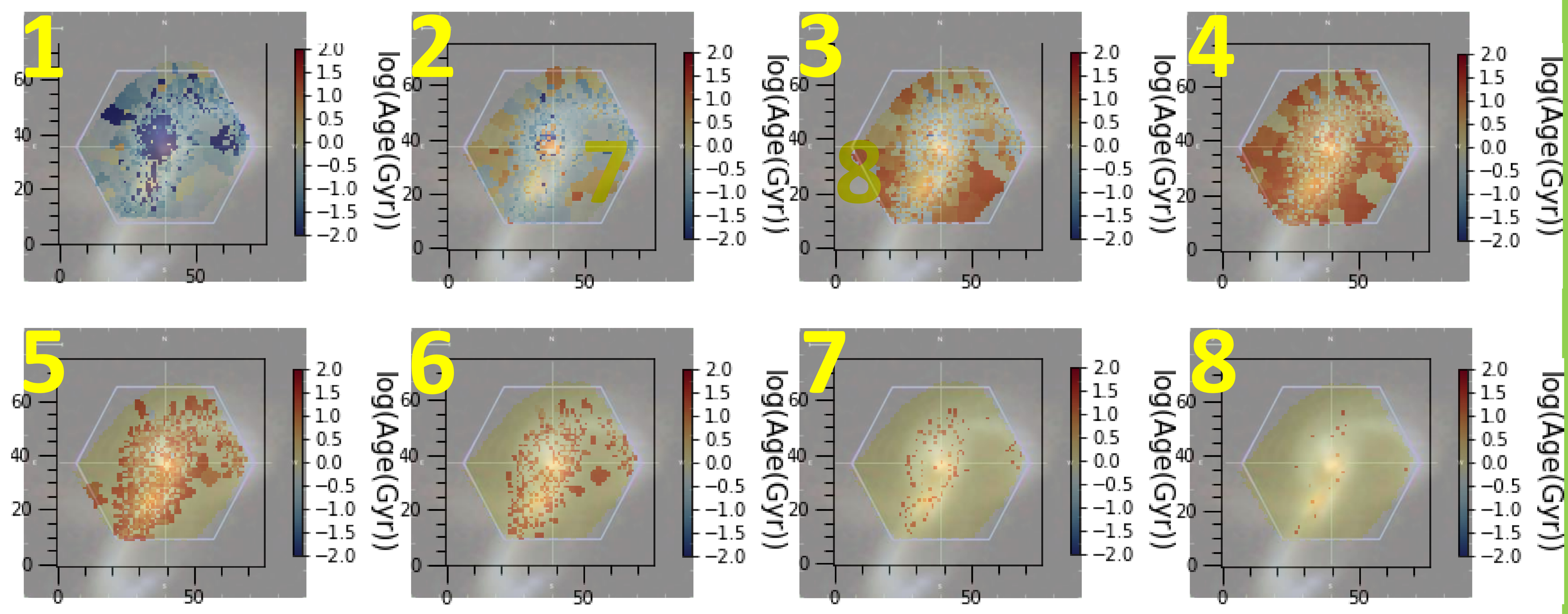


Investigation:

After identifying interacting galaxies using our method, we have used MaNGA and MaNGA FIREFLY Value Added Catalogue (Goddard et al. 2017 and Parikh et al. 2018) datamodels to analyze the behaviour of interacting and post-merger systems.

