Classifying Quenching Galaxies: Comparing Methods

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Abstract

Quenching galaxies are galaxies that are rapidly evolving from strongly star forming systems to galaxies with mostly old stars and low star formation rates. When identifying quenching galaxies, there are several methods in common use. Furthermore, there are several ways astronomers estimate the Star Formation Rate (SFR), in Solar Masses per year, and Stellar Mass (M*), in Solar Masses, of galaxies. For a large sample of galaxies, we used 6 derivations of M* and 4 for SFR, plotting them against each other for comparison. We also calculated and compared the specific SFR (sSFR), equal to SFR/M*, and compared the different methods of defining quenched galaxies.

Background

There are two main basic types of galaxies: those actively forming stars: Blue Cloud Galaxies (BC) and passive or quenched: Red Sequence Galaxies (RS) containing mostly old red stars. Galaxies in between (Green Valley Galaxies or GV) presumably are in the process of having their star formation quenched. What causes galaxies to quench is not well understood, and how galaxies evolve from BC to GV and then to RS is unclear. BC galaxies are mostly spiral or irregular, and most RS are elliptical.

Issues in studying galaxy quenching:

-Techniques of estimating SFR vary

-Techniques of estimating M* vary

-Definitions of quenched galaxies differs between studies

Galaxies in clusters have been shown to be more likely to be quenched than field galaxies, but the amount of quenching and how/where quenching happens in a cluster is uncertain. Evolution of galaxy morphologies is also uncertain. These uncertainties may be affected by the issues with SFR, M*, and sSFR.

Our Goal: For a large sample of galaxies, compare different methods for deriving SFR, M*, and sSFR, as well as different definitions of a quenched galaxy. The comparison is based on agreement, reliability, and relation to RS/GV/BC classification.

Sample and Data

- Sample: NASA Sloan Atlas (NSA; Wake et al. 2017): over 640,000 galaxies, 623208 excluding AGN and using field
- We eliminated Seyfert galaxies and galaxies in clusters and massive groups; only considered field galaxies.
- NSA Data: Optical fluxes from Sloan Digital Sky Survey (SDSS); UV fluxes from the GALEX satellite
- We combine the NSA data with 22 micron IR data from the AllWISE Catalog (Cutri et al. 2013)
- We used these data to:

-Derive M* using the Zibetti et al. (2009) method

-Classify galaxies into RS, GV, and BC using the method of Boselli et al. (2014)

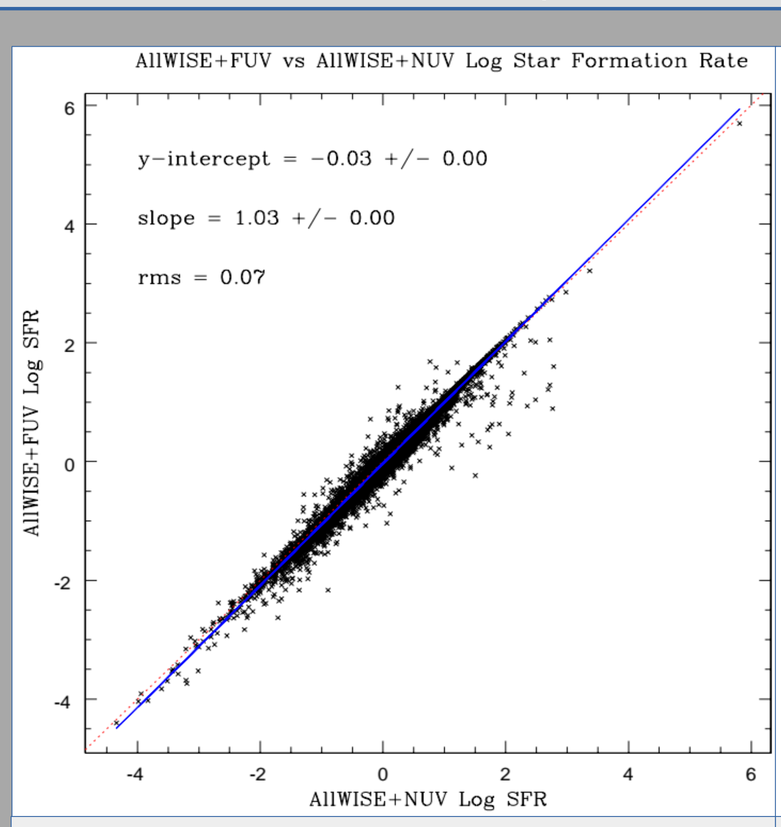
-Derive SFR's using the method of Hao et al. (2004)

