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Gravitational Physics and Astronomy

4-9 December 2022

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JOURNAL https://www.mdpi.com/journal/physics/special_issues/SPGPCC

EGYPTIAN CENTER FOR THEORETICAL PHYSICS
CENTER OF EXCELLENCE

Topic : Dark Matter and Gravitational Effects


Dark matter and Gravitational Effects

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$$v(R) = \sqrt{\frac{GM(R)}{R}}$$

Abstract

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Team Life-To & Beyond

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BE, BMSCE

I am an Aspiring Astrophysicist with a Mechanical Engineering background. I am deeply fascinated about the wonders of the cosmos and with this curiosity I explored every domain of physics and have a developed a passion for Research.
In attempts to satisfy my curiosity, I've read the works of many great scientists such as Richard Feynman, Michio Kaku, Stephen hawking, Carl Sagan and many more.

I am deeply interested in the project's topics like "Galaxies with anomalous fractions of Dark Matter", "supermassive black holes influence the evolution of galaxies" & "Fuzzball Model of Black Hole". I'm really excited to dive into the depths of the universe and observe it in all its glory.

Undergraduate | Theoretical Physics & Astrophysics Research | Mechanical Engineering at BMSCE'-25 |
My communication skills are excellent and I have a strong commitment and knowledge for research.

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My Affiliations & Memberships

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I am really excited to get opportunity to work in Astronomy .
I am enthusiastic about supporting the work and gaining the experience in Astronomy.

What is the Nature of Dark Matter?

The nature of dark matter (DM) is currently one of the most intriguing questions of fundamental physics. Yet, its existence is still debated, and relies on the observations of gravitational effects in largescale structures and in cosmology.

Abstract.

A systematic study of Gravitational effects of the dark matter through simulations of early universe, observations of Gravitational lensing of distant Clusters, Study of Colliding galaxies and Study of Spiral Galaxies.

There are various computer simulations which we run to visualize the formation of the universe. The standard cosmological model ΛCDM shows a remarkable agreement with all the observations from disparate scales. Finally, the combined results of are consistent with the large-scale structure data, and reveal that the ratio of baryonic mass over total matter mass is close to 15%, which is in agreement with the results at galaxy and galaxy cluster scales.

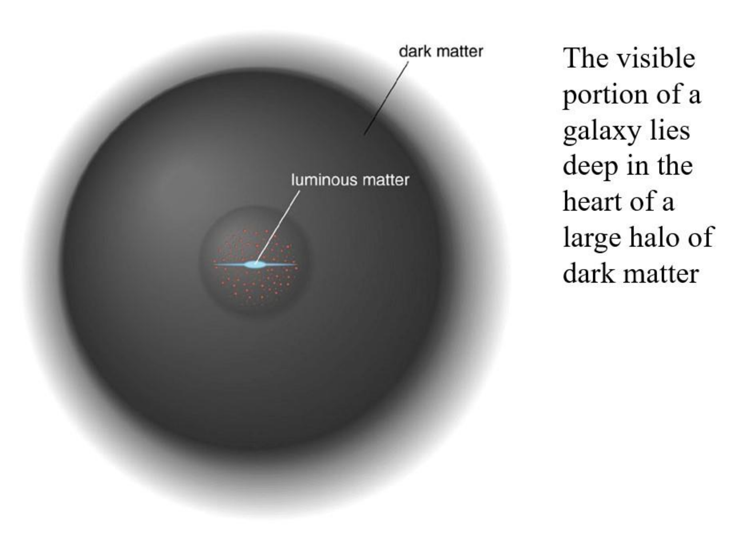


Image 1

Gravitational Lensing

The curvature of space-time near any gravitating mass (including dark matter) deflects passing rays of light - observably shifting, distorting and magnifying the images of background galaxies. Measurements of such effects currently provide constraints on the mean density of dark matter, and its density relative to baryonic matter; the size and mass of individual dark matter particles; and its cross section under various fundamental forces.

Although astronomers cannot see dark matter, they can detect its influence by observing how the gravity of massive galaxy clusters, which contain dark matter, bends and distorts the light of more-distant galaxies located behind the cluster. This phenomenon is called gravitational lensing.

