Baby Stars Lost in Space:
Extragalactic Star Formation in the M81 Group

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Figure 1. The M81 Group, showing each of the fields from the GHOSTS Survey.
http://www.stsci.edu/hst/HST_overview/programs/ghosts_v2/ngc3031/ngc3031.html

ABSTRACT: A blue star population within a particular galaxy or galaxy group represents stars which are very massive, and very young (relatively speaking), and thus, studying this population can help to characterize where new stars are being formed in that group. Using data from the Galaxy Halos, Outer disks, Substructure, Thick disks and Star clusters (GHOSTS) survey (Radburn-Smith et al 2011 Astrophysical Journal Supplement Series, 195, 18) we sought to explore a particular distribution of blue stars of the M81 group, which is made up primarily by the M81, M82, and NGC 3077 galaxies. While we were studying the 28 "fields" of data that were taken around M81–mostly along its major and minor axis–we mapped the blue stars of this galaxy (at least, those which fell within the GHOSTS fields) and, after plotting the blue star distribution of the group, we identified numerous blue stars in several regions not expected to host new star formation, under the current understanding of galactic evolution. Using additional tools including isochrones and synthetic stellar populations, we verified that the observed objects could reasonably be interpreted as blue stars.

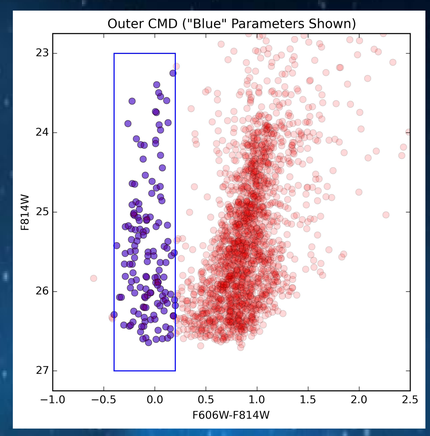

Figure 2.
This plot is a color-magnitude diagram of all of the "outer fields" that were imaged using Hubble's ACS (the WFC3 fields were determined to contain less reliable data for this endeavor); that is, fields 08, 14, 16, 17, 20, 22, 24, 26, and 28. The box shown outlines the constraints set in order to define what a "(bright) blue star is." Stars which have a f606−f1814 value between −0.4 and +0.2 (this is a characterization of a star's colour, based on a comparison two filter values), and which have a f814 value between 23 and 27 (this is a characterization of a star's magnitude using one filter) are considered "bright blue," and are the stars that we focused on throughout this endeavor.

OBJECTIVES

Initially, we sought only to determine whether there were any abnormalities in the distribution of blue stars in the M81 Group. Upon finding such abnormalities, we then set out to determine the cause of the unexpected star formation, as well as to determine whether this was predictable under the current model of stellar evolution.

STELLAR SURPRISE

This research endeavor began by analyzing computer imaging data from the the GHOSTS survey, using IPython Notebooks. By choosing parameters to define "Blue Stars" within the M81 group (as shown with the blue box in the colour-magnitude diagram above), we were able to sort through this data and to plot only the stars which fit our chosen parameters on a Right Ascension vs. Declination plot of the entire M81 group. Looking at this plot, there were some datapoints that were surprising. The plot suggested that there were blue stars (and therefore *new* stars) located at extreme distances from the bodies of any of the three nearby galaxies. These surprising data points are those shown on the large image to the left.

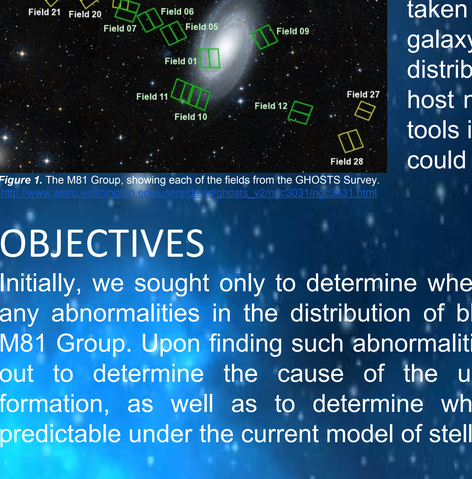

Figure 4. Isochrone overplot of color-magnitude diagram for the stars in the observed fields.

