Tracking the Evolution of Simulated Galaxies

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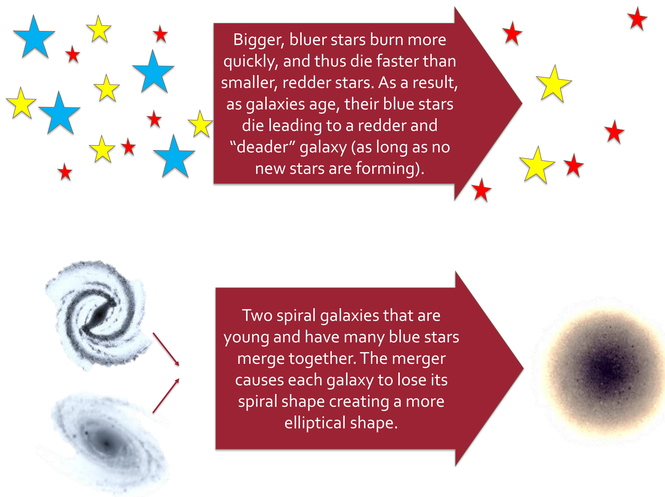
ABSTRACT

Galaxies can only be viewed from one perspective and at one moment in time and as a result, it is extremely difficult to study how they evolve in time. So, simulated galaxies are used to better understand these properties. One theory, which simulations can help us test, is that galaxies evolve from blue spiral galaxies to red elliptical galaxies. The simulated galaxies used in this research are created by evolving a mock universe through time in a supercomputer using known physics equations. Then, synthetic images of this simulated galaxy are produced using python code and the SUNRISE software. Once this is complete, we can analyze the images for properties such as the galaxy's color and shape, and track how the galaxy's color evolves throughout time. This will then allow us to return to the simulations to see what was physically happening-- a merger, star formation, etc.- in the galaxy's history that caused the change in color.

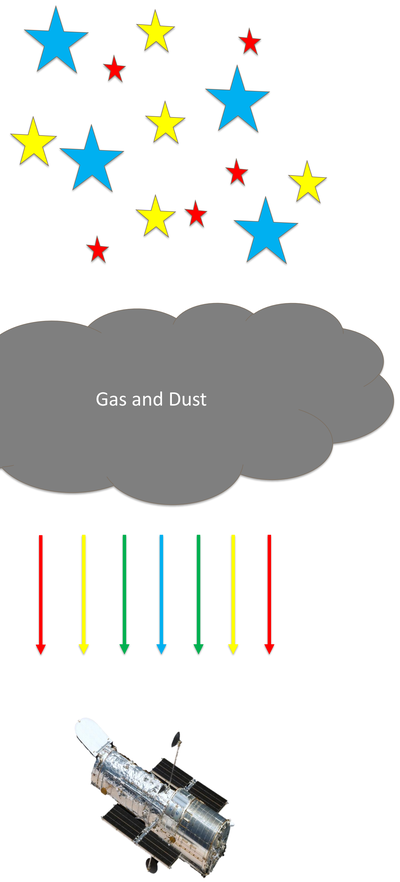
INTRODUCTION



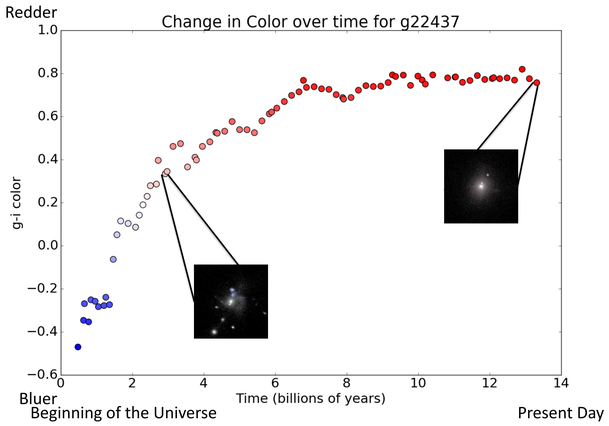
The combination of aging and mergers are what are believed to cause a blue spiral galaxy to evolve to a red elliptical galaxy. Because we cannot watch an entire star's lifetime, much less a galaxy's, we use simulations to model galaxy evolution to determine if our predictions are correct and if they align with the galaxies that we can observe in our universe.

METHODS

The diagram below represents how the SUNRISE software works. The first portion of SUNRISE, `sfrhist`, builds a time specific template of the galaxy. This information is then passed to the second step, `mcrx`, which determines how the light from the stars will interact with gas and dust. The final step, `broadband`, utilizes information from `mcrx` to create the images that would be seen through a telescope if these galaxies were observable. Accompanying data files are also created. After these files are created, a Python script is used to extract information from these files and create the plots shown to the right.



RESULTS



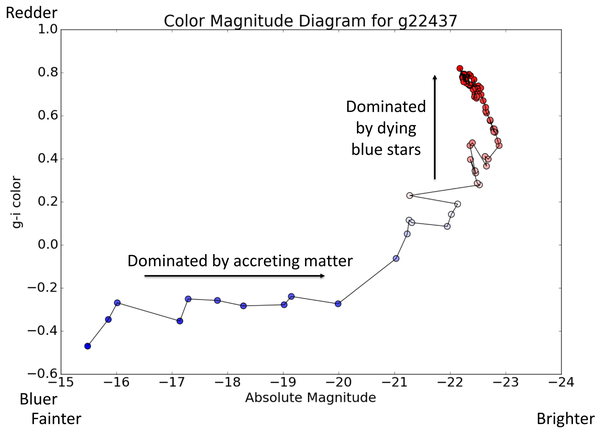


Figure 1 (Above):
shows the change in the galaxy's color over time (where the x-axis is in billions of years, and the final point is at present day). The images show a much more turbulent, bluer galaxy earlier in the galaxy's life, but a much more stable, red galaxy at present day.

"g" and "i" are each a filter used to extract information on the magnitude or brightness of the galaxy. Where "g" represents a 477 nm wavelength corresponding to the color green. "I" represents a 762.5 nm wavelength corresponding to the near infrared. The "g-i" value is representative of the color of the galaxy, by comparing the brightness of the galaxy in one color as compared to the other. This is also shown by the color of the markers on the plots

Figure 2 (Below):
The figure on the right portrays the color magnitude diagram for the galaxy. The black line traces the evolution of time. As the galaxy evolves, the galaxy accretes more mass, and as a result grows in brightness, as shown on the x-axis. Also, as the large blue stars die, the galaxy becomes redder, as shown on the y-axis.

CONCLUSIONS/SIGNIFICANCE

The plots created match the overarching theory regarding the evolution of a galaxy. Additionally, in the images created by SUNRISE, the evolution from a blue spiral galaxy going through many mergers towards a quiescent, red elliptical galaxy can be seen easily. This is confirmed in the plots that were created showing the evolution of the color of the galaxy over time. This information would suggest that theories surrounding galaxy evolution are correct. Additionally, the initial conditions defined to create such an accurate simulation must also be correct, thus giving us information regarding the environment in which galaxies form.

FUTURE WORK

There are a total of 16 MUGS galaxies, which will be analyzed in the same fashion as g22437. Additionally, using Sloan Digital Sky Survey Data, a direct comparison can be made between these simulated galaxies and observable galaxies. By comparing the 16 MUGS galaxies with observable galaxies, the initial conditions that observable galaxies were created in, and their evolution to present day can be analyzed, leading to a deeper understanding of galaxies.

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