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The Darkness of Dark Matter and Dark Energy

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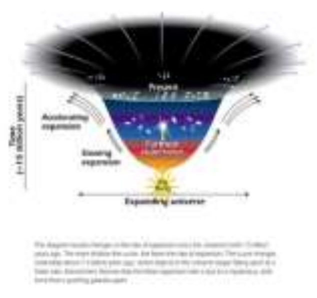
Abstract— The visible universe—including Earth, the sun, other stars, and galaxies—is made of protons, neutrons, and electrons bundled together into atoms. Perhaps one of the most surprising discoveries of the 20th century was that this ordinary, or baryonic, matter makes up less than 5 percent of the mass of the universe. The rest of the universe appears to be made of a mysterious, invisible substance called dark matter (25 percent) and a force that repels gravity known as dark energy (70 percent).Cosmological observations provide compelling evidence that about 95 percent of the content of the universe reside in two unknown forms of energy, which we call dark matter and dark energy-the first resides in bound objects in the form of non-luminous matter, the later in the form of a zero point energy that pervades the whole universe. In this article I shall try to explore the essentials of dark matter and dark energy, with particular emphasis on the experimental evidence.

Index Terms— Axion, Baryonic, Galactic, Gravitational Lensing

I. INTRODUCTION

Galaxies in our universe seem to be achieving an impossible feat. They are rotating with such speed that the gravity generated by their observable matter could not possibly hold them together; they should have torn themselves apart long ago. The same is true of galaxies in clusters, which leads scientists to believe that something we cannot see is at work. They think something we have yet to detect directly is giving these galaxies extra mass, generating the extra gravity they need to stay intact. This strange and unknown matter was called "dark matter" since it is not visible.



Ever since the dawn of civilization, man has been fascinated by the stars, planets and other heavenly objects, wondering what essentially the magnificent universe around us is made up of. More than eighty years ago, Edwin Hubble established the expansion of the universe with his pioneering observations of galaxies .Since then galaxies have been the fundamental tools for understanding the structure and evaluation of our Universe.

After decades of exhaustive and increasingly precise astrophysical observations, scientists today have evidence that what we have always thought of as the actual universe- the planets, stars, galaxies, all the matter in space –represents less than even a mere 5 percent of what's actually out there. The rest is something they call as "dark matter" (23%) and approximately 73% is something even more mysterious, which they call as 'dark energy". This article aims to introduce the reader to the enigmatic concept of dark matter and shed some light on the exciting questions such as why do we need dark matter, what is it believed to be consisting of etc

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II. DARK MATTER

Unlike normal matter, dark matter does not interact with the electromagnetic force. This means it does not absorb, reflect or emit light, making it extremely hard to spot. In fact, researchers have been able to infer the existence of dark matter only from the gravitational effect it seems to have on visible matter. Dark matter seems to outweigh visible matter roughly six to one, making up about 27% of the universe. Here's a sobering fact: The matter we know and that makes up all stars and galaxies only accounts for 5% of the content of the universe! But what is dark matter? One idea is that it could contain "supersymmetric particles" – hypothesized particles that are partners to those already known in the Standard Model. Experiments at the Large Hadron Collider (LHC) may provide more direct clues about dark matter.

Many theories say the dark matter particles would be light enough to be produced at the LHC. If they were created at the LHC, they would escape through the detectors unnoticed. However, they would carry away energy and momentum, so physicists could infer their existence from the amount of energy and momentum "missing" after a collision. Dark matter candidates arise frequently in theories that suggest physics beyond the Standard Model, such as supersymmetry and extra dimensions. One theory suggests the existence of a "Hidden Valley", a parallel world made of dark matter having very little in common with matter we know. If one of these theories proved to be true, it could help scientists gain a better understanding of the composition of our universe and, in particular, how galaxies hold together.

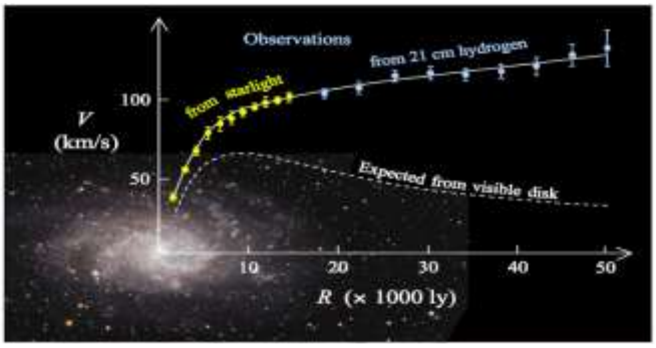
Dark matter is a term used to describe matter that can be inferred to exist from its gravitational effects, but does not emit or absorb detectable amounts of light. The story of dark matter can best be divided into two parts. First I would discuss the experimental signals as a consequence of which I believe that dark matter exists. Second is the collection of possible explanations as what it is made up of.

