Star-forming early-type galaxies under SDSS MaNGA view

Zhen-Kai Gao (高振凱), Chorng-Yuan Hwang (黃崇源)

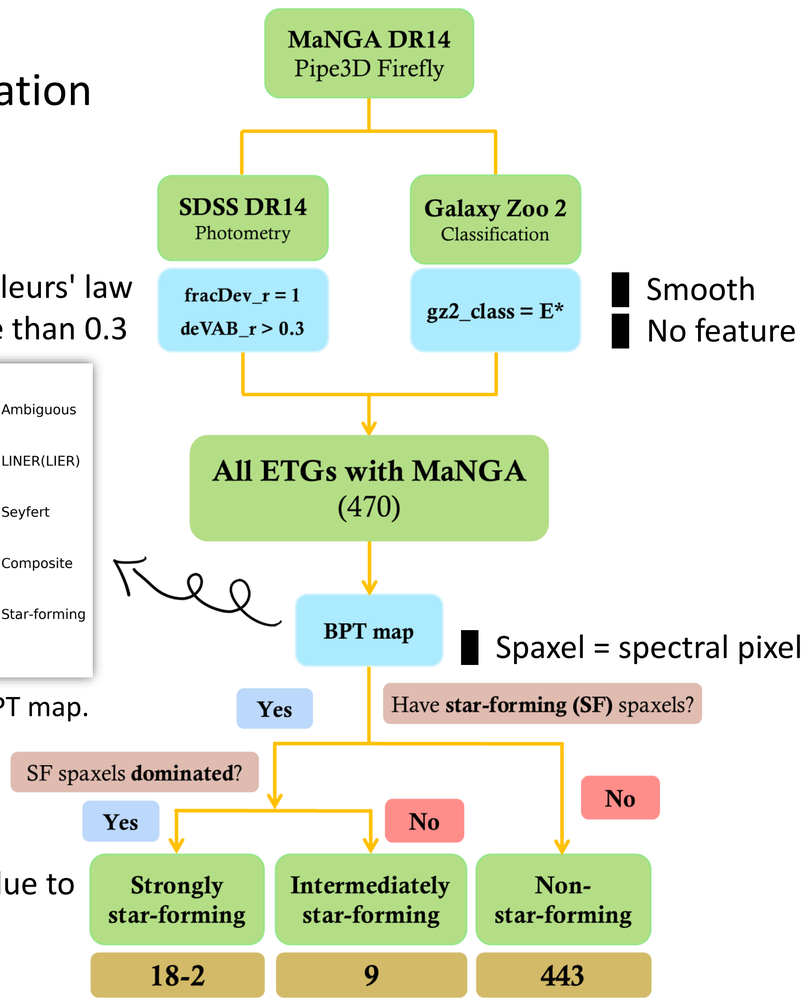
Graduate Institute of Astronomy, National Central University, Zhongli Dist., Taoyuan City, Taiwan (R.O.C.)

Abstract

Most of the early-type galaxies (ETGs) are thought to be red and passive, while previous studies found some blue ETGs now experiencing star formation. Those ETGs with star formation usually have characteristics of low mass and being in the low-density environment. Due to the lack of neighbors in normal size, the major merger could hardly contribute to these star formation event. Minor merger and cold accretion are thus the two main origins of the gas reservoir inside the star-forming ETGs. To trace the origin of the material for star formation, we adopted the observations from SDSS MaNGA integral field spectroscopy (IFS) to investigate where the gas came from, how the newly coming gas interacts with the host galaxies, and after these, where the new-born stars reside.

Sample

Selection & classification



- Well fitted to de Vaucouleurs' law
- A/B ratio of ellipse more than 0.3

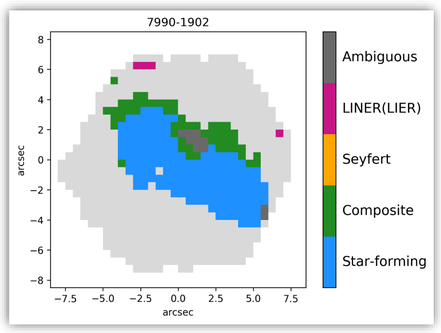


Figure 2. An example of BPT map.

- Smooth
- No feature

- Spaxel = spectral pixel

- Two of 18 are removed due to
  - △ Merger
  - △ Half outside the IFU

Figure 1. Selection and classification tree of our sample with SDSS MaNGA observation.

