Does Dark Matter Matter?

New Mexico Adventures in
Supercomputing Challenge
Final Report
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Executive Summary

I have created several computer models to test the validity of the Modified Newtonian Dynamics (MOND) theory, an alternative to the widely accepted dark matter theory. The MOND simply makes one small change to Newton's Law of Gravity that causes stars on the edge of a galaxy to speed up, while not affecting stars farther in. So far my models have done nothing except re-prove that the MOND physics do indeed show stars rotating at the speeds they do in the real universe. Another model that would test other aspects of the theory is still in progress.

Introduction:

For about 200 years the world has accepted Newton's law of gravity as an important, infallible part of physics; until recent years no evidence has been observed to contradict it. Contemporary observation of space, however, shows stars on the edges of galaxies rotating faster than Newton's second law of motion would predict. Could he have been wrong? Rather than admit anything of the sort, recent scientists have 'invented' a substance called Dark Matter. Allegedly, this matter makes up 90% of the universe, and can only be detected by its gravitational pull on other matter.

In 1983, another explanation to the rotational velocities issue was proposed by Mordehai Milgrom, Modified Newtonian Dynamics (MOND). Instead of taking Newton's laws on blind faith, Milgrom suggested that his second law may need a slight alteration. The gravitational pull of one object on another may become, for a very large distance, much stronger than expected.

Newton's Second Law of Motion:

$F=ma$ (Force=mass*acceleration)

MOND modified:

$F=m\mu(a/a_0)a$ (force=mass*μ(acceleration/critical acceleration)*acceleration)

$\mu(x)$ is a function that gives 1 when x is much larger than 1 and gives x when x is much smaller than 1:

$\mu(x)=1 \mid x>>1$

$\mu(x)=x \mid x<<1$

a_0, the critical acceleration, is a constant.

$a_0=1.2*10^{-10}\ ms^{-2}$

Using MOND, when the acceleration is smaller than a_0, the normal formula changes, causing increased rotational velocity for stars far from the center of a galaxy. Also, note that the speed of light divided by the approximate age of the universe equals a_0. So, if the speed of light started at zero and has been constantly accelerating at this rate, it would reach the speed it is now.

The modification causes the rotational velocity of stars on the edge of a galaxy to change as such:

Normal rotational velocity:
$V=(Gm/r)^{1/2}$ (Velocity=(Gravitational constant*mass/distance)^(1/2))

MOND (over very large distances):
$V=(Gma_0)^{1/4}$ (Velocity=(Gravitational constant*mass*critical acceleration)^(1/4))

m is the total mass of the galaxy.
r is the distance between the center of the galaxy and the star in question.
G is the gravitational constant:
$G=6.673*10^{-11}\ m^3kg^{-1}s^{-2}$

So, because the velocity under MOND is no longer divided by the distance, after a certain point the velocity of stars stops decreasing as the distance increases.

Description:

To test the validity of the MOND theory, I have attempted to create a working computer model of a galaxy using the modified second law of motion. Because of the limitations of the computational resources I have available, I just made a few mini-galaxies with 10-15 stars, some using MOND physics and some for comparison with standard Newtonian physics. The models with standard physics invariably were unable to hold themselves together due to the miniscule amount of matter in the galaxies. The MOND models, however, showed the stars orbiting one another in what appears to be a realistic manner.

I unfortunately am unable to thus far make a more realistic model due to the limitations of my programming knowledge and the hardware I have access to. Mainly, I simply cannot get even close to enough stars. The computational power needed increases proportional to the square of the number of stars, so even with my most high-speed model I could not have more than about 1000 and still be able to watch it move. A real galaxy would have billions of stars.