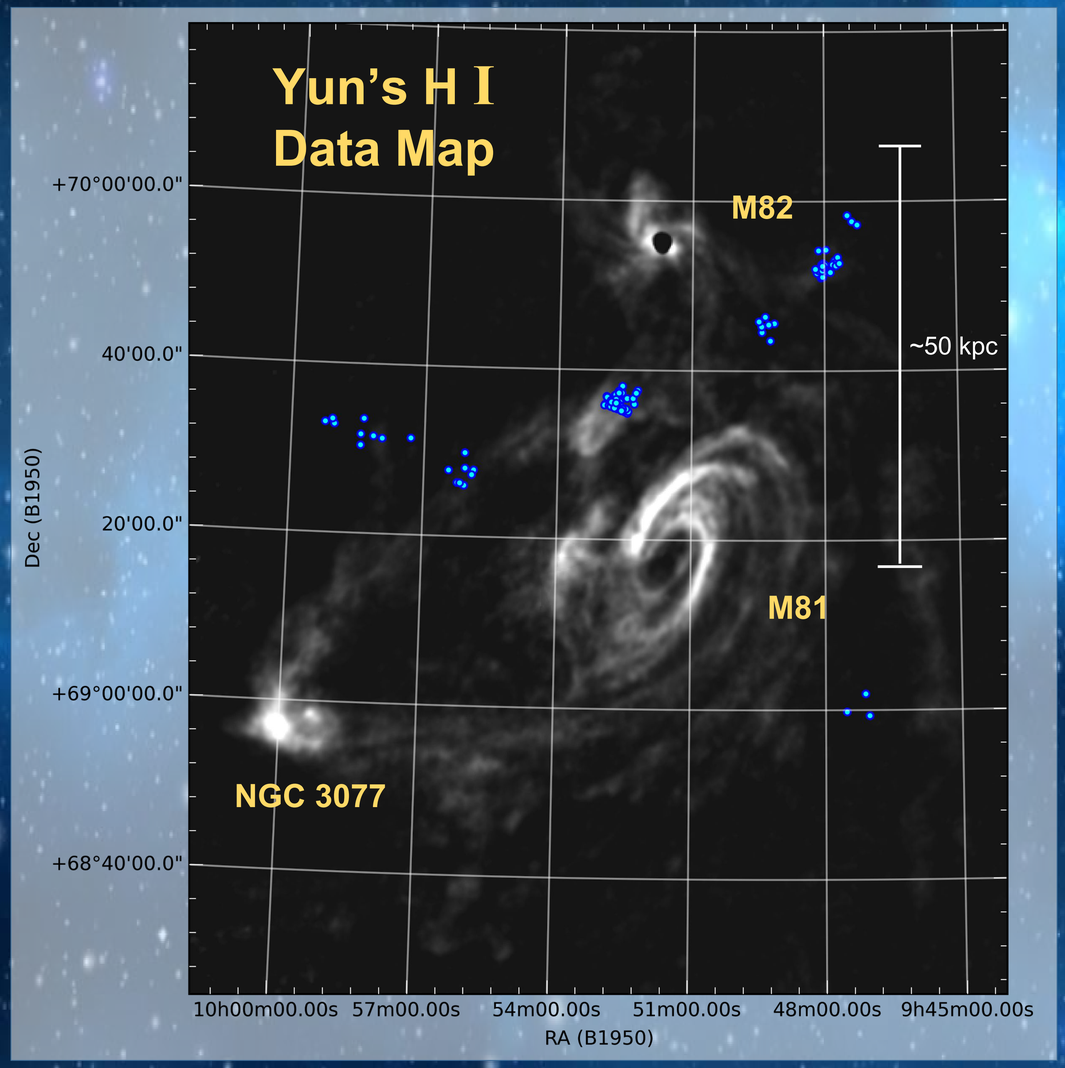

Figure 3 (Right). This is a map of the H I data from the Yun study with the blue stars of the outer fields overplotted. Not that with the M81 group at a distance of about 3.6 Mpc, in this image 1 arcmin ≈ 1 kpc.

ISOCHRONE CONFIRMATION

A number of isochrones were plotted over the stars from the observed HST GHOSTS fields, and the image to the left demonstrates that the observed stars in these fields fall within the bounds of expected blue giant and RGB stars. Because the overplot shows the isochrone's stars and the observed stars inhabiting the same region, we were able to assume that the observed data points were, in fact, the type of stars for which we were searching.

HYDROGEN CLOUDS

After comparing the reported locations of the blue stars to the plots of neutral Hydrogen clouds (H I) from the 1994 Yun paper, there appeared to be a possible solution to the mysterious blue stars. By overlaying these two plots (shown left), we were able to indeed see how the H I clouds might be responsible for previously unknown stellar formation on the outskirts of the M81 system.

CONCLUSIONS

- With the chosen parameters defining a "bright blue" star, there appear to be several pockets of such stars present in the M81 Group quite distant from any of the major galaxies it contains.
- There are "tidal bridges" of H I stretched between these galaxies which have features that include small branches and independent clouds.
- The locations of the pockets of blue stars coincide with higher density regions of the H I cloud structure, which indicates that the H I clouds may be dense enough to support significant stellar formation, at enormous distances from any of the galaxies in the M81 group.
- These H I bridges are believed to be the sites of stellar growth and development, in excess of the anticipated amount, based on the findings of prior observations.
- Data analysis using isochrones and synthetic stellar populations appears to match the observed data, indicating that this star formation is in agreement with our current understanding of stellar formation and evolution.

REFERENCES

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