Stellar Populations in Simulated Galaxy Clusters

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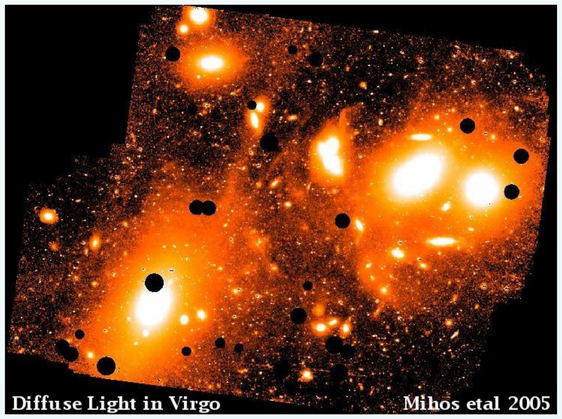
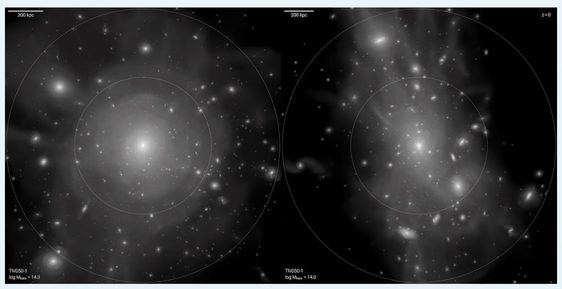
Main Idea

- Use simulations to better understand the formation of intracluster light and provide and evolutionary context for the information coming from the Hubble Space Telescope (HST) in its study of the Virgo Cluster ICL
- Dr. Mihos and his collaborators will be receiving HST observations Virgo Cluster ICL in the following year. This work is being done in preparation for analyzing and understanding that data



Introduction and Background

Galaxy clusters are dynamic regions where interactions and mergers between galaxies frequently take place. This process removes stars from their host galaxies relegating them to the intra cluster space. These stars are still gravitationally bound to the cluster but are no longer part of any galaxy, forming the intra cluster light (ICL). The process of forming galaxy clusters occurs over extremely long timescales that are not observable. Since the ICL stars are closely tied to the formation process of the cluster, so studying the properties of the ICL can reveal what formation processes took place. Properties of the ICL stars such as color, chemical composition, and age are very important for studying the formation of the ICL and how far along in the evolutionary process a cluster is.

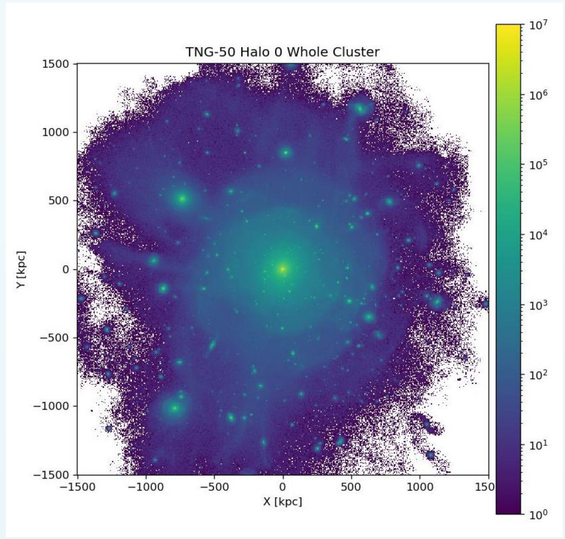


Studying the ICL of galaxy clusters with telescopes is challenging due to observational constraints with resolving individual stars. Telescope observations also only give a 2D image of the cluster making a lot of information very hard or impossible to determine. Simulations include every piece of information for every particle within it, allowing the ICL to be studied in detail. Using the Illustris TNG simulations which model galaxy formation the properties of ICL stars can be studied and used to better understand observational results.

Steps/Methods

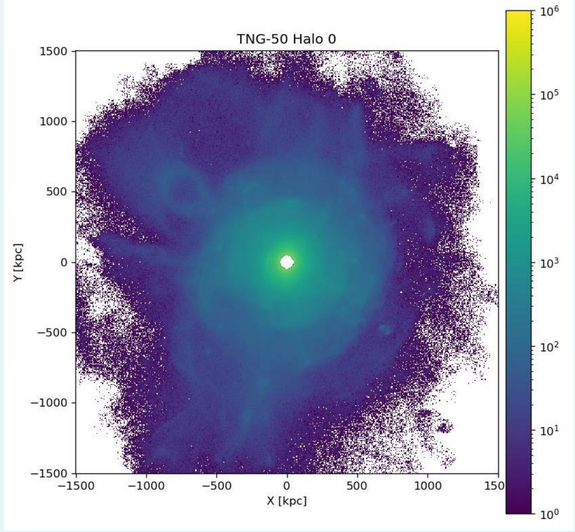
1.Understand the data from the simulations. Learn how to download and work with it

a. TNG-50 simulation was selected because it has the best resolution and allows individual particles to be analyzed in detail
b. Within TNG-50, Halo 0, the largest galaxy cluster at redshift zero (current time) was chosen since it has a total mass closest to the Virgo Cluster
c. From Halo 0 information about the stars was downloaded only by taking the coordinates, age, chemical composition, density, and luminosity of each star particle



