Movement Through the Void

Purpose

We plan to show evidence of dark matter through observation of discrepancies between the predicted Keplerian galactic orbits and the corresponding real data. We hope to also investigate the distribution of this dark matter.

Abstract

The purpose of our project was to show evidence of dark matter through observation of discrepancies between the predicted Keplerian galactic orbits and the corresponding real data.

To accomplish this, we simulated galaxy dynamics using the programming language Python and the VPython module to run the visuals. Important parts of the program include a body class; acceleration due to gravity, movement from acceleration, and orbit velocity functions; and a Kuzmin disk system for generating random bodies. Combined, these and proper testing procedures led us to accurately simulate a randomly generated disk galaxy with accurate orbit velocities.

The data for this project was collected by observing the movement of the galaxy simulation visual and from the curve that showed how the velocities of bodies changed according to their radial location in the galaxy.

Ultimately, we found that our animation of the movement of our generated galaxy and its corresponding velocity graph accurately reflected current scientific research in the same realm as this project. The observed velocities curve reflected the "real world" velocities curve, and we could clearly see the difference in orbit velocities of outer stars as opposed to the inner ones. This accounted for the discrepancies mentioned earlier, and provided the evidence of dark matter we'd hoped to find.

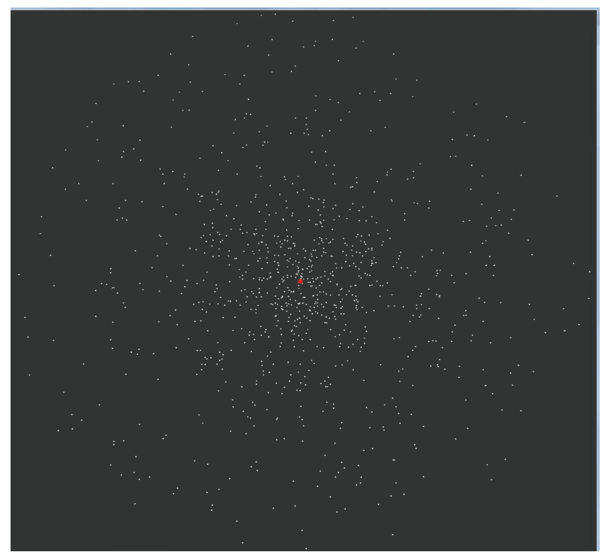
Methodology

Please note that for this entire project we wrote the code to analyze the data and build the model, it was not a downloaded or pre-written code of any form.

1. Create a body class
   a. the creation of a new class type will allow elegant and versatile code to created, and allow a simple way to save all data in a single place for each body
   b. storage of :
      i. mass
      ii. velocities
      iii. position
2. Simulate acceleration due to gravity Code
   a. will allow us to compute acceleration between two bodies over a timestep
3. Simulate movement from acceleration Code
   a. uses velocity stored in the body class to move the body a distance in a timestep
4. Combine steps 1 - 3 to move bodies in a timestep with gravity
   a. this will allow us to move bodies through gravitational fields and see realistic results
5. Test the system in step 4 by simulating the movement of the solar system
   a. use realistic masses and velocities to simulate movements and allow for troubleshooting
6. Create an orbit velocity function
   a. will allow the user to set the body velocity to an orbit velocity around a center mass
7. Create a Kuzmin disk system for generating random bodies
   a. utilize the Kuzmin disk equation to generate masses of disks which will then create the correct distribution of mass at the appropriate radii
8. Combine steps 1 - 7
   a. this will generate a random galaxy with the correct realistic input and set all the bodies to orbit correctly
9. Add animation for all the bodies and movement
   a. this will allow a video to be shown while the program is running via the VPython module
10. Render and plot the velocity curve
    a. add in functions to render the frames and measure the velocity at different radii
    b. this will allow us to visualize the data in galaxy form and in the form of a velocity graph
11. Write dark matter compensation code
    a. add in functions to figure out how much dark matter was needed
    b. create the dark matter needed
12. Plot the dark matter distribution