-Calculate sSFR = SFR/M*

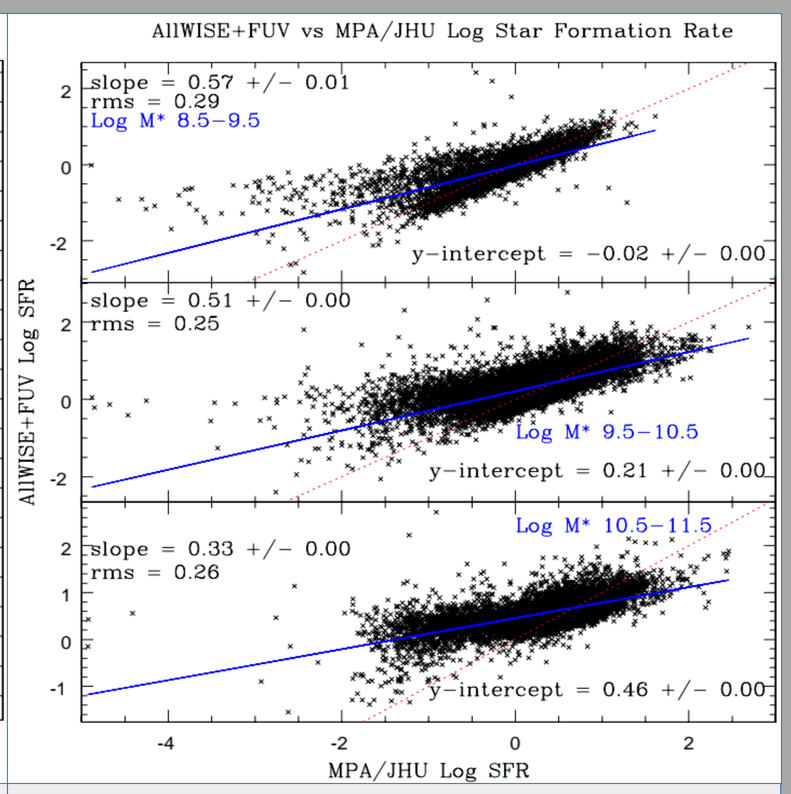
- The MPA/JHU Catalog (Brinchmann et al. 2004) independently used SDSS spectra and images to derive SFR, M*, and sSFR

Conclusions

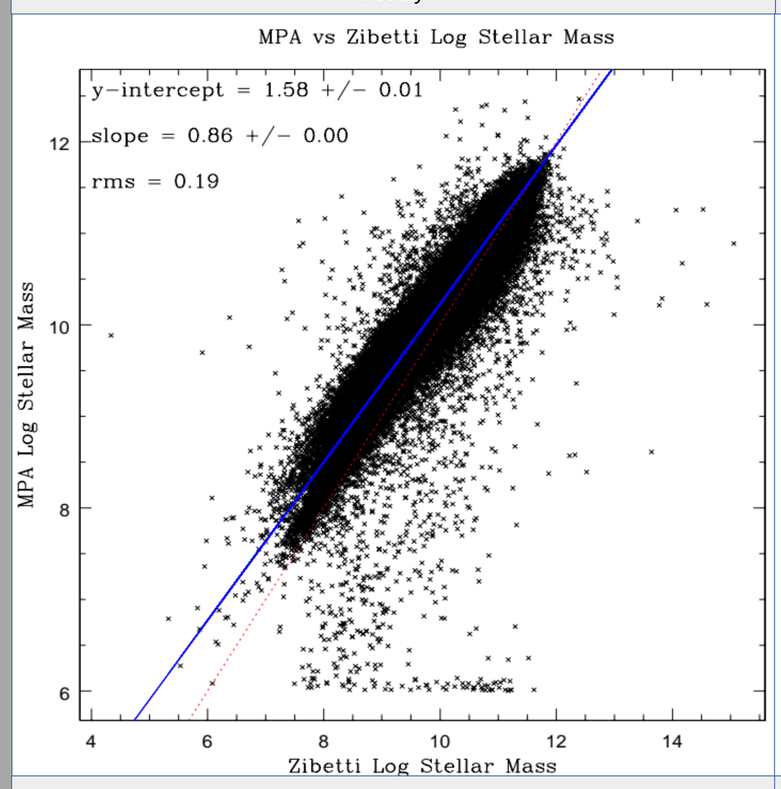
Looking at the histogram MPA sSFR vs RS/GV/BC, the line sSFR = -11 separates the RS and BC galaxies well. GV are spread in between. In NUV – r vs MPA sSFR, the line of NUV – r = 4.5, used by Haines et al. (2015) to define quenched galaxies differs significantly from sSFR < -11, used by McGee et al. (2011) and Wetzel et al. (2012) to select quenched galaxies. Some galaxies considered quenched by the first method are not by the second method. Overall, there are large discrepancies in estimating M*, as well as in SFR, and subsequently sSFR. AllWISE+FUV and AllWISE+NUV SFR's agree well, but AllWISE+FUV and MPA SFR's do not. We suggest that AllWISE+FUV overestimates SFR at log SFR < 0 due to contamination from older stars.