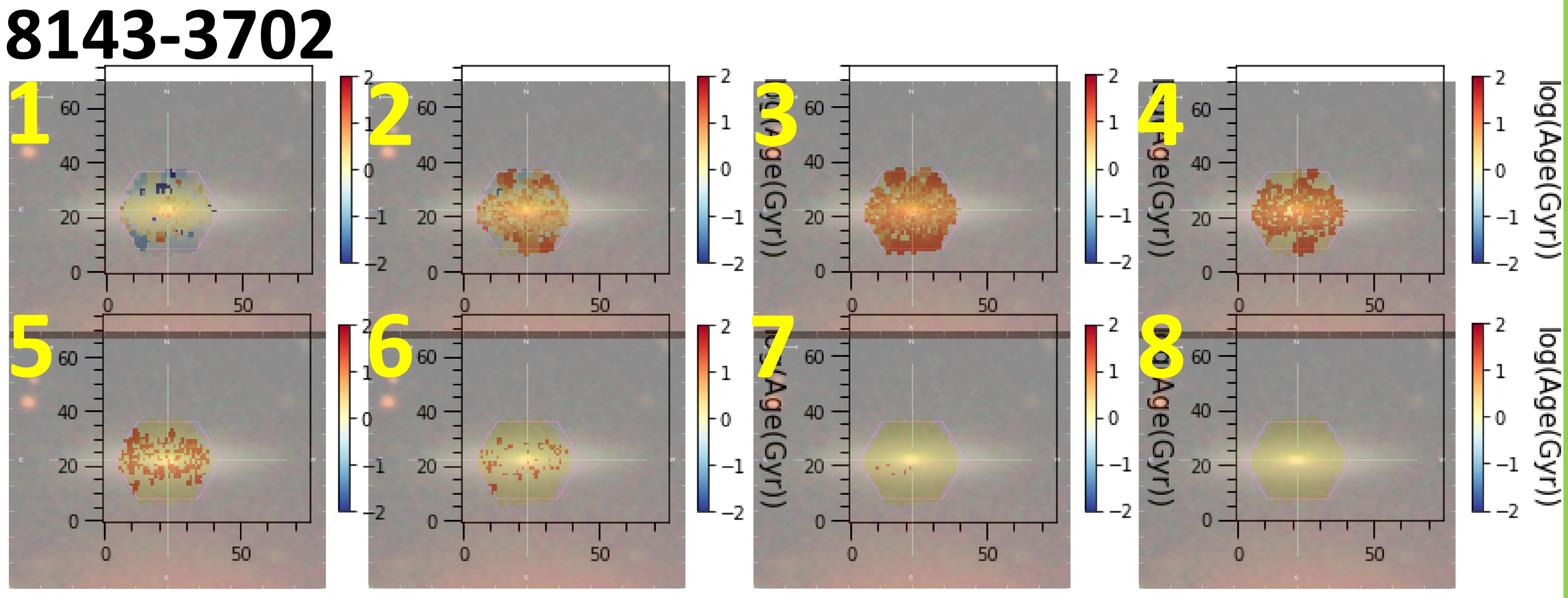
The MaNGA FIREFLY VAC applies the SED Fitting code FIREFLY (Wilkinson et al. 2016) onto MaNGA DAP Voronoi binned spectra, which returns spatially resolved stellar population properties such as stellar population age. Each spectra was resolved into a maximum of 8 SSPS which were then ordered from youngest to oldest, giving a quantitative SFH of the galaxy. The interacting galaxy (galaxy B) on the left) shows young stellar populations (blue areas in top left plot) particularly in the areas where the galaxies are interacting, indicating recent star formation possibly being induced by the merger event. There is also recent star formation occurring in the center of the system.

Star Formation History of Interacting Galaxy 7443-12703



As for the post-merger galaxy (galaxy C) on the left), the star formation history maps show that the younger stellar populations (blue regions, age < .1 Gyr) lie in a ring-like structure around the core of the galaxy. The central region does not have as young stellar populations, indicating that star formation activity was more recent in the ring. This shows a consistency with previous simulation works such as Moreno et al. (2015).

Star Formation History of Post-Merger Galaxy 8143-3702



Issues:

Not all interacting systems show similar disturbances in their dynamical maps, and not all post-mergers have counterrotation. There is no 'common' feature among all mergers/post-mergers, so machine learning networks cannot be trained with a single criteria for classification.

Conclusion – Future Works

From our works, we can see that focusing on certain features in the dynamical structure maps of galaxies can be a supplementary method to classify galaxies as interacting. In particular, classification of post-mergers may be done with greater accuracy by looking for features such as counterrotation.

Future works will look to:

a) Look for further characteristics in other dynamical maps such as gas kinematics
b) Design a machine learning technique that is trained using multiple dynamical maps in addition to optical images
c) Do quantitative analysis on the effects of galaxy interaction of local physics of galaxies