III. DARK ENERGY

After the Big Bang, the universe began expanding outward. Scientists once thought that it would eventually run out of the energy, slowing down as gravity pulled the objects inside it together. But studies of distant supernovae revealed that the universe today is expanding faster than it was in the past, not slower, indicating that the expansion is accelerating. This would only be possible if the universe contained enough energy to overcome gravity — dark energy. More is unknown than is known. We know how much dark energy there is because we know how it affects the universe's expansion. Other than that, it is a complete mystery. But it is an important mystery. It turns out that roughly 68% of the universe is dark energy. Dark matter makes up about 27%. The rest - everything on Earth, everything ever observed with all of our instruments, all normal matter - adds up to less than 5% of the universe. Come to think of it, maybe it shouldn't be called "normal" matter at all, since it is such a small fraction of the universe. Dark energy makes up approximately 68% of the universe and appears to be associated with the vacuum in space. It is distributed evenly throughout the universe, not only in space but also in time – in other words, its effect is not diluted as the universe expands. The even distribution means that dark energy does not have any local gravitational effects, but rather a global effect on the universe as a whole. This leads to a repulsive force, which tends to accelerate the expansion of the universe. The rate of expansion and its acceleration can be measured by observations based on the Hubble law. These measurements, together with other scientific data, have confirmed the existence of dark energy and provide an estimate of just how much of this mysterious substance exists.

IV. WHY DOES THE UNIVERSE NEED DARK MATTER?

If you took a look at all the galaxies in the Universe, measured where all the matter you could detect was, and then mapped out how these galaxies were moving, you'd find yourself quite puzzled. Whereas in the Solar System, the planets orbit the Sun with decreasing speed the farther away from the center you go—just as the law of gravitation predicts—the stars around the galactic center do no such thing. Even though the mass is concentrated towards the central bulge and in a plane-like disk, the stars in the outer regions of a galaxy whip around it at the same speeds as they do in the inner regions, defying predictions. Obviously, something is missing. Two solutions spring to mind: either there's some type of unseen mass out there making up the deficit, or we need to modify the laws of gravity, as we did when we leapt from Newton to Einstein. While both of these possibilities seem reasonable, the unseen mass explanation, known as dark matter, is far and away the superior option.



First off, the answer has nothing to do with individual galaxies. Galaxies are some of the messiest objects in the known Universe, and when you're testing the very nature of the Universe itself, you want the cleanest environment possible. There's an entire field of study devoted to this, known as physical cosmology. (Full disclosure: it's my field.) When the Universe was first born, it was very close to uniform: almost exactly the same density everywhere. It's estimated that the densest region the Universe began with was less than 0.01% denser than the least dense region at the start of the hot Big Bang. Gravitation works very simply and in a very straightforward fashion, even on a cosmic scale, when we're dealing with small departures from the average density. This is known as the linear regime, and provides a great cosmic test of both gravitation and dark matter.

On the other hand, when we're dealing with large departures from the average, this places you into what's called the non-linear regime, and these tests are far more difficult to draw conclusions from. Today, a galaxy like the Milky Way may be be a million times denser than the average cosmic density, which places it firmly in the non-linear regime. On the other hand, if we look at the Universe on either very large scales or at very early times, the gravitational effects are much more linear, making this your ideal laboratory. If you want to probe whether modifying gravity or adding the extra ingredient of dark matter is the way to go, you'll want to look where the effects are clearest, and that's where the gravitational effects are most easily predicted: in the linear regime.

We call something "dark" because it (almost) neither emits nor absorbs electromagnetic radiations. Historically the observational evidence for the existence of dark matter came from analyses of galactic dynamics and cosmic microwave radiation. The following discussions in this section show that the observed luminous objects can not have enough mass to support the observed gravitational effects

V. GALACTIC ROTATION CURVES

The rotation curve of a disc galaxy (also called a velocity curve) is a plot of the orbital speeds of visible stars or gas in that galaxy versus their radial distance from that galaxy's centre. The rotation curves of spiral galaxies are asymmetric, so the observational data from each side of a galaxy are generally averaged. Rotation curve asymmetry appears to be normal rather than exceptional.