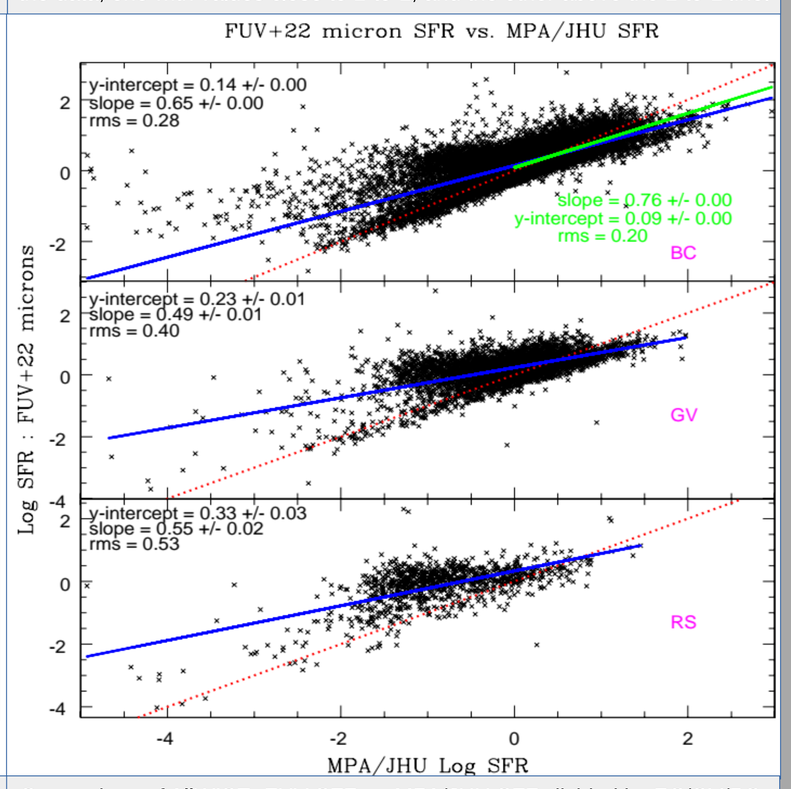
Comparison of AllWISE+FUV SFR vs AllWISE+NUV SFR. The 1-to-1 line is in red and the line of best fit is in blue. They follow the 1-to-1 line very closely.



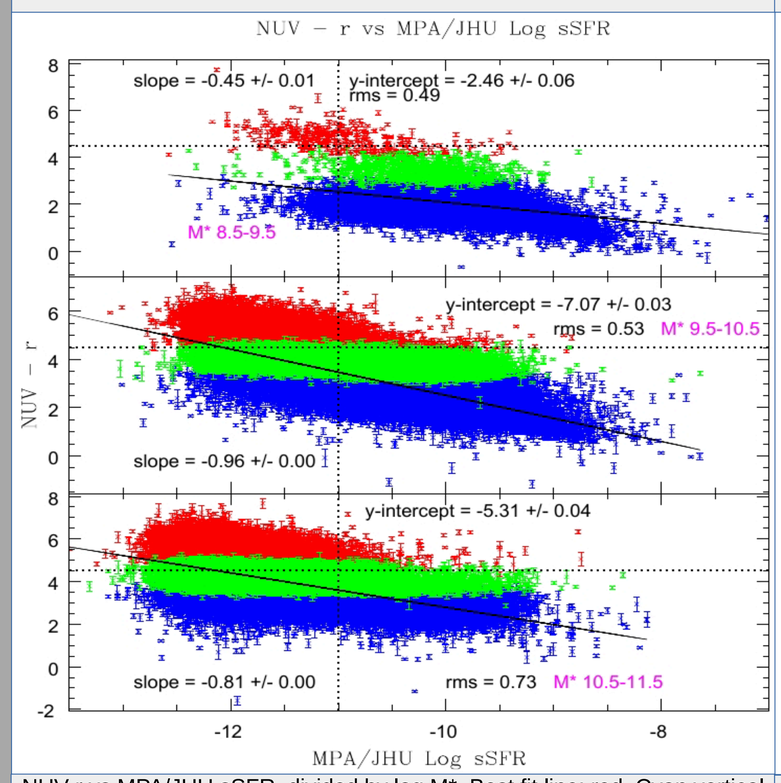
Comparison of AllWISE+FUV SFR vs MPA/JHU SFR divided by M* into 3 groups (1-to-1 line: red, line of best fit: blue.) We can see two branches in the data, one with values close to 1-to-1, and the other above the 1-to-1 line.