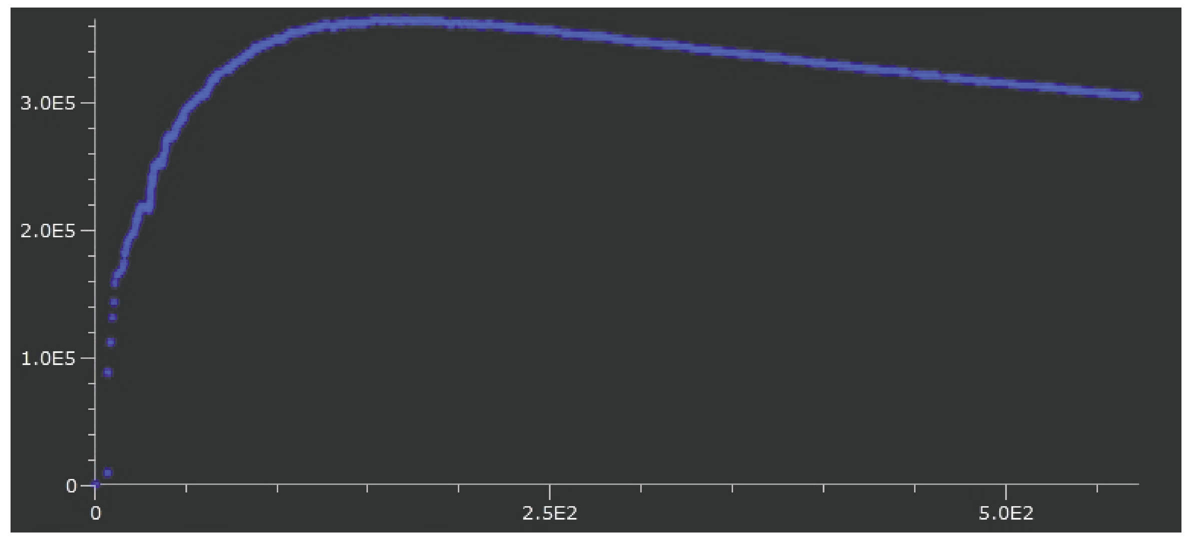
Data & Analysis

Original Render



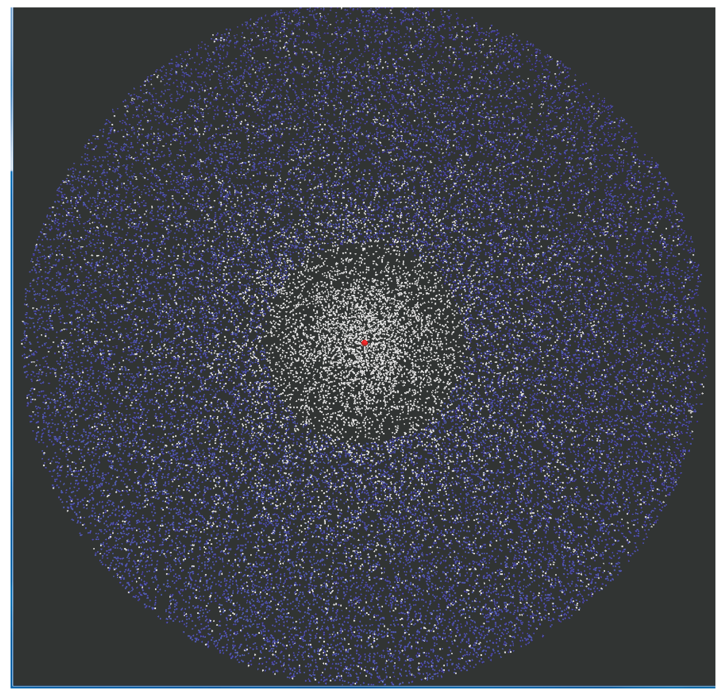
Rendering of 1000 body galaxy which we extracted the velocity curve from.

