Interactions in galaxy evolution:
A new perspective from CALIFA and MaNGA surveys

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Interactions in Galaxy Evolution

How properties change as merger evolves?

Joshua Barnes, HST
Star Formation Rate (SFR) in Interacting Galaxies

Ellison+13: SFR enhancement in pairs and post-merger SDSS galaxies using single fiber aperture spectra (e.g., Barton+00, Ellison+08, Knapen & James09)
Metallicity dilution in the central region of pairs and post merger galaxies compared with a control sample (e.g., Kewley+06, Ellison+08, Patton+13)

Figure 10. The AGN excess, defined as the fraction of SDSS galaxies (2006), relative to the fraction of AGN of their respective controls. The offset for galaxies in the SDSS post-merger sample.

Following Scudder, Ellison & Mendel (2012a) and Scudder et al. (2012b), we calculate the metallicity of star-forming galaxies according to the formalism of Kewley & Dopita (2002), as recently re-assessed by Kewley & Ellison (2008). In order to be consistent with our previous work, we require that galaxies are classified as star forming according to the criteria of Kauffmann et al. (2003b) and have a S/N > 300 km s$^{-1}$. The post-mergers are even more metal poor, with a median $\Delta [\text{O/H}]$ $\sim -0.1$. Since $\Delta [\text{O/H}]$ $\sim -0.07$, the post-mergers have occurred in these galaxies relatively recently. The low observed metallicities in our post-merger sample support the conclusion drawn from the SFRs that coalescence is likely to enrich the metallicity of the gas. There are a few differences between our current work and that of Ellison et al. (2011) matched only in mass and redshift, whereas this paper also considers the case of mass ratio differences. The AGN excess is therefore a measure of how much metal-enrichment will follow a starburst, simulations predict that the frequency of AGN, which peaks at $\sim 40 h^{-1}$ kpc, is 2.5 times the control value at $\sim 1 h^{-1}$ kpc. We have experimented with the SDSS selection, as the lowest number of AGNs is used here. However, having experimented with the SDSS selection, we found an AGN excess only out to $\sim 5 h^{-1}$ kpc, whereas the control sample has AGNs up to $\sim 80 h^{-1}$ kpc. This is seen out to large separations. The first is the different range of mass ratios that are classified as an AGN according to the definition of Stasinska et al. 2008; Cid-Fernandes et al. 2011; Yan & Ellison 2010; Ellison et al. 2011). Due to the uncertain nature of LINERs (e.g. Stasinska et al. 2008; Cid-Fernandes et al. 2011; Yan & Ellison 2010; Ellison et al. 2011), it is preferable to restrict ourselves to Seyfert-like BPT lines for this basic classification. We adopt the Stasinska et al. 4C H A N G E S I N M E T A L L I C I T Y
Interactions in Galaxy Evolution

How spatially resolved observables (SFR and metallicity) evolve during the interactions?
Calar Alto Legacy Integral Field Area

- 937 galaxies from SDSS/DR7 of all Hubble Types
- >660 galaxies with PMAS/PPAK-IFU @ CAHA 3.5m
- diameter $45'' < D_{25} < 80''$, redshift $0.005 < z < 0.03$
- representative for nearby galaxies in $9.4 < \log(M_{\text{stellar}}/M_\odot) < 11.4$
- ~ 550 galaxies observed
Stellar-Gas Kinematic (Mis)alignments

Fig. C.1. Appendix

Barrera-Ballesteros+15a

Barrera-Ballesteros+14
Emission line Fluxes and EW(Hα) maps

Sample Sizes

103 Interacting B-B+15a

80 Control B-B+14

Barrera-Ballesteros+15b

Flux ratios \(\sim\) Metallicity

EW(Hα) \(\sim\) sSFR
EW(Hα) distributions (as proxy for sSFR)

Barrera-Ballesteros+15b

Fraction (SF) vs log(EW) for central and extended apertures.

Increment in central sSFR in interacting sample.
Central Metallicity in Star-forming galaxies

Small deviations in $12+\log(O/H)$ for both samples
Metallicity at different aperture sizes

@ Central: Similar or even larger metallicities in interacting sample
@ Extended: Dilution in metal content for interacting galaxies

Other process than inflows could enrich the central material in interacting galaxies (stellar/nuclear feedback)

Similar as in numerical simulations (Torrey+2012)
MaNGA Survey

Mapping Nearby Galaxies at APO

- 10,000 galaxies (!) at z ~ 0.03
- Roughly flat mass distribution
  \( \log(M^*) \sim 8.7 - 11 \)
- Coverage to 1.5 and 2.5 \( R_e \)
- \(~1400\) galaxies (\textbf{MPL-4}) already analyzed (PIPE3D, Sanchez+15)
Interacting galaxies in MPL-4

Catalogues:
- NSA v1.0.0
- Xiao-Hu Yang's group (ASIAA)
- Galaxy Zoo classification

240 paired galaxies covering different interaction stages
Radial Variations: Interacting vs Control

Barrera-Ballesteros, Lin et al. (in prep)
Radial Variations: Interacting vs Control

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We are learning a lot from IFUs!

• Central sSFR is enhanced in Interacting galaxies. Moderately suppressed in outer regions (see also numerical simulations by Moreno+15).

• Similar central metallicities (i.e., no dilution): stellar/AGN feedback also play a significant role (Torrey+13).

• IFU surveys with statistical meaningful samples allows us to understand the complex evolution of interacting galaxies.

• In particular, MaNGA is providing a unique scenario to test the radial change of the SFR and gas metallicity.