Morphology of ionized gas

Hα emission line as a tracer

Flux map

An indicator of **star-forming region**

Spheroid (14/16) | **Disk-like** (1/16) | **Thin-sided** (1/16)

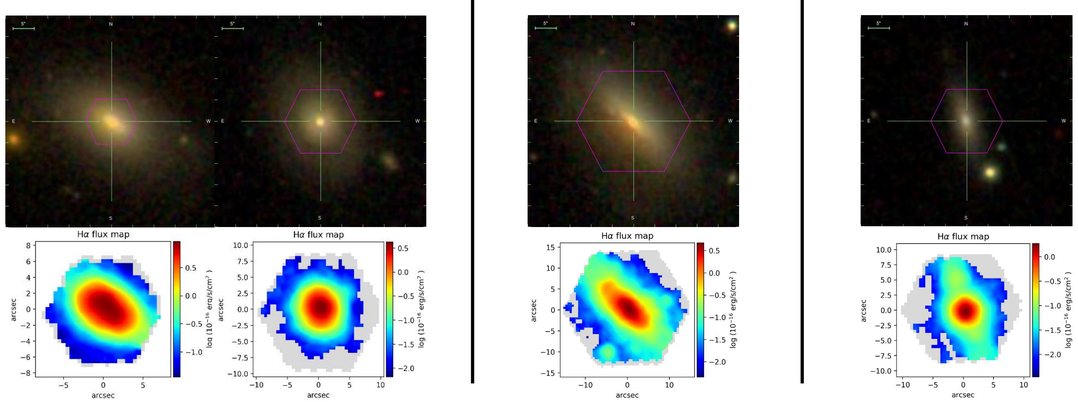


Figure 3. Three types of Hα flux morphology with false color image from SDSS DR14.

Equivalent width map

A proxy for **specific star formation rate**

Spheroid (11/16): **Normal** (9) | **Shifted** (2)

Ring-shaped (1/16)

Multiple components (4/16)

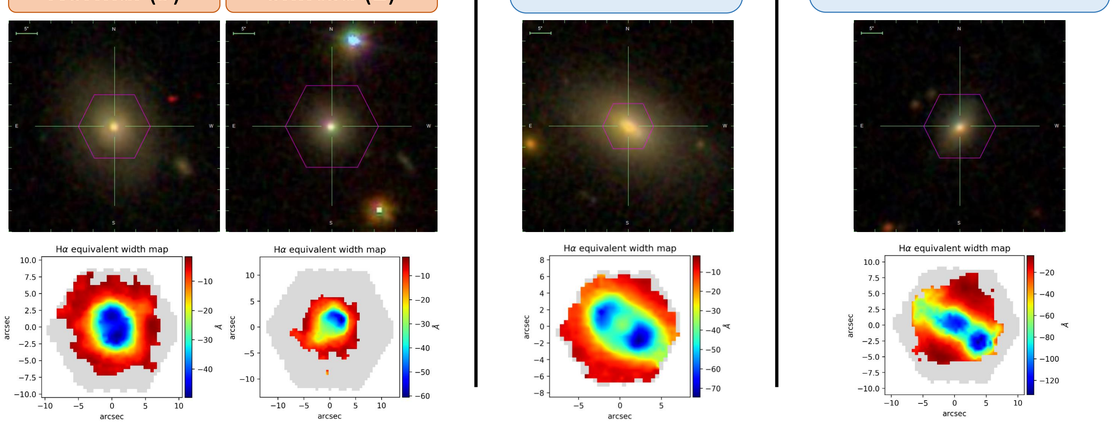


Figure 4. Three types of Hα EW morphology with false color image from SDSS DR14.

Velocity map

Ionized gas vs. stellar population

- We define the **radial rotational velocity (v_r)** as half the **radial velocity width**.
- Strongly star-forming ETGs are divided into three subgroup by their v_r of stars v_{r_*}.

	Strong	Intermediate	Weak
Number	3/16 (19%)	8/16 (50%)	5/16 (31%)
Criterion	$v_{r_*} > 120$ km s^{-1}	$120 \geq v_{r_*} > 70$ km s^{-1}	$v_{r_*} \leq 70$ km s^{-1}
Alignment	3/3 (100%)	3/8 (38%)	2/5 (40%)

Table 1. Properties of the strongly star-forming ETGs in three different radial rotational velocity subgroups. Examples of alignment can be seen in Figure 5.