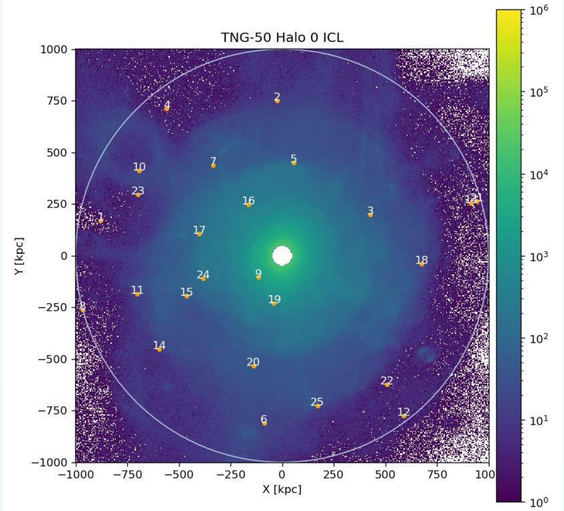
2. Remove galaxies from the TNG-50 Halo 0

a. TNG organizes the data in halos and subhalos. Halo 0 is the large galaxy cluster that contains hundreds of galaxies which are the subhalos.
b. The galaxies were removed by binning the Halo 0 data radially and cutting out any bins that are overly dense compared to the region around it, keeping only the ICL



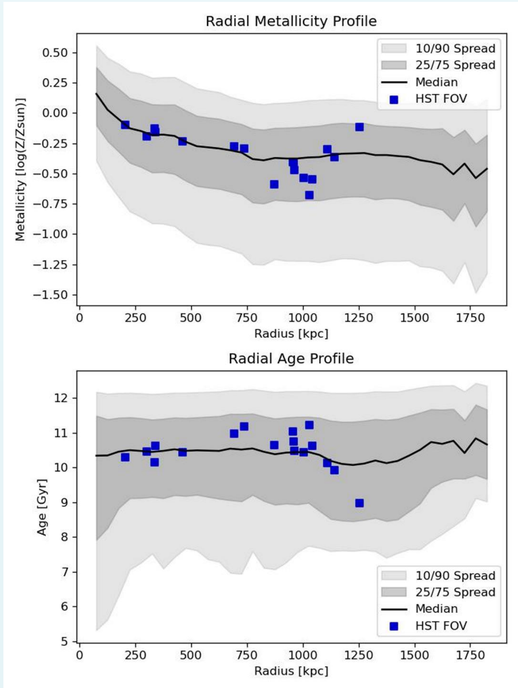
3. Write code that analyzes the cluster ICL in boxes the size of HST's field of view (FOV)

a. Hubble's ACS camera has an FOV of 202-by-202 arcseconds
b. Random coordinates throughout the cluster are chosen and a box is constructed around them with the area of the ACS FOV
c. The data in these boxes are then extracted and analyzed individually and in comparison to the total ICL



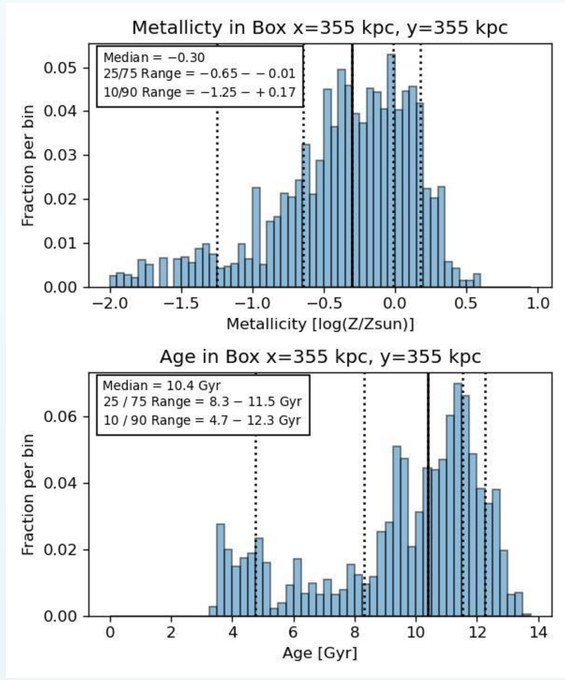
4. Use the simulated ICL data and ACS sized random boxes to learn about trends in the ICL's chemical composition and age

a. A radial chemical composition and age diagram are created, showing the overall radial properties of the ICL
b. Histograms of the individual boxes are constructed to view how properties between regions compare



Results

- The ICL stars are predominantly old (6-10 Gyr) and metal poor
- There is significant variation in stellar properties from field to field, with many of these variations able to be traced back to recent stripping events
- Within the radial profile and individual fields, a significant portion of the ICL stars are more metal rich than previous HST surveys of the Virgo Cluster has found indicating that metal rich stars may have been missed in earlier studies due to observational constraints.



Future Steps

Currently the information from simulations is being combined with ArtPop stellar population modelling to create mock HST and JWST color-magnitude diagrams of the ICL stars. These CMD models will help clarify the connection between observations and the true underlying intracluster star populations in galaxy clusters. Our goal is to develop a method that determines the age and chemical composition of the ICL stars from the mock observed CMDs, in preparation for HST imaging of the Virgo Cluster coming next year.

References

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