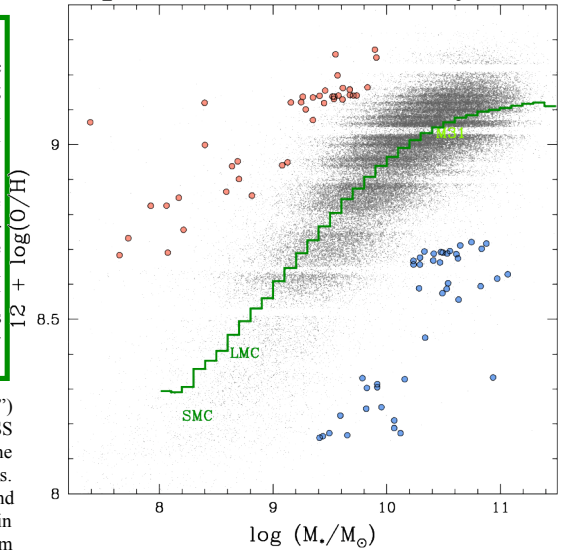
Outliers from the Mass–Metallicity Relation

Molly S. Peeples, Richard W. Pogge, & K. Z. Stanek
The Ohio State University
Department of Astronomy

Introduction

The mass–metallicity relation (*right*) has an intrinsic scatter of ~0.15 dex. Since most star-forming galaxies fall on this locus, we can attempt to learn about galaxy evolution from those galaxies that lie in unusual parts of this parameter space.

We find that, as a population, the outliers from the mass–metallicity relation represent relatively short-lived phases in the lives of galaxies. We postulate that the high-metallicity outliers are nearing the end of their star formation, whereas the low-metallicity outliers are the result of relatively pristine outer gas being driven into the galaxy centers during a merger event.



Right: Oxygen abundance (a proxy for "metallicity") v. stellar mass for star-forming galaxies from SDSS DR4 (grey points). The green histogram denotes the median oxygen abundance in bins of stellar mass. The metal-rich dwarf galaxies are denoted in pink and the massive low-metallicity outliers are denoted in blue. Abundances and stellar masses are from Tremonti et al. (2004).

Low-mass high-metallicity galaxies

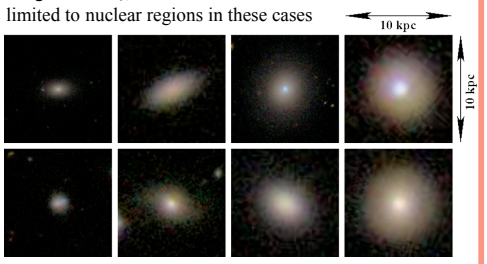
- Undisturbed morphologies
- Relatively isolated environments
- Approaching or on red sequence
- Relatively low gas fractions probably cause of observed high oxygen abundances ⇒ running out of star forming fuel ⇒ probably transitional galaxies nearing end of star formation
- See **Peeples, Pogge, & Stanek 2008; ApJ in press; arXiv:0804.2647**

High-mass low-metallicity galaxies

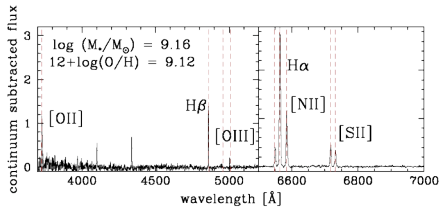
- Almost all appear to be mergers or post-mergers
- Very blue; high specific star formation rates
- Observed low abundances probably result of relatively low-metallicity gas funneled into galaxy centers during merger
- Look for upcoming Peeples et al. (2008) paper on astro-ph

Morphologies of high-metallicity low-mass outliers

- Smooth, undisturbed, compact
- Occasional blue and/or bright core (see top two rightmost images below); other studies indicate star formation is limited to nuclear regions in these cases

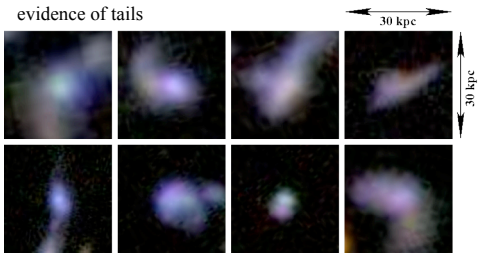


Sample spectrum used to verify O/H is relatively high:

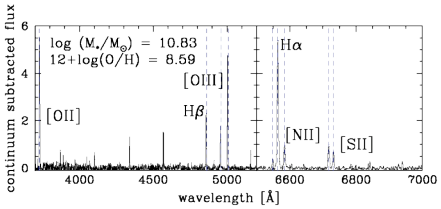


Morphologies of low-metallicity high-mass outliers

- Strongly interacting, merging, or post-merging systems
- Some double-nuclei seen; more compact galaxies show evidence of tails



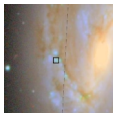
Sample spectrum used to verify O/H is relatively low:



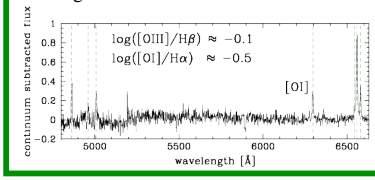
Eliminating contamination

SDSS DR4 is a large sample; not all of the outliers from the mass–metallicity locus are galaxies with truly extreme metallicities for their mass and luminosity. A large percentage of the contaminating objects are sources which have been misidentified as star-forming galaxies. We also require our outliers to also be outliers in the more directly observable 12+log(O/H) v. M_z, M_g, and M_B planes.

Right: At low masses, HII regions misidentified as individual galaxies are a large source of contamination.

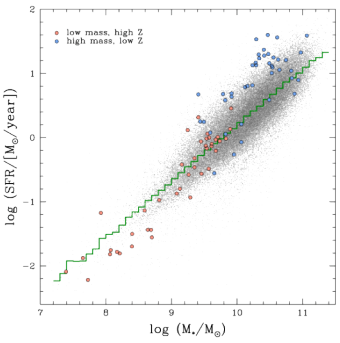


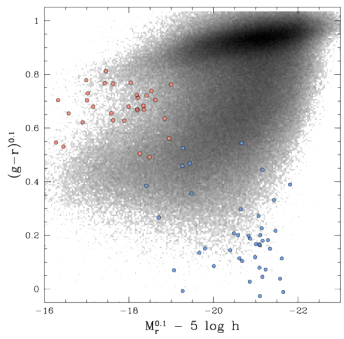
Below: At low metallicities, low-level AGN (as indicated by strong [OI]λ6300 emission) are a significant contamination source:



Star Formation Rates and Integrated Colors

Right: Star formation rate (SFR) v. stellar mass; the grey points are the star-forming galaxies from SDSS DR4. The green histogram denotes the median star formation rate in bins of stellar mass. The low-mass high-metallicity galaxies are denoted in pink and the high-mass low-metallicity outliers are denoted in blue. In general, the low-mass outliers tend to have lower than expected SFRs, while the high mass outliers have high SFRs for their masses. Star formation rates are from Brinchmann et al. (2004); stellar masses are from Tremonti et al. (2004).





Left: Color–magnitude diagram for the spectroscopic galaxy sample from SDSS DR6. The high-metallicity low-mass galaxies are denoted in pink and the low-metallicity high-mass outliers are denoted in blue. Many of the high-metallicity outliers are approaching or already on the red sequence, suggesting that these are indeed transitional galaxies. Conversely, the low-metallicity outliers are extremely blue, which is indicative of very little dust and is probably a result of their large star formation rates. The *k*-corrections are calculated using the low-resolution templates of Assef et al. (2008).