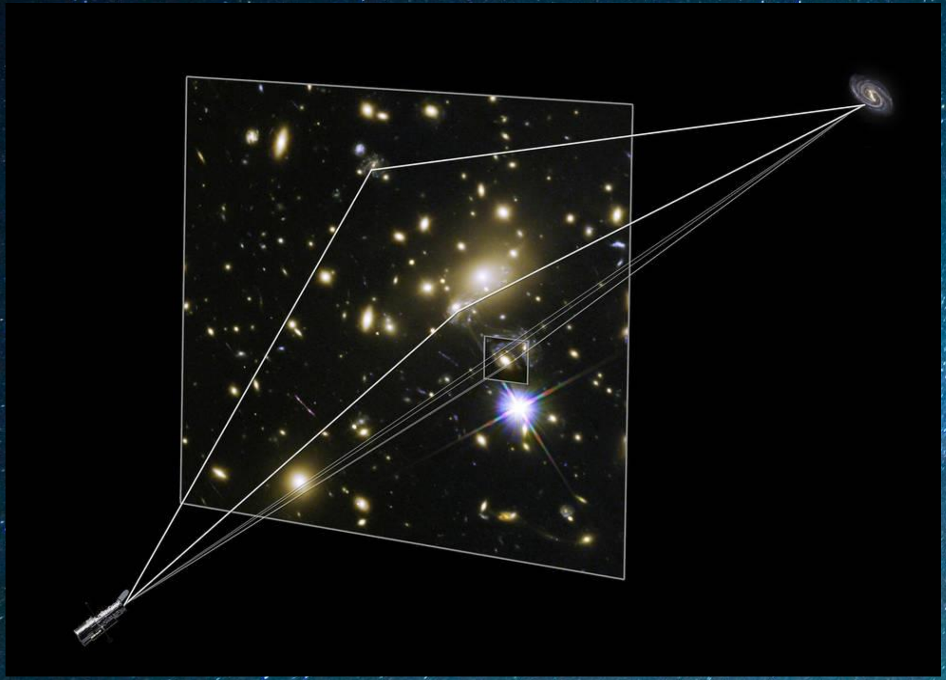


Image 2

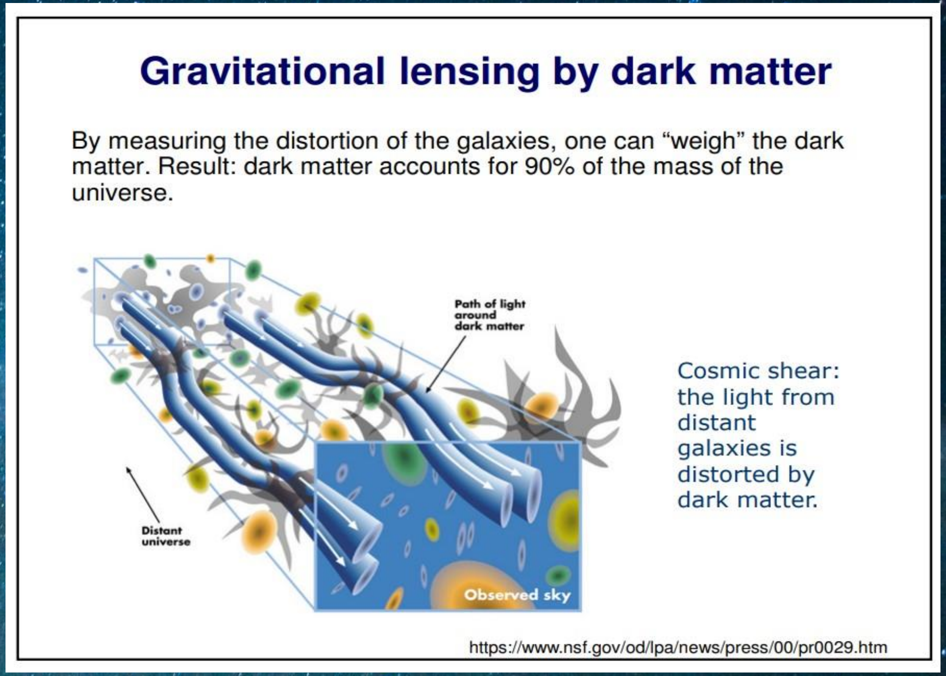


Image 3

Bullet Cluster Collision

The Bullet Cluster is composed of two clusters of galaxies that collided and moved past each other, though this is not clear when viewing the region solely in visible light. Multi-wavelength observations of the Bullet Cluster provided the first strong observational evidence that dark matter does not interact with normal matter, or with itself, and holds the majority of mass in a galaxy cluster. Astronomers use visible-light images to map the location of the clusters' mass, based on how the light of background galaxies is warped. Most of that mass is dark matter. X-rays show that the majority of normal matter, in this case gas, is in a different location than the dark matter of each cluster—it lags behind. This is because the normal matter of the two galaxy clusters collided, while the dark matter sailed through