Original Velocity Curve



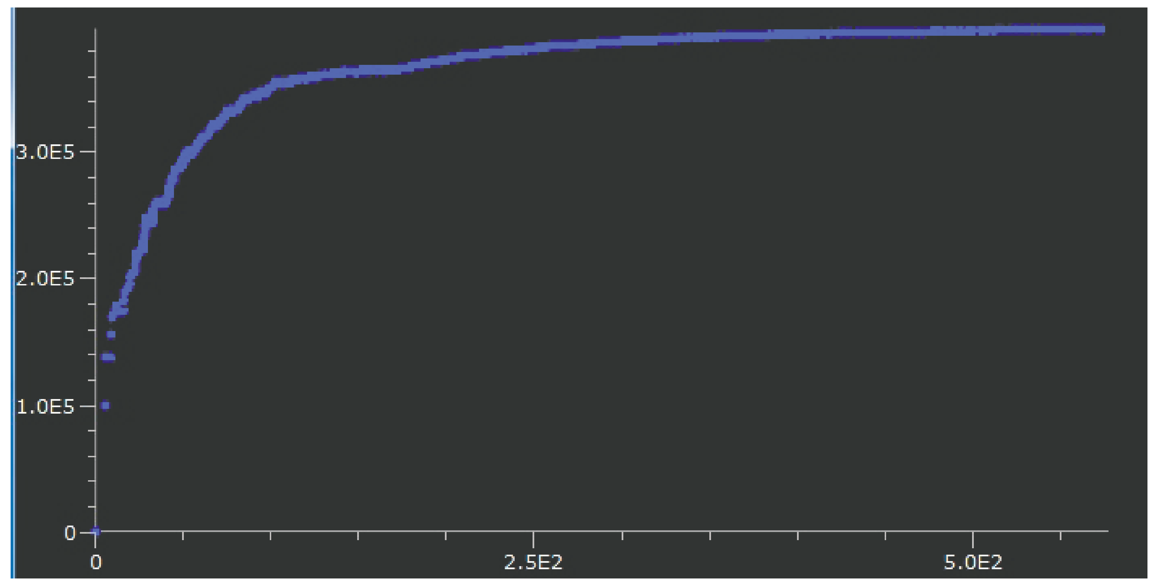
The velocity curve for the galaxy when no dark matter was present.

Dark Matter Render



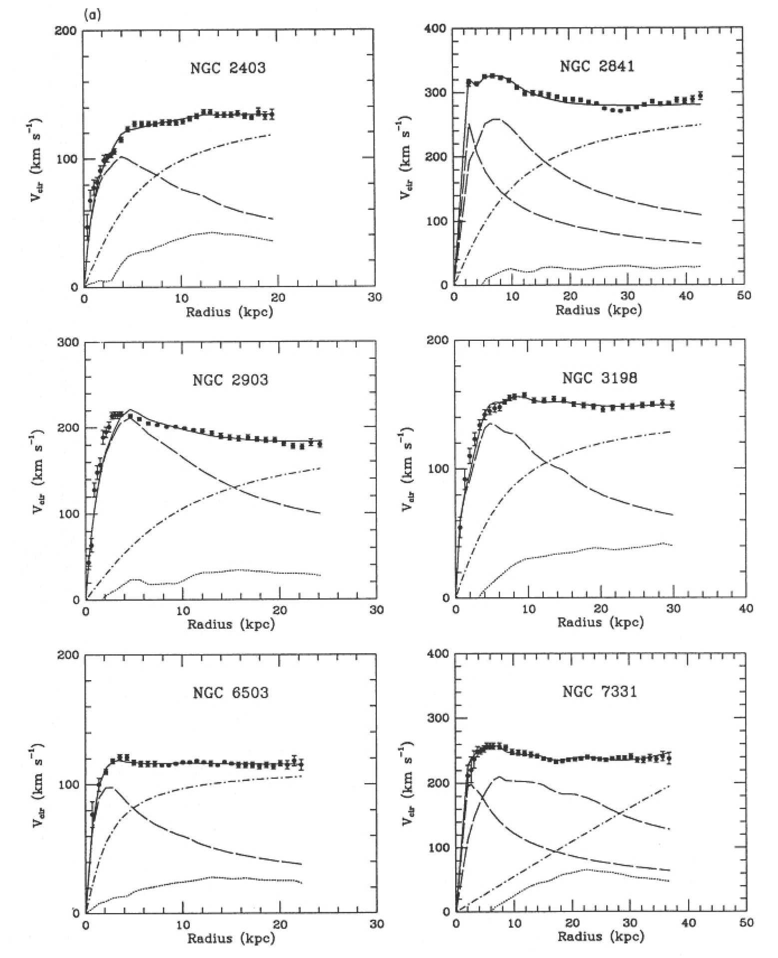
Rendering of 10 , 000 body galaxy with dark matter added