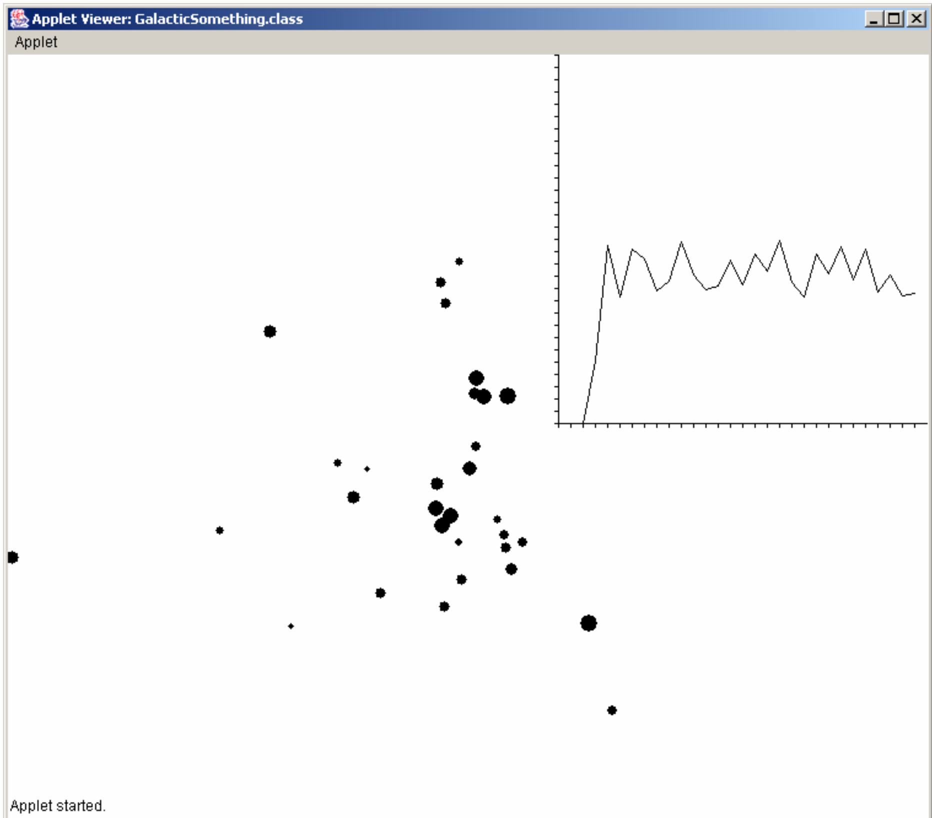
Another hindrance was the nature of the physics engine itself. Unable to make a continuous model, I had to compute the pull of stars in iterations. This forced me to either choose between fast program speed and many stars, or large and inaccurate program iterations and few stars. So, the model that does actually have 1000 stars is much less accurate.

Results

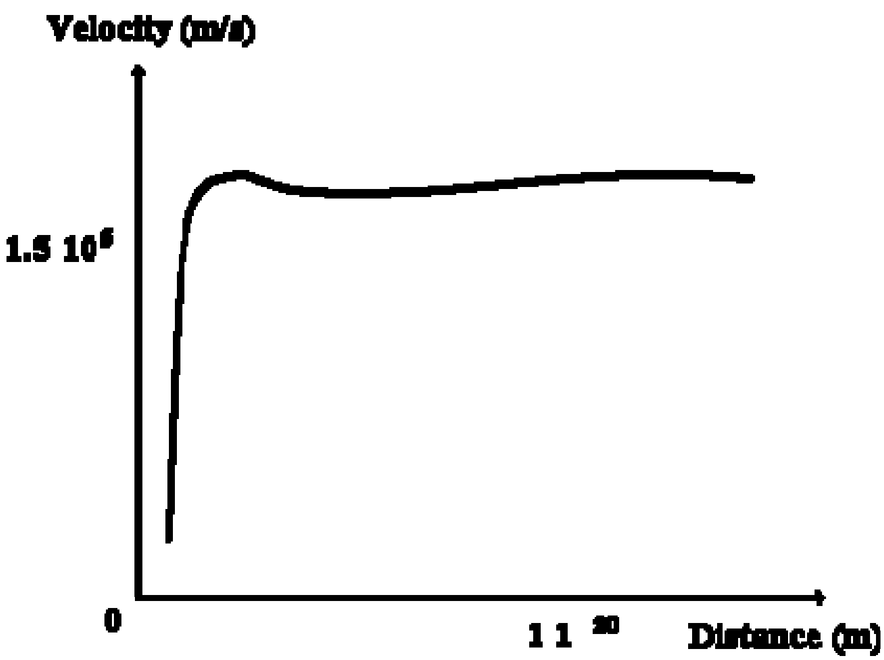
So far results have been rather inconclusive, owing to the aforementioned limitations. I have only observed from my models what others have already proved: MOND physics allows for the inconsistencies observed in rotational velocities. This can be seen in the Appendix. As to whether or not a galaxy with MOND physics will act in a manner parallel to what is observed in real galaxies, I have not yet determined.

As I continue to work on the project, I hope to develop a continuous model. Using calculus to integrate the velocity over the iteration period, I can allow the stars to continuously pull on one another, and have an even faster program speed. This way I could have a model that is not only fast enough to include more stars, but still more accurate than any model I have now. Then I should be able to compare the overall activity of a real galaxy to that of the model, and come up with conclusive evidence.

Appendix



screenshot of one of my programs and the associated velocity and distance graph



actual velocities observed

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