and kept going without interacting at all. Many mysteries remain as to the nature of dark matter, and the Bullet Cluster provides key evidence in the scientific investigation.

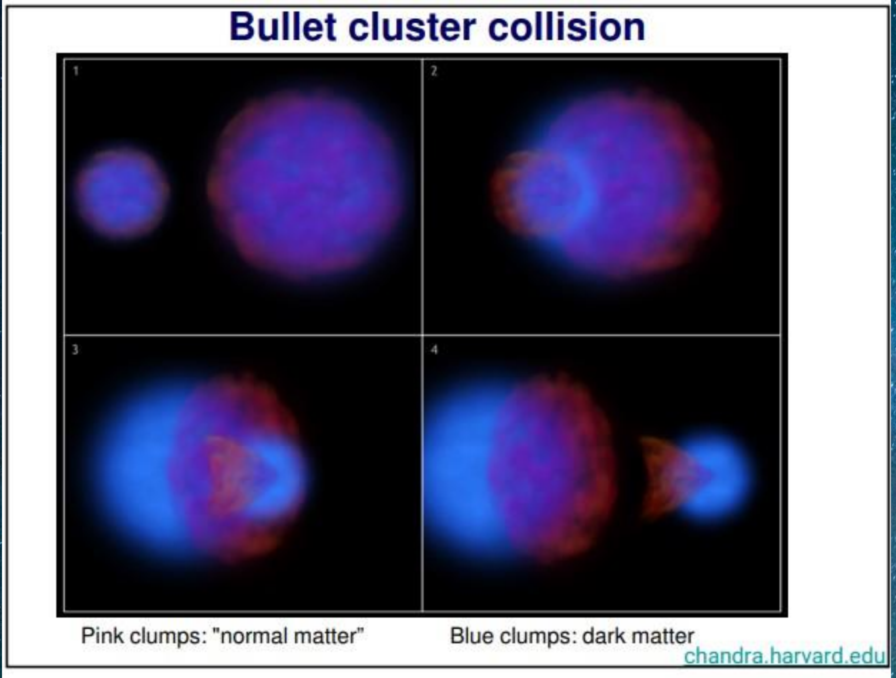


Image 4

Image 5

Rotation of Spiral galaxies

The gravitational force of this dark matter is presumed to be responsible for the high rotational velocities of stars and gas in the disks of spiral galaxies. A significant discrepancy exists between the experimental curves observed, and a curve derived by applying gravity theory to the matter observed in a galaxy. Theories involving dark matter are the main postulated solutions to account for the variance.

- It makes the outer parts of galaxies rotate faster than expected from their starlight.
- It makes galaxies in clusters orbit faster than expected from the total starlight of the galaxies.
- Confines the hot X-ray gas that would otherwise evaporate from a galaxy cluster.

