The environmental effect on star formation in low-mass galaxies

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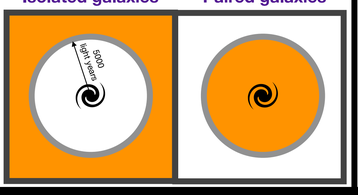
Abstract The interaction between low-mass galaxies are of critical importance for the growth and evolution of galaxies. The star formation can be enhanced during interactions between massive galaxies, but very few studies focus on the interaction between low-mass galaxies. In this work, we explored the current star-formation surface density in both isolated and interacting galaxies and look for enhanced star formation during the interactions. A galaxy will be considered as a galaxy pair candidate if the physical separation between it and its closest low-mass galaxies is smaller than 5000 light years, otherwise it will be put into the isolate galaxy sample. This sample intentionally excludes galaxies with a massive galaxy neighbor nearby as massive neighbors can harass low-mass companion galaxies and can cause them to become quenched. This project is the first attempt to systematically study how the internal star-formation activities of low-mass galaxies are influenced by outer environment.

The evolution scenario of a galaxy can be rewritten when it is accompanied by another galaxy. We investigated how the internal star-formation activities of a low-mass galaxy are altered by its environment. Comparing the spectral measurements in isolated galaxies and paired galaxies, an enhancement of star-formation is found when the low-mass target galaxy is interacting with a low-mass neighbor galaxy. Our results support the opinion that the interaction-triggered star-formation enhancement can be observed not only in merging massive galaxies, but also in the interacting system of low-mass galaxies.

Sample Selection

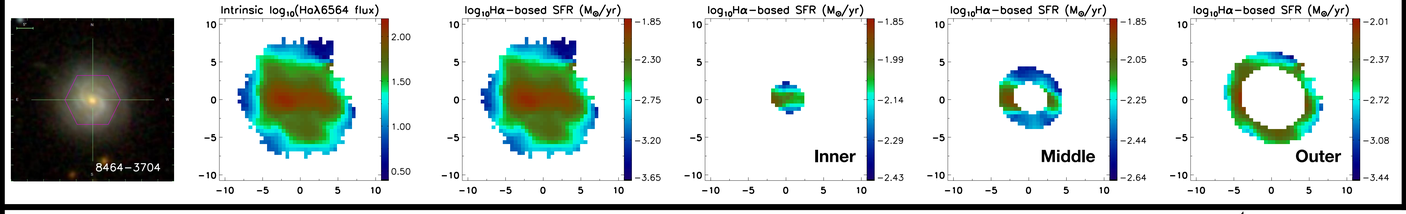
Our sample includes 107 isolated galaxies and 510 paired galaxies. Galaxies in our sample have a median mass of 2.8 billion solar mass and a median distance of 420 million light years. The observational data for this work is extracted from the fourth-generation Sloan Digital Sky Survey (SDSS-IV) / Mapping Nearby Galaxies at Apache Point Observatory (MaNGA) survey[1].

The criteria of the selection procedure is described by the following images. The low-mass MaNGA target is described by the black galaxy symbol, the gray circle stands for the neighborhood within 5000 light years. The tangerine region represents the position of its nearest low-mass neighbor galaxy.



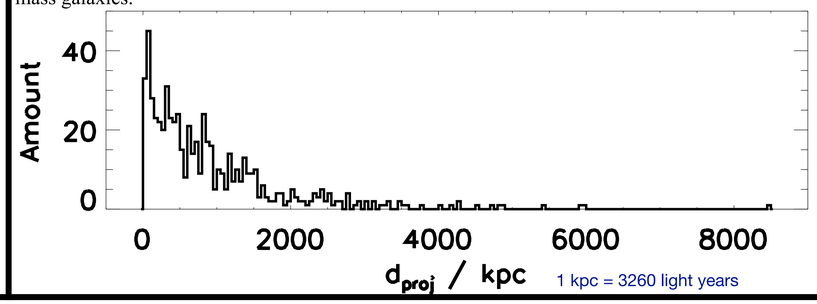
Star-formation Rate Surface Density Calculation

