Galactic Dynamics in the Era of Large Surveys
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Kinematic asymmetry of galaxy pairs

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Abstract. The interaction between galaxies is believed to be the main origin of the peculiarities of galaxies. It can disturb not only the morphology but also the kinematics of galaxies. These disturbed and asymmetric features are the indicators of galaxy interaction. We study the velocity field of ionized gas in galaxy pairs based on MaNGA survey. Using the `kinemetry` package, we fit the velocity field and quantify the degree of kinematic asymmetry. We find that the fraction of high kinematic asymmetry is much higher for galaxy pairs with $d_{\rm p} \leqslant 30h^{-1}$kpc. Moreover, compared to a control sample of single galaxies, we find that the star formation rate is enhanced in paired galaxies with high kinematic asymmetry. For paired galaxies with low kinematic asymmetry, no significant SFR enhancement has been found. The galaxy pairs with high kinematic asymmetry are more likely to be real interacting galaxies rather than projected pairs.

Keywords. galaxies: interactions, galaxies: kinematics and dynamics

1. Introduction

Galaxy pairs are usually considered as galaxies that are experiencing interactions. Their member galaxies show a series of peculiar properties (e.g., enhanced SFR), especially for the close pairs (e.g., projected separation $d_{\rm p} \leqslant 30h^{-1}$kpc) (Ellison *et al.* 2008). Numerical simulations suggest that this phenomenon originates from the strong tidal effect during the first passage (Barnes & Hernquist 1996). Many studies have shown that the properties of galaxy pairs depend on the projected separations. However, the projected separation is not a physical indicator to quantify whether galaxy pairs have experienced a strong tidal effect. Projection effect can cause two galaxies to form an observational pair even that they are not physically associated. Systems after a close encounter can also have relatively large projected separations.

Numerical simulations predict that the tidal effect can disturb the kinematics. Recent integral field spectrograph (IFS) observations find some evidence about the tidal-induced irregularity of velocity field (Barrera-Ballesteros *et al.* 2015). To further explore the relationship between the interaction and kinematics, we use MaNGA (Bundy *et al.* 2015) data to study the velocity field of galaxy pairs.

2. Data and Method

The galaxy pair sample is selected from SDSS (see Feng *et al.* 2019 for details). The total SFRs and stellar masses are taken from Salim *et al.* (2016). In total, 523 paired galaxies and 1848 isolated galaxies are studied in our work. We use `kinemetry` package to fit the Hα velocity field of each galaxy (Krajnović *et al.* 2006) provided by MaNGA DAP (Westfall *et al.* 2019). The degree of kinematic asymmetry can be quantified by $v_{\rm asym}$, which is proportional to the ratio between the strength of asymmetrical and symmetrical

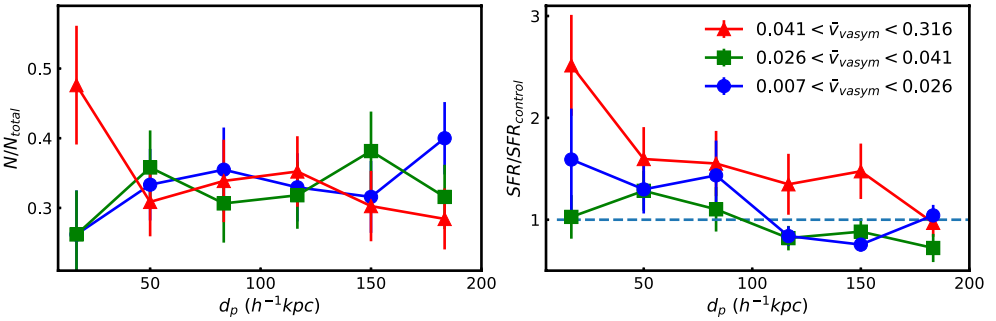

Figure 1. Left panel: the fraction of paired galaxies as a function of $d_{\rm p}$. Right panel: the SFR enhancement as a function of $d_{\rm p}$. The color coded lines indicate three subsamples with different $v_{\rm asym}$.

components (Bloom *et al.* 2018). With this definition, the larger $v_{\rm asym}$ value indicates higher asymmetry of velocity map. We divided our pair and control samples into three groups according to $v_{\rm asym}$ and analyzed their properties.

3. Result and Discussion

We show the results in Figure 1. The left panel shows that the pair fraction for the group with the highest $v_{\rm asym}$ depends on $d_{\rm p}$. When $d_{\rm p} \leqslant 30h^{-1}$kpc, it increases up to 50% from 30%. The right panel shows that the $v_{\rm asym}$ values are correlated with the total SFRs. For the paired galaxies with high $v_{\rm asym}$ values, their SFRs are significantly enhanced compared with isolated galaxies. While in the case of subsamples with low $v_{\rm asym}$ values, their SFRs show little enhancement.

The paired galaxies with high kinematic asymmetry show the typical characteristics of interacting galaxies (enhanced SFR). We suspect this kind of paired galaxies maybe have experienced stronger tidal effect. In the simplest case, the galaxies, which are separating after a close encounter, should be affected by tidal force for a longer time. We considered those paired galaxies with high kinematic asymmetry are likely at the post-encounter stage.

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