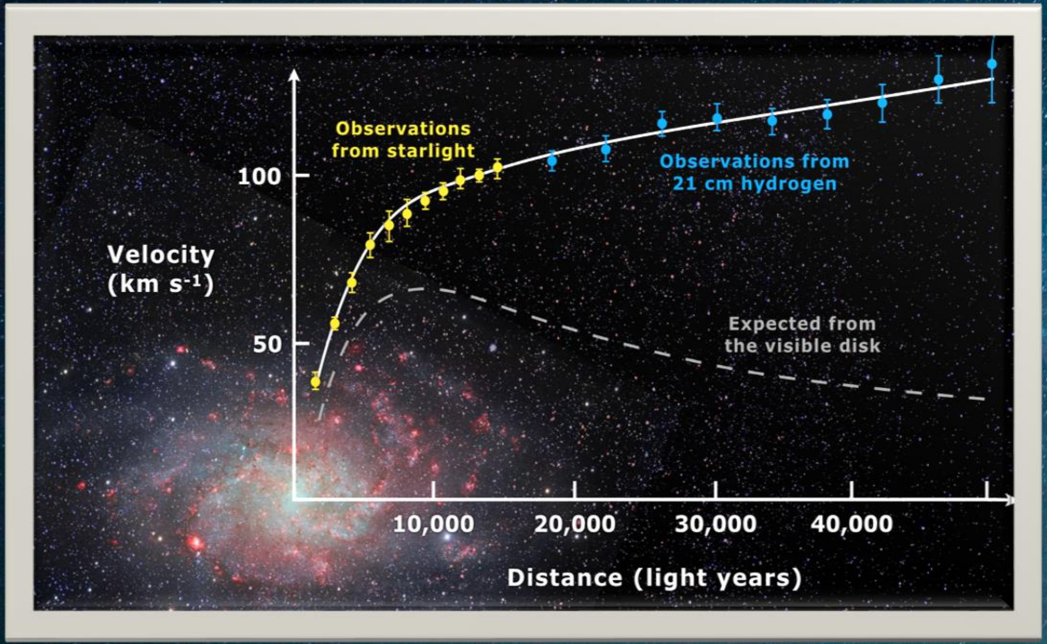


Image 6

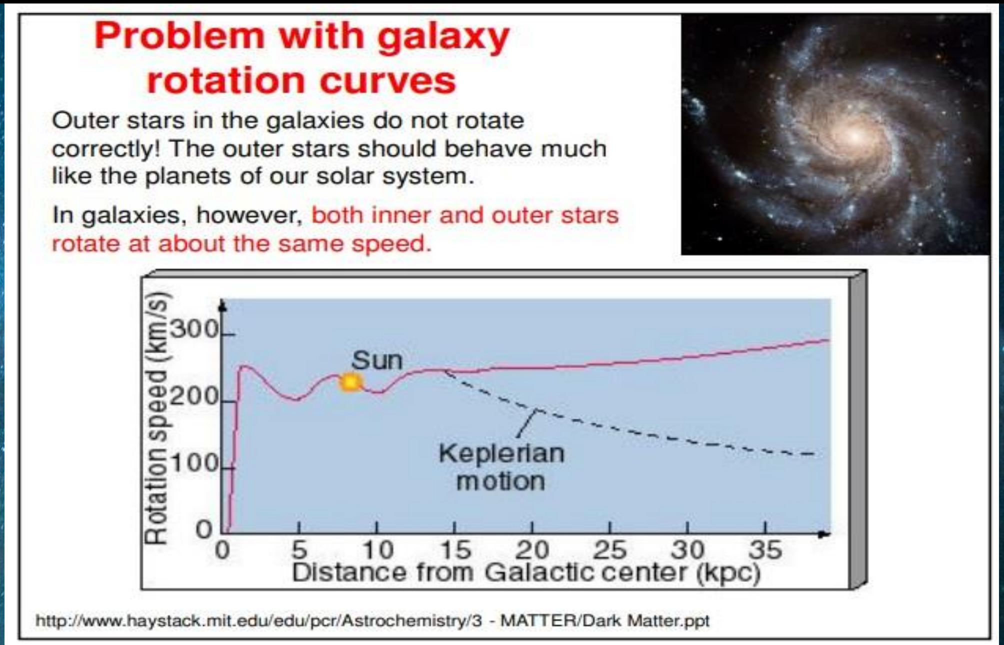
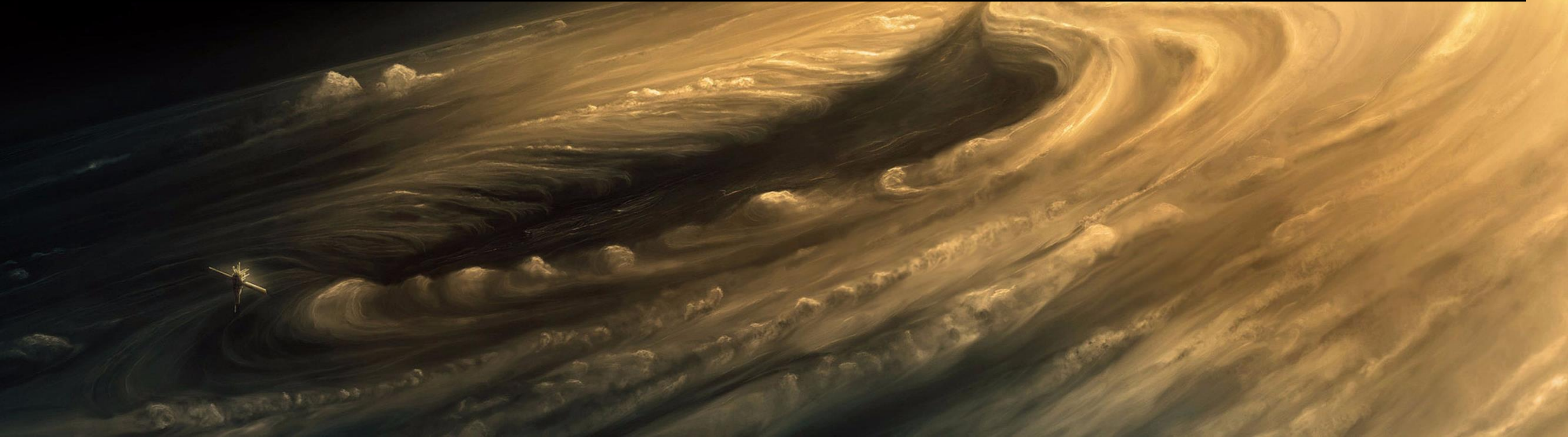


