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Dark Matter in Our Galaxy

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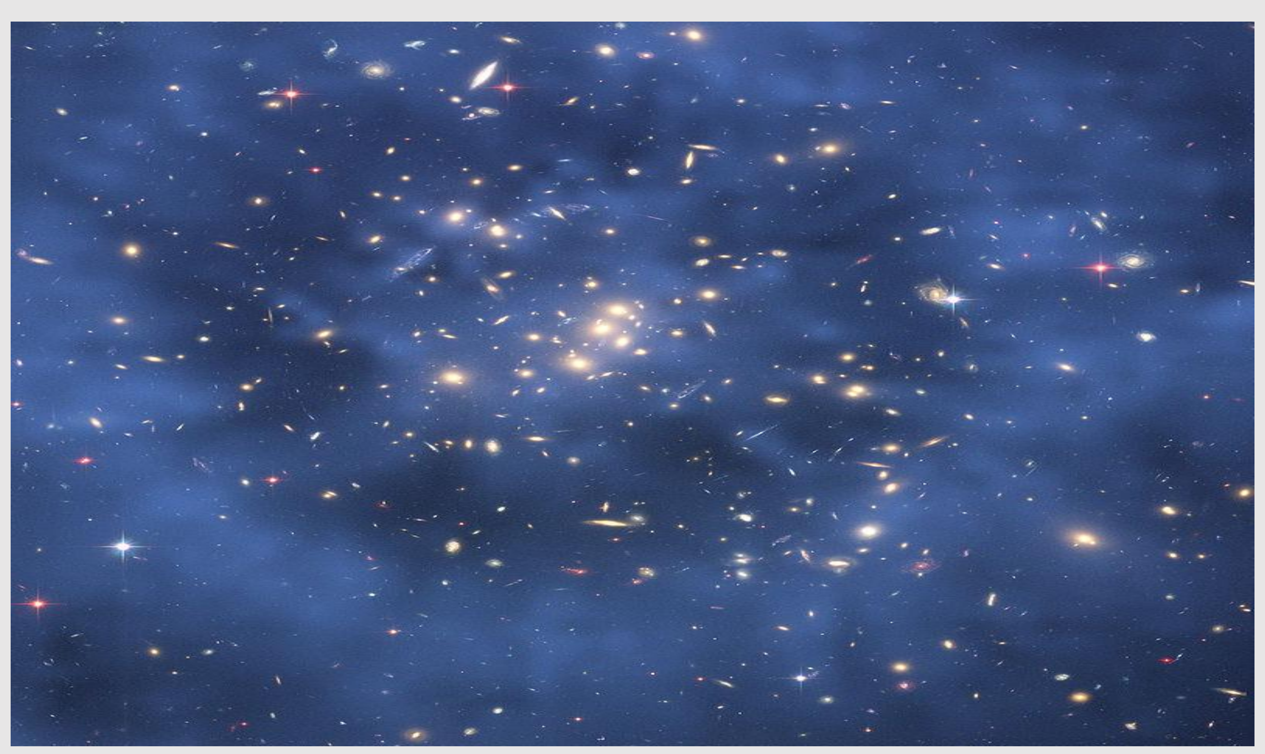
Abstract:
While at PARI with Duke TIP we were researching a topic in astrophysics. Our group, Oort and Zwicky, researched the effect of dark matter on our galaxy. We used multiple radio telescopes to gather the data we needed in order to answer the question. We eventually came up with a solution:

- There is dark matter in the Milky Way
- The flat rotational curve proves that velocity is proportional to distance from the galactic center in the Milky Way

Therefore, we can conclude that the mass needed to create the flat rotational curve observed is dark matter because there is not enough visible mass to account for the observed curve.

