It’s a Zoo Out There: Utilizing the Galaxy Zoo Morphological Classification Results in Conjunction with the Sloan Digital Sky Survey

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Abstract
Within the results of the Sloan Digital Sky Survey (SDSS)’s Data Release 7, a group of faint red galaxies has been found to exhibit enhanced clustering on small scales. Recent evidence suggest that these are satellites clustering in the outer, massive halos of galaxy clusters, but photometrically these satellites behave differently from both bright red and faint blue galaxies. These faint red galaxies are especially disky for similarly-colored ellipticals, with their Sersic index and shape suggesting the presence of small structures seen usually in spirals; they consistently display characteristics that fall between the traditional red elliptical and blue spiral galaxies, and we believe them to be a morphological transition phase. Using the quantitative traditional red elliptical and blue spiral galaxies, and we believe them to be a morphological transition phase. Using the quantitative classification results might be skewed in favor of elliptical classifications, due to the public’s inexperience with the system and features becoming much harder to discern in faint galaxies. While we can say more about our sample after this, more work is necessary to determine whether anything meaningful can be extracted even with the skewed classifications.

Methods and Results
- \textbf{200,000 galaxies in common between GZ and SDSS}
- Matched by their position data and SDSS identification numbers
- Initial analysis based on user classifications as either smooth (traditionally elliptical), or a disk with features (spiral or other disk type), or if there was no consensus. Consensus was regarded as an agreement of 75% or more users
- Also data regarding presence of a bar or a bulge, spiral arms, etc.

Figure 1: Zehavi and Janowiecki, showing the observed clustering correlation function vs the scale of separation for the entire sample of galaxies separated by magnitude.

Figure 2: Zehavi and Janowiecki, showing the observed clustering correlation function vs the scale of separation for only the red galaxies of the sample.

Population definitions:
- Red: \((M_g - M_r) \geq 0.21 - 0.03 M_r\)
- Blue: \((M_g - M_r) < 0.21 - 0.03 M_r\)
- Dim red: \(M_r \geq -19\), Red (\(M_g - M_r\))
- Dim blue: \(M_r \geq -19\), Dim (\(M_g-M_r\))
- Bright red: \(M_r < -21\), Red (\(M_g-M_r\))

Figure 3: SDSS image examples of galaxies within each of our population samples.

Figure 4: Color-Magnitude diagram for each of the general classifications; left: ellipticals; middle: spirals; right: no consensus reached. Of interest are the fork in the spiral classification extending into the dim red section, and the large spread of the (also-bimodal) galaxies lacking consensus.

Figure 5: Normalized histogram of the GZ responses to the question of whether each galaxy was “smooth.” The vast majority of agreement is after about 75%, suggesting that we did select a good cutoff for the certainty qualification.

Figure 6: Normalized histogram of the GZ responses to the question of whether there is something “odd” about each galaxy.

Conclusions
- The difference between the volume-cut sample and the redshift-cut sample is obvious in the color-magnitude diagram – both faint and bright objects are discriminated against by either the flux limit (faint objects fall off faster) or the redshift limit (most bright red galaxies are very far away), so the shape is different from the complete SDSS sample used to generate the color-cutting criteria.
- The classification results might be skewed in favor of elliptical classifications, due to the public’s inexperience with the system and features becoming much harder to discern in faint galaxies.
- While we can say more about our sample after this, more work is necessary to determine whether anything meaningful can be extracted even with the skewed classifications.

Figure 7: Steinmetz et al simulation of spiral galaxy formation, showing the slow accretion of smaller objects over time.

Figure 8: “Grand Design” spiral Andromeda in different wavelengths, showing regions of star formation within the arms.

Figure 9: Mihos et al simulation of the formation of the Cartwheel Galaxy, one of many examples seen of a merger.

Figure 10: SDSS images used to teach GZ users, featuring a blue spiral, a red disk, and a red elliptical.

References
- Zehavi et al 2011
- Please see senior project paper for additional references on the topic.

Acknowledgements and Contact information
Special thanks to Idit Zehavi, Steven Janowiecki, and Jason Davis. Using data from SDSS III DR7 and GZ 2.
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