It was Swiss astronomer Fritz Zwicky in 1933 who, while studying clusters of galaxies, found that mass in the galactic plane must be more than the material that could be seen. By applying Viral Theorem, i.e. the total kinetic energy should be half of the total gravitational energy, Zwicky estimated the total mass of the cluster based on the motion of galaxies near its edge and compared it to the one based on the number of galaxies and total brightness of the cluster. He found that there was about four hundred times more estimated mass than was visually observable.

Further evidence for dark matter came from the measurements of rotations of spiral galaxies in 1950's and 1960's. By the virtue of Virial theorem, astronomers expected the stars near the center of a galaxy, where the visible mass is concentrated, to move faster than the stars at edge. However, what they actually observed was that the stars at the edge of the galaxy had nearly the same rotational velocity as the stars near the center.

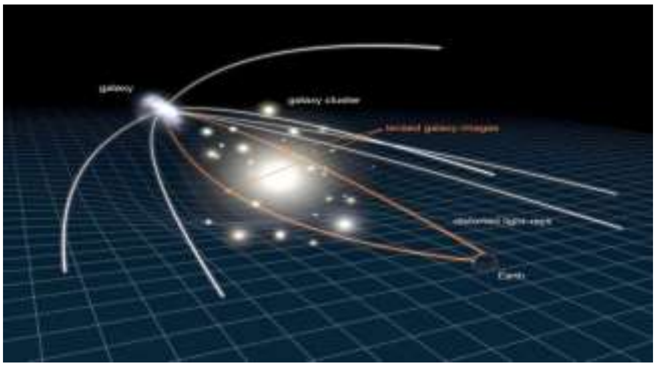
Both these observations implied that the galaxies and galactic clusters must contain an 'invisible' form of matter-"dark matter"- in a proportion substantially larger than the 'visible' matter, responsible for the observed gravitational effects. As astronomers focused their attention to dark matter, they began to collect additional evidence for its existence.

VI. CONFINEMENT OF HOT GAS IN THE GALAXIES

Expecting to find pools of hot gas, which had previously gone undetected and which might account for the mass being attributed to the dark matter, some of the astronomers turned their attention to galactic clusters. The basic technique was to estimate the temperature and density of the gas from the energy and flux of the x-rays using X ray telescopes, which would further enable the mass of the galactic cluster to be derived. The measurement of hot gas pressure in galactic clusters by X ray telescopes, such as Chandra X Ray Observatory by NASA, have shown that the amount of superheated gas is not enough to account for the discrepancies in mass and the visible matter approximately constitutes only 12-15 percent of the mass of the cluster. Otherwise, there won’t be sufficient gravity in the cluster to prevent the hot gas from escaping.

VII. GRAVITIONAL LENSING

Gravitational lensing is useful to cosmologists because it is directly sensitive to the amount and distribution of dark matter. This is because the amount of light bending is sensitive only to the strength of the gravitational field it passes through*, which is mostly generated by the mass of the dark matter in the Universe. This means that to measure the amount of lensing on a patch of sky, we don't need to know anything about what kind of galaxies we are observing, how they form and behave or what colour light they emit. This makes gravitational lensing a very clean and reliable cosmological probe as it relies on few assumptions or approximations. Lensing can therefore help astronomers work out exactly how much dark matter there is in the Universe as a whole It has been shown that the clusters and super clusters can distort space-time with their immense masses. Light rays emanating from a distant object behind a cluster pass through the distorted space-time, which causes the rays to bend and converge as they move towards an observer. Therefore, the cluster acts like a large gravitational lens. By measuring the angle of bending, the mass of the gravitational lens can be calculated- the greater the bend, the more massive of the lens. Using this method , astronomers have confirmed that the galactic clusters indeed have high masses exceeding those measured by the luminous matter, thereby providing additional evidence for the existence of dark matter.