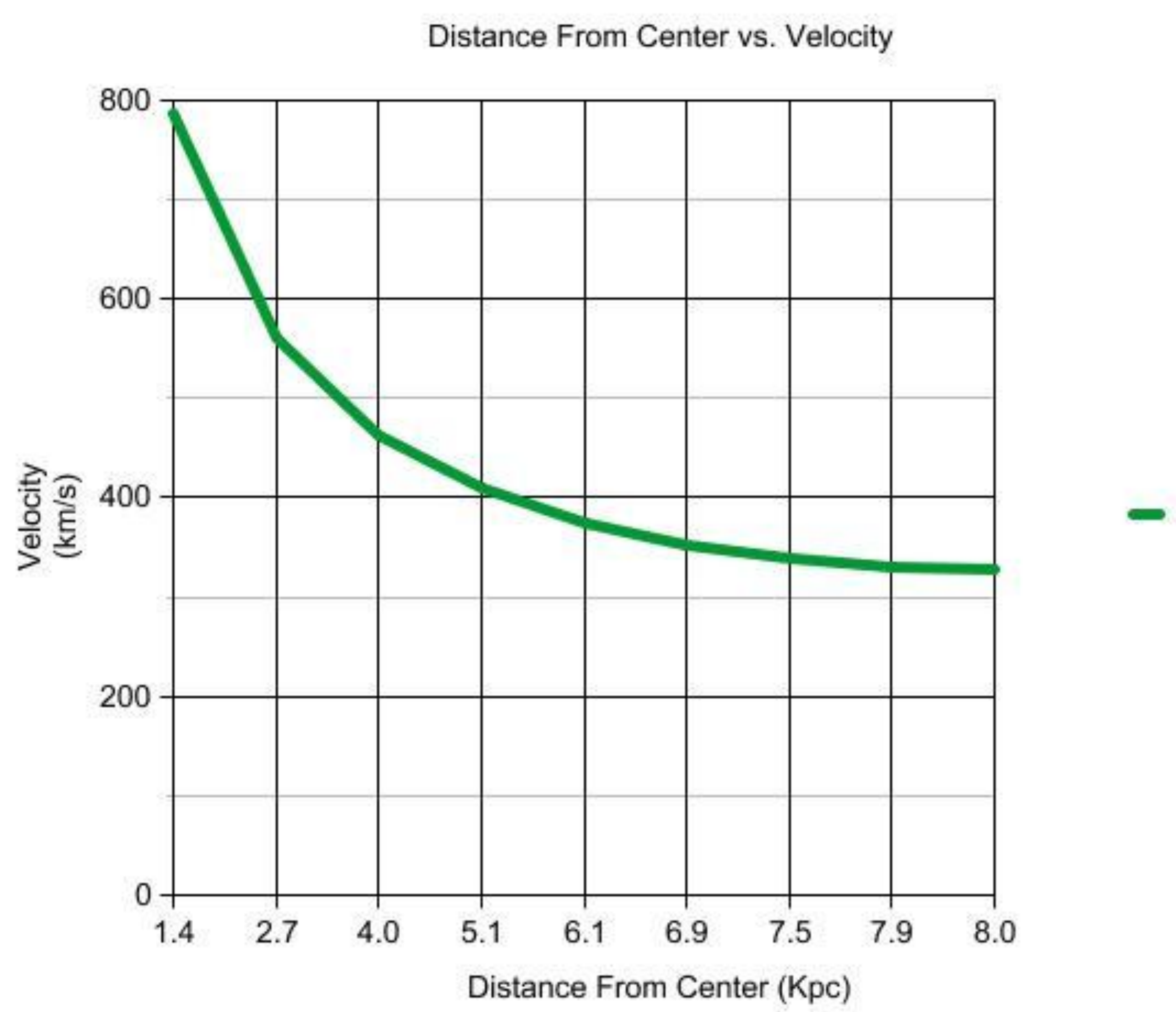
Introduction:
The purpose of this research is to measure the amount of dark matter within the Milky Way Galaxy. Dark matter is matter in our universe that cannot be detected with any kind of light-measuring device; therefore, scientists know very little on the subject, but the idea has been present for decades. However, dark matter does interact with matter via the Gravitational Force. An astronomer named Fritz Zwicky was the first scientist to propose the idea of dark matter in 1933, but the topic was neglected until the 1970s. Despite years of scientific research, astronomers still know very little about dark matter.