Image 7

Conclusion

We mostly have “negative” information from astrophysics and searches for new particles. Dark matter has no electric charge, shows no color charge (property of quarks and gluons that is related to the particles' strong interactions), No strong self-interaction, Does not seem to decay: stable, or very long-lived. The most significant property of dark matter is its gravitational effects thus it bends space around it. Extraordinary Dark Matter can be regarded as Weakly Interacting Massive Particles (WIMPS), which are mysterious neutrino-like particles.

Computer simulation Models involving WIMPs explain how galaxy formation works and WIMP models agree better with observations.



A New Perspective towards the Study of Dark Matter.

The more bizarre proposed solutions to the dark matter problem require the use of little understood relics or defects from the early Universe. One school of thought believes that topological defects may have appears during the phase transition at the end of the GUT era. These defects would have had a string-like form and, thus, are called cosmic strings. Cosmic strings would contain the trapped remnants of the earlier dense phase of the Universe. Being high density, they would also be high in mass but are only detectable by their gravitational radiation.

Lastly, the dark matter problem may be an illusion. Rather than missing matter, gravity may operate differently on scales the size of galaxies. This would cause us to overestimate the amount of mass, when it is the weaker gravity to blame. This is no evidence of modified gravity in our laboratory experiments to date

References of Image used-:

- Image 1: Dark matter. Adapted from “2010 Pearson Education, Inc. Chapter 22 Dark Matter”
- Image 2:Gravitational lensing . Adapted from https://www.nasa.gov/content/discoveries-highlights-shining-a-light-on-dark-matter
- Image 3: Dark matter Lensing . Adapted from “nsf.gov/press release”
- Image 4: Bullet Cluster Collision. Adapted from “*NASA/CXC/M Weiss*”
- Image 5: Colliding Galaxies. Adapted from “Chandra :Photo Album : 1E 0657-56 :: 21 Aug 06 ”
- Image 6: Light Curve. Adapted from “ESA/NASA/Hubble Telescope and Universe Today”
- Image 7: Spiral galaxy. Adapted from “Haystack.mit.edu/Astrochemistry”


THANK YOU FOR LISTENING