If we know something about the distances to the galaxies we look at with our telescopes, lensing can also tell us about the nature of dark energy because the amount of dark energy affects how galaxies and clusters form and develop. Measuring their distribution with distance through gravitational lensing can help us constrain the amount of dark energy in the Universe to a higher degree of precision. The light from distant galaxies began travelling towards us many millions (or even billions) of years ago, providing a window into the early Universe. This means that it is also possible to work out if the amount of dark energy changes over time by observing galaxy structures at different distances from us. Thus, gravitational lensing is a clean probe of the Universe and has much to tell us about its two most mysterious components - **dark matter and dark energy**.

VIII. FLUCTUATIONS IN COSMIC MICROWAVE BACKGROUND RADIATION

Cosmic Microwave Background radiation(CMBR) can be cosidered as the radiation left over from an early stage in the development of the universe. The analysis of CMBR reveals what the universe was like when it was only a few hundred thousands years old, long before galaxies and the clusters of galaxies were found. The intensity of CMBR is very nearly the same in all directions however small variations of a fraction of a percent have been detected. These fluctuations (anisotropics) are due to clumps of matter that were either hotter or cooler than the average, representing the seeds of all future structures-the satrs and gallaxies of today. The rate at which these clumps would grow in a hot, expanding gas can be calculated from different admixtures of the normal visible matter photons,protons, neutrons etc , and dark matter. Comparison of such calculations with the observations of CMBR by planck mission team in 2013 have shown that the total mass energy of the known universe contains 4.9 percent ordinary matter, 26.8 percent dark matter and 68.3 percent dark energy. Thus, dark matter is estimated to constitute 84.5% of the total matter content in the universe , while dark matter plus dark energy constitue 95.1% of the total matter energy content of the universe.

IX. WHAT DOES THE DARK MATTER CONSIST OF?

Based on the compelling experimental evidence, as discussed above, most of the astronomers agree that the dark matter exists. but then the question arises-WHAT IS THE ACTUAL NATURE OF THIS DARK “DARK MATTER”? There are number of plausible speculations on the nature of the dark matter.

Astrophysical observations could provide indirect evidence for neutralinos. On astrophysical scales, collisions of neutralinos with ordinary matter are believed to slow them down. The scattered neutralinos, whose velocity is degraded after each collision, may then be gravitationally trapped by objects such as the Sun, Earth, and the black hole at the center of the Milky Way galaxy, where they can accumulate over cosmic time scales. Such dense agglomerates could therefore yield an enhanced signal for the postulated neutralinos of cosmic origin.

Another possible signal may come from collisions between two neutralinos, which are believed to result in pairwise annihilation of the neutralinos in dense condensates of such particles. This process would be highly energetic, with energies of billions of electron volts (eV)—much higher than the energy of solar neutrinos, which does not exceed tens of millions of eV. The neutrinos resulting from neutralino annihilation should carry a distinct signature that could be observed with neutrino telescopes designed to search for dark matter of this kind. Neutrinos (for example, from annihilating neutralinos deep within the solar core) are the only particles associated with neutralino annihilation or decay that are likely to escape from their place of birth.

Most **scientists** think that dark matter is composed of **non**-baryonic matter. The lead candidate, WIMPS (weakly interacting massive particles), have ten to a hundred times the mass of a proton, but their weak interactions with "normal" matter make them difficult to detect.

The astrophysical observations discussed here indicate that axions and neutralinos may have been abundantly produced in the early universe and/or inside stars. These two types of particles remain the favorite candidates for dark matter and other celestial phenomena. As ever more sensitive detectors are built, more definitive evidence for or against neutralinos and axions should become available. Existence of one does not preclude existence of the other: The dark matter in the universe may contain both of these particles, as well as many other, as yet unforeseen ones.

X. BARYONIC DARK MATTER

Some astronomers believed that the missing matter could simply be made up of the regular baryonic matter(the protons and neutrons), however more difficult to detect. Such dark matter candidates are referred to as Massive Compact Halo Objects (MACHOS), which are believed to be large objects residing in the halos of galaxies, but eluding detection because they have very low luminosities. Such objects include brown dwarfs, white dwarfs, neutron stars and even black holes. However , the theory of Big-Bang Nucleosynthesis as well as the experimental evidence from anisotropies in CMBR observed by NASA's Wilkinson Microwave Anisotropy Probe (WMAP) and Planck mission team have produced an upper bound (-5%) on the total amount of baryonic matter in the Universe. So far we have seen around 1% of the baryonic matter in the Universe. This indicates that the MACHOs probably contribute somewhat to the dark matter mystry, but there are not simply enough of them to account for all the dark matter in the Universe, most of the dark matter is thus attributed by the non-baryonic stuff.