Corrected Velocity Curve

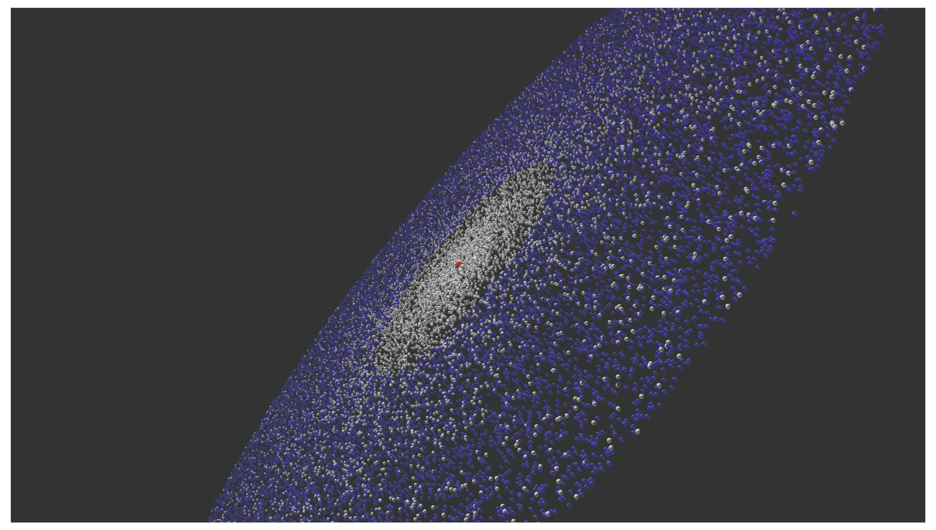


Tangential velocity vs. radial distance.
Velocity curve of the galaxy once dark mater was used to compensate for the lack of matter needed to raise the tangential velocity.

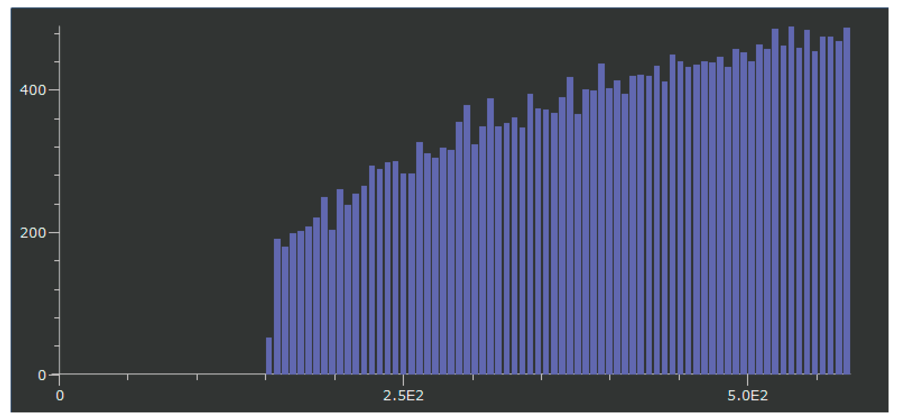
NASA ' s Data



Conclusions



Our models showed that there was a need for dark matter in galaxies, affirming our statement of intent. The models predicted the movement of stars within the galaxies accurately, according to the Keplerian model, while the real data contradicted the model, this gave us evidence for dark matter. These models were accurate the data collected from them matched professional work from NASA. The most significant takeaway was the difference in the velocity curves of galaxies. While our velocities began to fall shortly after the radius exceeded the dense central bulge of the galaxy, the real curve remains constant and does not taper off. This is astounding considering that once the radius is beyond a majority of the galactic mass, the velocity should decrease consistently. This proposes a new view of galaxies constructed of small amounts of visible matter, surrounded by immense clusters of dark matter that maintain the outer orbit velocities. From measuring this distribution we can observe that dark matter exists more frequently in outer regions of galaxies.



Dark matter vs. radial distance
This is the dark matter distribution that resulted from the simulation