Young and Intermediate Age Globular Clusters in the Early-type Post-Starburst Galaxy, AM 0139-655
Aparna Maybhate (STScI), Paul Goudfrooij (STScI), Thomas Puzia (STScI), François Schweizer (Carnegie Observatories) and David Carter (LJMU)

Abstract
Using deep HST/ACS images, we study the globular cluster system of the elliptical galaxy, AM 0139-655 (PGC 6240). We present evidence for the presence of three distinct subpopulations of globular clusters in this galaxy: a centrally concentrated young population (~0.4 Gyr), an intermediate-age population (~1 Gyr) and the old, metal-poor population. Interestingly, the brightest shell harbors some of the youngest clusters observed. This seems to indicate that the same merger event was responsible for the formation of both the shells and the young GCs.

Introduction
The globular cluster systems of many giant ellipticals show bimodal color distribution, indicating the occurrence of a second event of cluster formation in these systems. The merger model suggests that metal-rich clusters are formed during the major mergers of gas-rich galaxies [1,2]. Mergers leave their imprints on the morphology of the remnant in the form of shells, tidal tails, ripples, etc. These galaxies are good laboratories to test if these events were accompanied by any cluster formation. We study the early-type shell galaxy, AM 0139-655. It has several shells around the main body and an E+A spectrum [3]. The aim is to search for globular clusters in this galaxy and check for the presence of multiple populations and their correlations with the galaxy morphology.

Color Distribution
AM 0139-655 was observed with the WFC of ACS using the F475W and F814W filters. The images were combined using MULTIDRIZZLE. Source finding was done on an image obtained by combining the F475W and the F814W images. Various criteria based on the FWHM and the compactness of the source were considered in addition to the color to make the final lists of GC candidates.

The color distribution is bimodal with peaks at g-I = 0.85 and g-I = 1.35. The blue peak is bluer than that expected for the old metal-poor population. Comparison with Simple Stellar Population (SSP) models [4] show that these could be young, metal-rich clusters of age ~0.4 Gyr. The redder peak corresponds to the old, metal-poor clusters.

The blue clusters are more centrally concentrated as compared to the red ones. The brightest shell associated with this galaxy lies about 15 kpc to the East of the galaxy center. It harbors 7 clusters, all of which lie in the color range 0.70 < g-I < 0.91 (and hence ages 0.25-0.4 Gyr). Thus, it appears that all the clusters in this shell were formed during the latest burst of star formation. It seems likely that the event responsible for the shell formation also gave rise to the young GCs.

Luminosity Functions
We studied the luminosity functions of the blue and the red clusters separately. The LF of the blue clusters could be fit by a power law with index ~ -1.8, as expected for young clusters. However, contrary to what is expected for the old clusters, we could not fit the LF of the red clusters by a single gaussian. In addition to this, the red peak in the color distribution has a broad tail. Since clusters of solar metallicity with ages in the 1-2 Gyr range would have g-I colors similar to those of the old metal-poor population, we checked for the presence of multiple subpopulations in the red cluster distribution. As we have no information about the nature of the progenitors in the merger, we test for a range of typical specific frequencies from that of ellipticals (S_e=3) to late-type spirals (S_e=0.5) [5]. We estimate the contributions from the old population for each value of specific frequency, fit them by a gaussian and subtract them. Interestingly, we find that the residuals can be fit quite well with power laws with an index between -1.7 to -1.8. Hence, the red cluster distribution has contributions from an old, metal-poor GC population and an intermediate age (1-1.5 Gyr) metal-rich GC population.

Summary & Conclusions
- Analysis of deep ACS images of AM 0139-655 reveals a rich population of GC candidates.
- The g-I color distribution of the clusters shows two distinct peaks at 0.85 and 1.35, corresponding to the young metal-rich population (age ~0.4 Gyr) and the old metal-poor population (age ~14 Gyr) respectively.
- The luminosity function of the blue clusters can be fit by a power law of index ~ -1.8.
- We model the luminosity function of the red clusters as a combination of the old clusters with a gaussian distribution and a younger, intermediate age population with a power law distribution (index ~ -1.7 to -1.8) and hence show that the red cluster LF is a result of two separate GC populations formed at distinct epochs.
- The ages of the young and intermediate age populations are younger than or comparable to the expected lifetimes of the shell structures formed during the merger. Also, the brightest shell contains only blue clusters, indicating that the same merger event could have been responsible for the formation of both the shells and the younger GCs.

References

Acknowledgements
Support for this work was provided by NASA through grant number GO-10227 from the Space Telescope Science Institute.