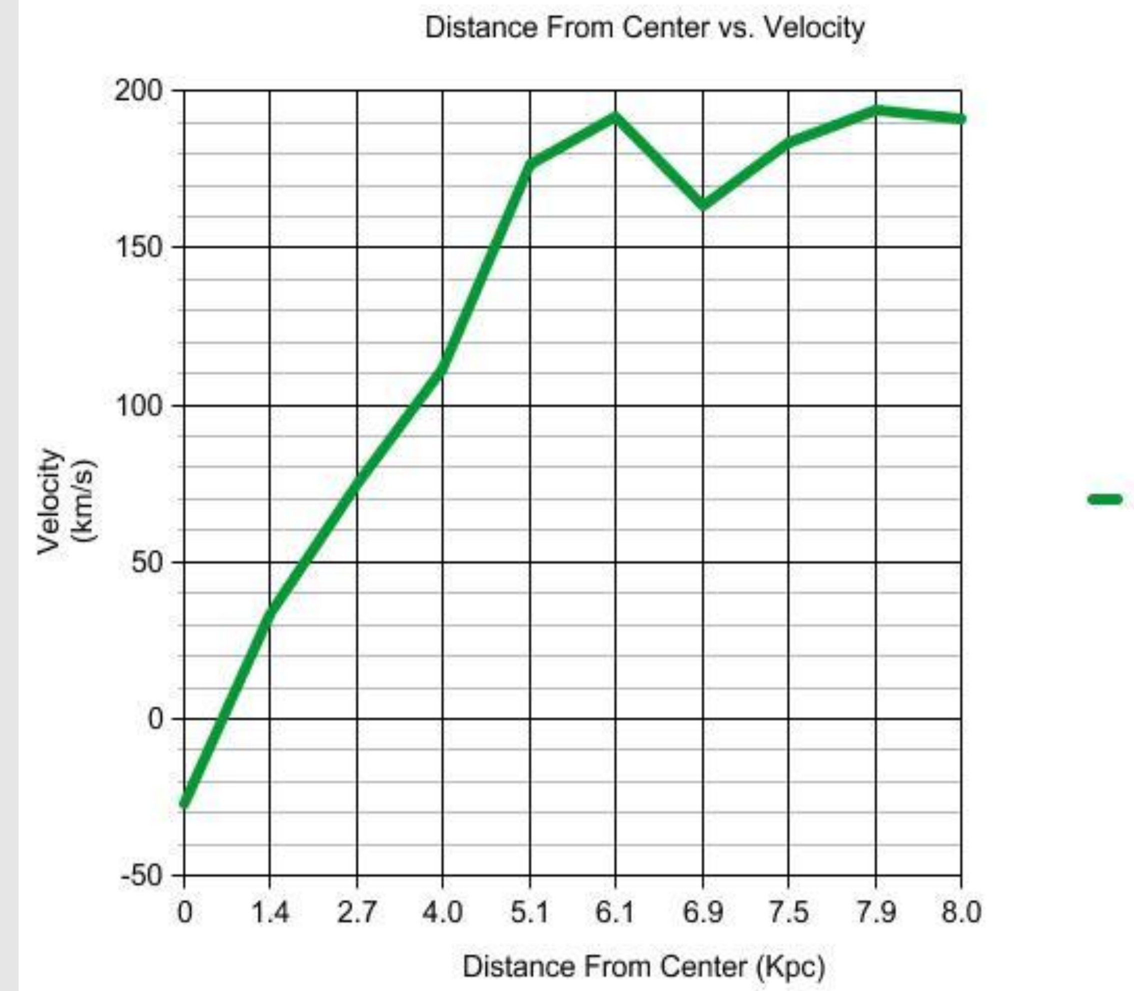
Objectives:
- Use radio telescopes to find the intensity of neutral hydrogen lines along the galactic plane
- Calculate the Doppler shift of the neutral hydrogen lines to find the velocity in different areas of the galactic plane
- Calculate their distance to the center of the galaxy
- Find the rotation curve of the galaxy and calculate the amount of dark matter in the Milky Way

Materials and Procedures:
- We used the National Radio Astronomy Observatory in Green Bank
- Scanned the Galactic equator at 10° RA intervals
- We measured the Doppler shift in the neutral hydrogen's frequency (1420.41 MHz)
- We then used: $v = \frac{\Delta f}{f_o}(c)$ to find velocity of the gas
- Then we had to compensate for the velocity of the Sun around the Galactic center and the Earth's movement around the Sun using:
  $$v = v_r - v_o \sin(l^{II}) + v_{lsr}$$
- Finally, we calculated the distance of the gas from the Galactic center using: $R = R_0 \sin(l^{II})$

Results:



Expected Keplerian Curve



Observed Flat Curve

Conclusion:
Clearly, the expected and observed graphs are different. In the Keplerian Curve, $v \propto \frac{1}{\sqrt{R}}$; in the Flat Curve, $v \propto$ R first (this is expected in a solid body, and the Galactic center is dense enough to rotate in this manner; the Keplerian Curve should also behave in this manner at lower R values), but then the curve flattens out. The only way that the velocities could remain constant as R increases is if mass is continually added the further from the Galactic center we go. Since the visible Milky Way separates into clusters and stars at higher R values, it should obey Kepler's Laws. Our curve shows that there is extra mass that is not visible to us because the Milky Way does not seem to follow Kepler's Laws. This is what is known as dark matter.

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Image from: http://hubblesite.org/newscenter/archive/releases/2007/17/image/a/

Citations: www.nasa.gov