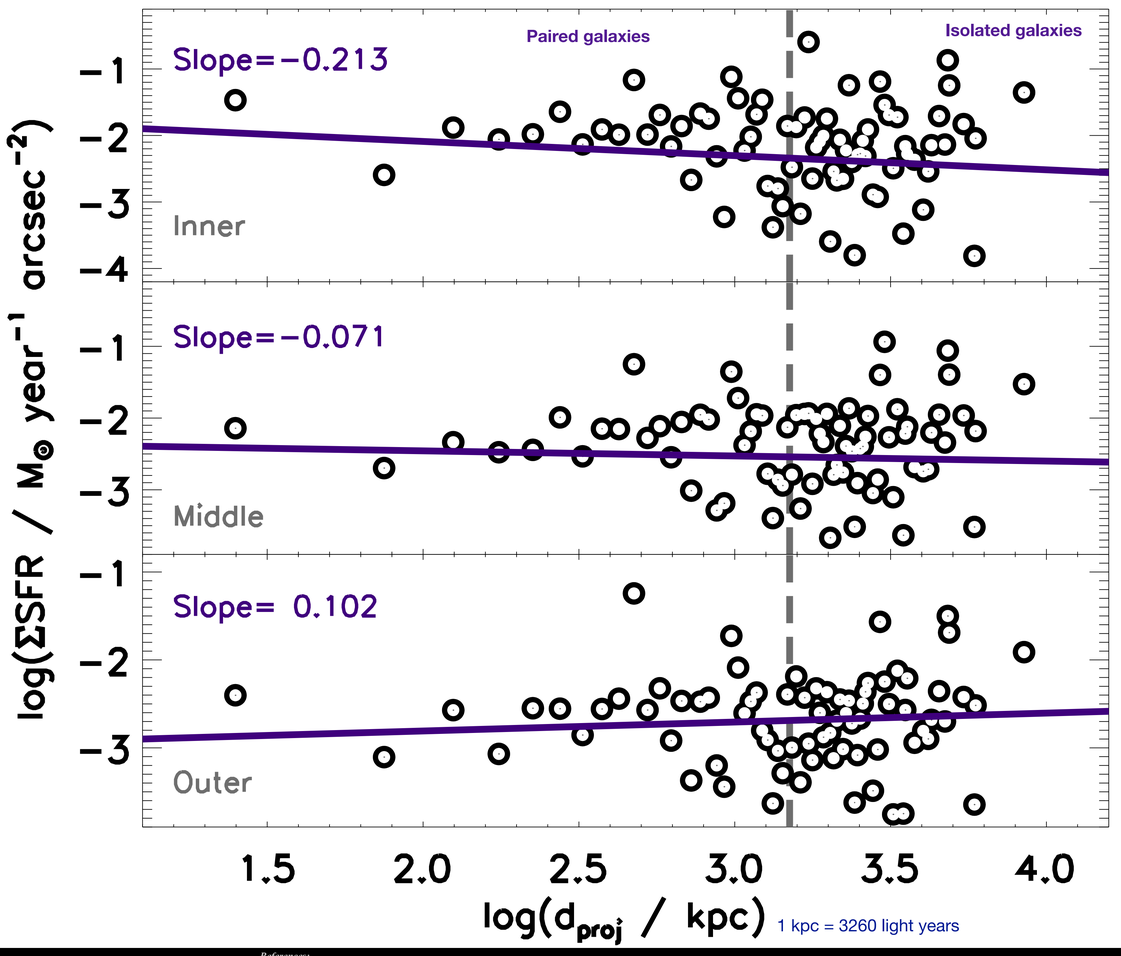
Ionized hydrogen, traced by the Hα emission line, is widely used to trace regions of active star formation as the massive stars heat and ionize the gas in their surroundings. In this work, the intrinsic Hα energy flux is adopted to calculate the current star-formation rate (SFR) by using the relation in Weilbacher & Fritze-v. Alvensleben 2001[2]. We radially bin the SFR maps into three regions using ellipses that span a distance along the semi-major axis $0 \leq R/R_e < 0.5$ (Inner), $0.5 \leq R/R_e < 1.0$ (Middle), $1.0 \leq R/R_e < 1.5$ (Outer). The SFR surface density (ΣSFR) is further calculated by dividing the total SFR within each annulus by the area. The ΣSFR in these three regions of each galaxy is derived to explore how galaxy interactions influence their internal processes. The SFR maps of a MaNGA paired galaxy are shown as an example. The unit of energy flux in MaNGA is 10^{-17} erg/s/cm^2/spaxel. The x-axis and y-axis represents the angular offset to the coordinates of the galactic center.



Separation-weighted ΣSFR

We bin our sample into different groups based on their projected separation (d_{proj}) to their nearest low-mass neighbor galaxy. For the convenience of calculation, the kilo-parsec (kpc) is adopted as the unit of d_{proj}, 1 kpc is equivalent to 3260 light years. The weighted-average ΣSFR is further derived to explore the environmental impacts on the star-formation behavior of low-mass galaxies.





Results:

The gray dashed line shows where projected separation is 5000 light years (which is 1500 kpc). Data on the left side and right side describes the star-formation in paired galaxy and isolated galaxy, respectively.

- **Star-formation enhancement is observed when two low-mass galaxies are interacting with each other.**
  - **In general, most of the low-SFR galaxies are isolated.**
  - **The negative slopes in "Inner" region and "Middle" region indicate that the SFR surface density drops as the projected separation increases, which suggests that the interaction between low-mass galaxies have the ability to affect the star-formation activity in the involved galaxies.**
  - **SFR in the Inner region of a low-mass galaxy is more significantly enhanced when the target galaxy is interacting with another low-mass galaxy.**
  - **The star-formation activities in the outskirt are not significantly affected by the environment.**
- **Both isolated and paired low-mass galaxies have stronger star-formation activity in their central region.**

References:

[1] SDSS-IV / MaNGA:
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[2] Weilbacher, P. M. & Fritze-v. Alvensleben, U. 2001, Astronomy and Astrophysics, 373, L9