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PhD Thesis Summary

The Formation and Evolution of M33 as Revealed by its Star Clusters

It is widely accepted that large disk galaxies derive from the merger and accretion of many smaller subsystems. However, it is less clear how low-mass spiral galaxies fit into this picture. The best way to answer this question is to study the nearest example of a dwarf spiral galaxy. M33, is the only nearby late-type spiral galaxy and provides a notable connection between the earlier-type spirals, and the numerous nearby later-type dwarf galaxies. I have used star clusters to understand the structure, kinematics, and stellar populations of this dwarf spiral. Star clusters provide a unique and powerful tool for studying the star formation histories of galaxies. In particular, the ages and metallicities of star clusters bear the imprint of the galaxy formation process. I have carried out a comprehensive study of the M33 star cluster system, including deep photometry as well as high signal-to-noise spectroscopy. I have undertaken a photometric survey for extended sources in a 1° x 1° area centered on M33 using the MegaCam camera on the 3.6m Canada-France-Hawaii Telescope. This study mitigates the incompleteness present in the current catalogs of star clusters in M33, especially in the outskirts of this galaxy. I discuss the photometric properties of the sample, including color-color diagrams of 599 new candidate stellar clusters, and 204 confirmed clusters. Analysis of the radial density distribution suggests that the cluster system of M33 has suffered from significant depletion, possibly due to interactions with M31. Additionally, I present the morphological properties of 161 star clusters in M33 using ACS/HST images. I found that the position angles of the M33 clusters show a bimodality with a strong peak perpendicular to the position angle of the galaxy. This evidence supports tidal forces as the reason for cluster elongation. Finally, I present high-precision velocity measures of a variety of M33 star clusters, based on observations from the 10.4m Gran Telescopio Canarias and 3.6m William Herschel Telescope. The velocity of the clusters with respect to local disk motion increases with age for young and intermediate clusters. Analyses of these velocities along the major axis of the galaxy show no net rotation of the intermediate age subsample. Based on the results of this thesis project, we can attribute the anomalies of this star cluster system to either tidal stripping of M33's clusters by M31, or a very different, much calmer accretion history of M33 than large disk galaxies.

Overall, the different nature of these projects has exposed me to a variety of observational techniques, from PSF and aperture optical photometry, to long-slit and multi-object spectroscopy. The ultimate goal of this dissertation is to increase our understanding of the galaxy formation process. However, the results from these research projects have being of essential relevance for many other areas in the field star clusters. For example, the mechanisms of cluster destruction are still not clear. There is no consensus regarding the amount of disruption observed or the role of cluster mass and environment in the process. One of the main problems lies in the difficulty of producing complete cluster samples in different environments. Since the star-formation rate in M33 is known to have been constant for the last ~1Gyr, the M33 star cluster system is ideal for constraining the disruption mechanisms of clusters, or for studying the initial mass function. This study contains the deepest and widest-field ground-based M33 star cluster catalog to-date and will help to resolve those questions.

M33 is just one example of a substantial population of nearby dwarf spirals. I want to lay the foundation for subsequent studies of other dwarf spiral galaxies in the Local Volume. Located just at ~4 Mpc, NGC 300, NGC 7793, NGC 2403, and IC 342 are candidates for studies that will yield important information. As a result, I will be able to directly compare the ages and metallicities of the stars and clusters in these 4 Scd type galaxies. This will be the first time that the detailed constituents of a sample of dwarf spiral galaxies are compared in a self-consistent manner.

Derived Refereed Publication of this PhD Thesis:

1. Newly identified star clusters in M33: III. Structural Parameters
San Roman, I., Sarajedini, A., Holtzman, J. A. and Garnett, D. R., 2012, MNRAS, 426, 2427

2. Photometric Properties of the M33 Star Cluster System
San Roman, I., Sarajedini, A. and Aparicio, A., 2010, ApJ, 720, 1674

3. Newly Identified Star Clusters in M33. II. Radial Hubble Space Telescope/Advanced Camera for Surveys Fields
San Roman, I., Sarajedini, A., Garnett, D. R. and Holtzman, J. A., 2009, ApJ, 699, 839.

Publications in preparation:
4. Kinematics of M33 Star Cluster System
San Roman, I., Sarajedini, A., Aparicio, A. and Gallart, C. (expected submission Summer 2013)

5. Chemical abundances of M33 Star Cluster System
San Roman, I., Sarajedini, A., Aparicio, A. and Gallart, C. (expected submission Summer 2013)

This thesis work has been nominated as an outstanding contribution and has now been published in Springer Thesis Series. Springer Theses – the "best of the best": Internationally top-ranked research institutes select their best thesis annually for publication in this series. Nominated and endorsed by two recognized specialists, each thesis is chosen for its scientific excellence and impact on research.

In addition, this work was awarded with the 2012 Rodger Doxsey Prize, Honorable Mention, by the American Astronomy Society (AAS) based on the scientific merit of the dissertation research

PhD Thesis Document: http://www.astro.ufl.edu/~izaskun/Sanroman_thesis2012.pdf