Substructure in the Globular Cluster Populations of the Virgo Cluster Elliptical Galaxies M84 and M86

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Introduction

Hierarchical galaxy formation suggests that massive galaxies formed through continuous merging and accretion of smaller proto-galaxies. In this paradigm we expect the structure of the globular cluster systems of massive galaxies to reflect the complex accretion history of heirarchical galaxy formation. We have carried out a search for substructure within the globular cluster systems of M84 and M86, two giant elliptical galaxies the Virgo Cluster, using Kernel Density Estimation to emphasize anomalies in the spatial positions of the globular clusters within these systems.

Observations

- Data obtained using the Mosaic imaging camera on the Mayall 4-meter telescope
- Globular cluster candidates are classified by the following criteria: they are point sources, have magnitudes of V > 20, and are within 3-σ of the V-R vs. B-V color-color relation for Milky Way clusters
- 2250 globular cluster candidates were identified within the field

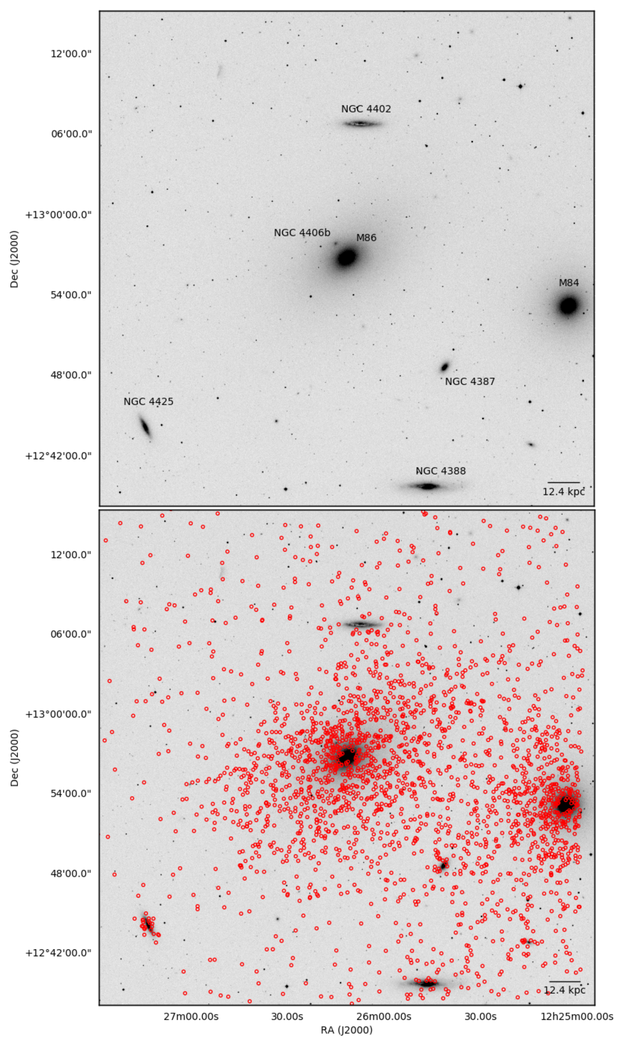

Fig 1: Upper Panel – A Digitized Sky Survey image of the field of view. Lower Panel – The same field with our sample of 2250 globular cluster candidates plotted on top of the image.

Estimating Surface Density

- Surface densities of the globular cluster systems were estimated using Kernel Density Estimation, with a Gaussian kernel of width 0.86 arcminutes.
- Iso-density contours have been added to emphasize surface density features.

Surface Density Map of Field

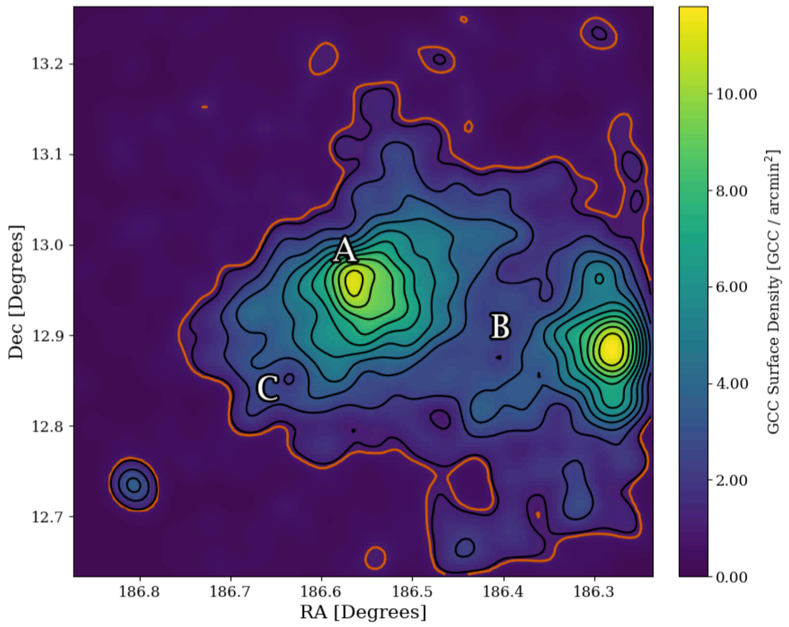

Fig 2: The estimated globular cluster candidate surface density within the field. The orange line encompasses the region where surface densities are larger than 99% of all simulated background fluctuations.