Aligned | **Misaligned**

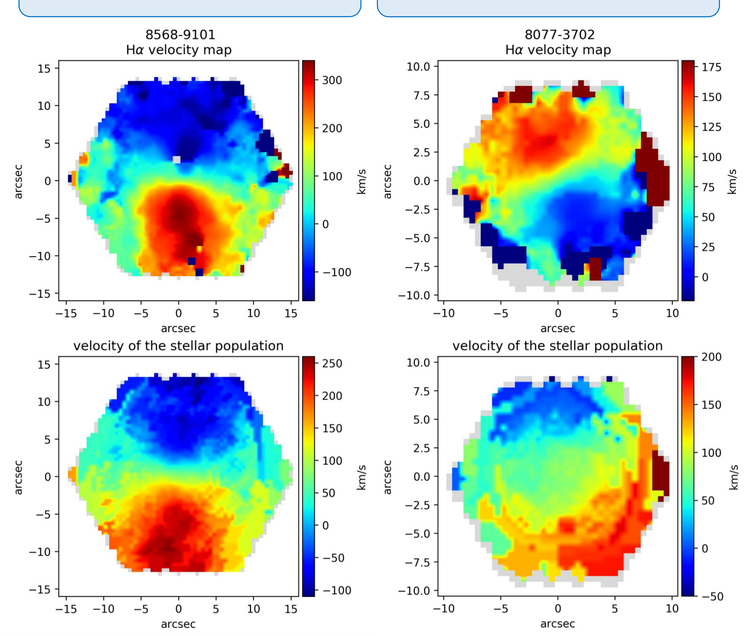


Figure 5. Examples of the alignment and misalignment. When velocity map of gas is aligned with that of stellar population, it is classified as aligned.

- Misalignment may imply that the gas should have an external origin (Davis et al. 2011).

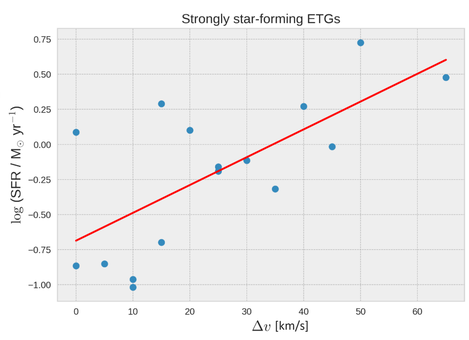


Figure 6. Relation between star formation rate (SFR) and velocity difference (i.e. $|v_{r_*} - v_{\rm gas}|$).

- The weak correlation (with R-value 0.69) in **Figure 6.** could be explained that stars and gas running towards different directions may trigger star formation easily.

Age gradient

How do old and young stars distribute?

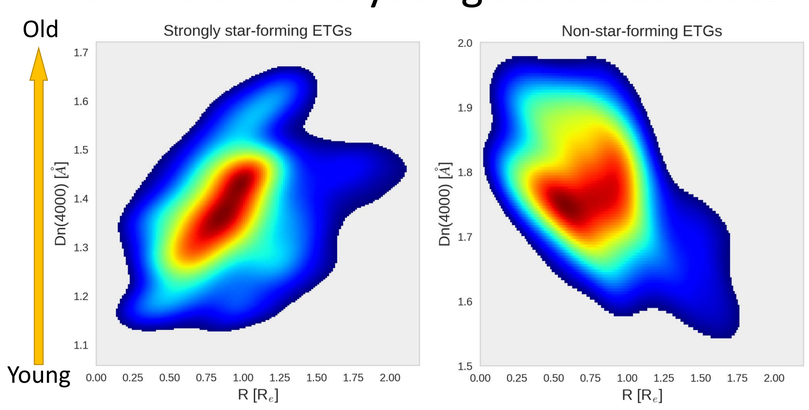


Figure 7. Gradients of Dn(4000) as a function of effective radius (R_e) of strongly star-forming and non-star-forming ETGs.

- Dn(4000) in Figure 7. could be an indicator of stellar age.
- Strongly star-forming ETGs show a radially increasing trend. It means that recent star formation seems to take place in the central part of the galaxies.
- In Figure 7. we can find that the non-star-forming ETGs as a whole are much older than the strongly star-forming ones. This may be related to the origin of gas from both cold accretion and minor merger that usually happen in low redshift (Kaviraj et al. 2011) to major merger used to take place in high redshift (Conselice et al. 2003).
- Non-star-forming ETGs show an inverse trend. This is consistent with previous studies (Li et al. 2015, Belfiore et al. 2016)

Summary

We analyzed star-forming ETGs using SDSS MaNGA data. We found that many ETGs with significant SFRs show misalignments between the gas and the stellar velocity distributions. Besides, some gas has spheroid distribution while others have ring-shaped or comprise multiple components relative to the relatively smooth distribution of stars (see EW maps). These results suggest that most of the gas in the star-forming ETGs might have an external origin.

References

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Conselice et al. 2003, AJ, 126, 1183
Davis et al. 2011, MNRAS, 417, 882
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izkgao@astro.ncu.edu.tw