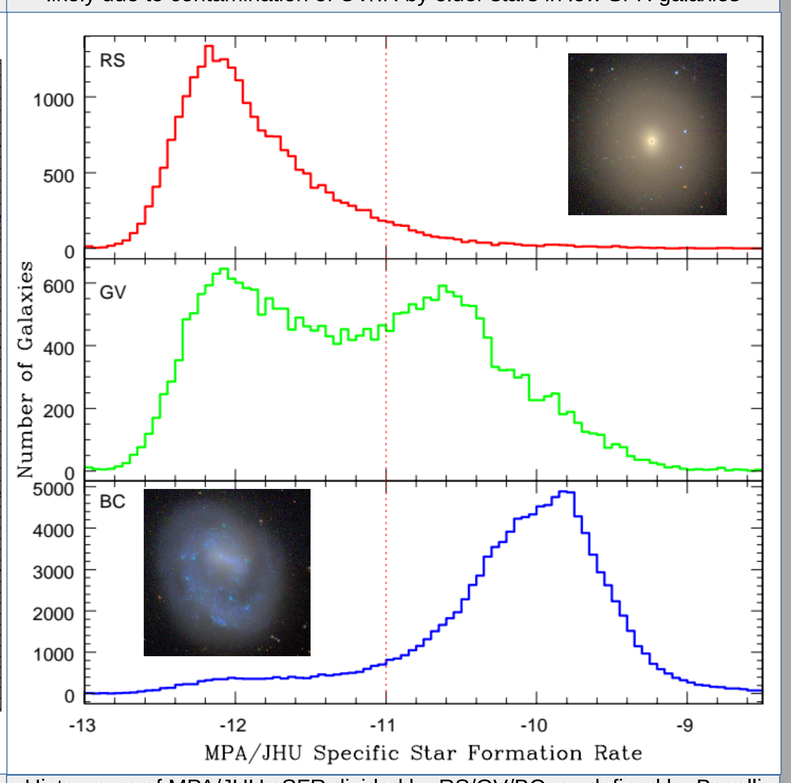
Comparison of MPA/JHU vs Zibetti M* Methods. The 1-to-1 line is in red and the line of best fit is in blue. Lots of discrepant points are present.



Comparison of AllWISE+FUV SFR vs MPA/JHU SFR divided by RS/GV/BC. 1-to-1 line: red, line of best fit: blue, line of best fit, slope, intercept for Log SFR MPA/JHU > 0: green. Two branches also visible here. Upper branch likely due to contamination of UV/IR by older stars in low SFR galaxies



NUV-r vs MPA/JHU sSFR, divided by log M*. Best fit line: red. Cyan vertical line: Log sSFR<-11 (McGee et al. 2011, Wetzel et al. 2012). Cyan horizontal line: NUV-r>4.5 (Haines et al. 2015). These are used to define quenched galaxies. Green/Red/Blue points correspond to GV/BC/RS type as defined by Boselli et al. (2014).



Histograms of MPA/JHU sSFR divided by RS/GV/BC, as defined by Boselli et al. (2014). The line of sSFR = -11 is in red dashes. RS are mostly below this line, and BC are mostly above, with GV spread out in the middle. Log sSFR < -11 (McGee et al. 2011, Wetzel et al. 2012) used to define quenched galaxies.

References

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