Interesting features in Figure 2 include:

- A globular cluster candidate surface density peak that is offset from the M86 globular cluster system center, marked with an **A**. This peak coincides with the spatial position of NGC 4406B, a dwarf elliptical galaxy that has been shown to be interacting with M86 (Elmegreen et al. 2000).
- A high surface density bridge between the M86 and M84 globular cluster systems, marked with a **B**.
- A flattening of the iso-density contours along the southeast side of the M86 globular cluster system, marked with a **C**. This feature shares the same general shape and position as a low-surface brightness substructure found by Mihos et al. (2017).

References and Acknowledgements

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- Elmegreen, D.M., et al., 2000, AJ, 120, 733
- Ko, Y., et al., 2017, ApJ, 835, 212
- Mihos, J.C., et al., 2017, ApJ, 834, 16
- Park, H.S., et al., 2012, ApJ, 757, 184

Kinematics of Clusters in the Field

- Combined the radial velocity data of globular clusters in our field from 2 surveys, Ko et al. (2017) and Park et al. (2012).
- Both surveys have a combined total of 118 globular cluster radial velocities across our field of view.

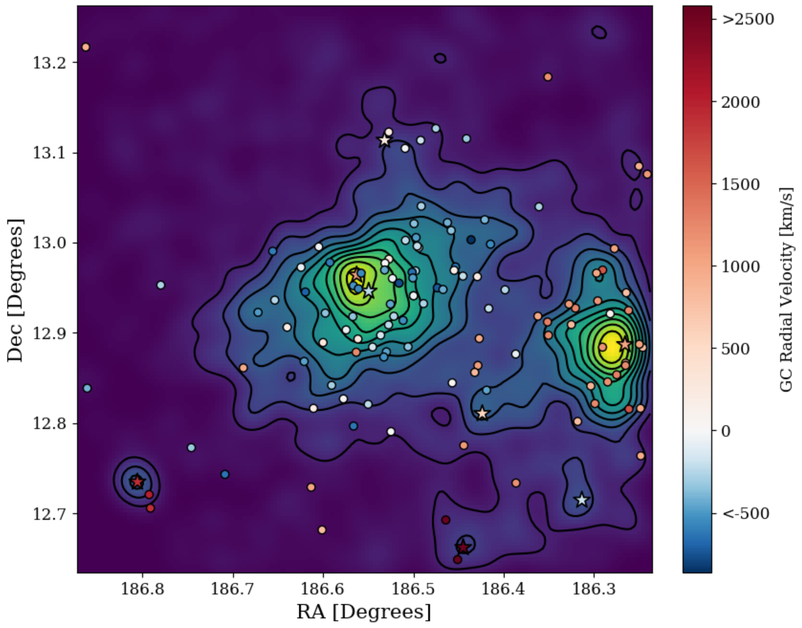

Fig 3: The spatial positions of globular clusters with radial velocities in our field. Globular clusters are represented by circles with colors representing their radial velocity. Galaxies in the field are represented by stars with colors indicating their measured radial velocity.

- There are clusters with a mix of radial velocities located in the bridge between the M86 and M84 globular cluster systems, suggesting it is populated by globular clusters from both galaxies or intracluster globular clusters.
- Clusters with radial velocities consistent with M84 are present across the field, including within the M86 globular cluster system and to the south of the M86

Conclusions

- We find evidence for tidal interactions disrupting the expected morphology of the M86 globular cluster system.
- There is a peak in the globular cluster surface density that is offset from the M86 globular cluster system center. This peak coincides with a dwarf elliptical that has previously been shown to be interacting with M86.
- A high globular cluster surface density bridge connects the M86 and M84 globular cluster systems. Examination of globular cluster radial velocities in the field reveal this bridge is populated by clusters with radial velocities consistent with either M86 or M84, suggesting a possible intracluster globular cluster population.
- We recover a substructure along the southeast side of the M86 globular cluster system that was previously reported in a paper searching for low-surface brightness substructures within the Virgo Cluster.