XI. .NON-BARYONIC DARK MATTER

The non-baryonic dark matter candidates can broadly be grouped into two categories, depending upon their respective masses and speeds: (1) Hot Dark Matter (HDM) and (2) Cold Dark Matter(CDM). CDM is composed of substantially massive particles expected to be moving at sub relativistic speeds, whereas HDM consists of particles with zero or nearly zero mass which are expected to be moving nearly at the speed of light, when the pre –galactic clumps began to form.

The classification has observational consequences for the size of clumps that can collapse in the expanding universe. HDM particles are expected to be moving so rapidly that clumps with mass of the order of that of a galaxy would quickly disperse. Only clouds with the mass of the order of thousands of galaxies, i.e the size of galaxy clusters, can form. Individual galaxies could have been formed later as the large cluster size clouds fragmented, in a top-down process. In contrast, CDM can form clumps of mass of the order of that of a galaxy or less. Galaxies would be formed first and clusters would be formed later as the galaxies merge into groups and groups into clusters in a bottom –up process.

HDM may include (massive) neutrons, but the top down formation scenario for galaxies has largely been ruled out by the observations of high red shift galaxies such as Hubble Ultradeep field. The observation with Chandra also shows many examples of clusters being constructed by the merger of groups and sub clusters of galaxies. This and the other line of evidence that galaxies are older than the groups and clusters of galaxies strongly support the CDM alternative.

The leading candidate for CDM is particles called WIMPS (Weakly Interacting Massive Particles). WIMPS could include large number of exotic particles, such as

Neutralions- Hypothetical particles that are similar to the neutrinos but are heavier and slower. In many models of beyond standard model particle physics, e.g. in the MSSM (Minimal Supersymmetric Standard Model), the lightest supersymmetric particle is generally thought to be the lightest neutralino. Although neutralions have not been discovered yet, they are a front runner in the WIMPs category.

Axions- Neutral particles with mass less than a millionth of that of an electron. Axions have a specific type of self interaction that makes them a suitable CDM candidate. Axions have a theoretical advantage that they solve the Strong CP Problem in Quantum Chromodynamics , but have not been detected yet.

Photinos- Fermionic partner of photon, similar to photons but with spin ½ , each with a mass ten to hundred times that a proton, predicted by supersymmetry. Photinos are unchanged and , true to the WIMP signature, interact weakly with matter. Till date , the experiments at the Large Hadron Collider (LHC) have failed to find any evidence for the existence of Photino.

XII. DETECTION OF DARK MATTER PARTICLES

If dark matter is made up of sub-atomic particles, then millions, possibly billions, of such particles must pass through every square centimeter of the Earth each second. Many experiments aim to test this hypothesis. Although WIMPs are popular search candidates, the Axion Dark Matter experiment (ADMX) searches for axions. Another candidate is heavy hidden sector particles that only interact with ordinary matter via gravity.

In view of the compelling experimental evidence in the favour of existence of dark matter, aggressive hunt for these particles is being carried out by scientists around the world. Broadly, two types of experimental searches for dark matter candidates are being pursued currently. These involve the direct detection of dark matter particles by some type of detector, and the detection of X-rays or gamma-rays from the decay or annihilation of dark matter particles.

These experiments can be divided into two classes: direct detection experiments, which search for the scattering of dark matter particles off atomic nuclei within a detector; and indirect detection, which look for the products of dark matter particle annihilations or decays.

XIII. DIRECT DETECTION

Direct detection experiments aim to observe low-energy recoils (typically a few keVs) of nuclei induced by interactions with particles of dark matter, which (in theory) are passing through the Earth. After such recoil the nucleus will emit energy as, e.g., scintillation light or phonons, which is then detected by sensitive apparatus. To do this effectively it is crucial to maintain a low background, and so such experiments operate deep underground to reduce the interference from cosmic rays. Examples of underground laboratories with direct detection experiments include the Stawell mine, the Soudan mine, the SNOLAB underground laboratory at Sudbury, the Gran Sasso National Laboratory, the Canfranc Underground Laboratory, the Boulby Underground Laboratory, the Deep Underground Science and Engineering Laboratory and the China Jinping Underground Laboratory.

If WIMPS constitute the dark matter, then a billion or more of them would be passing through our bodies every second in view of the abundance of dark matter in the universe. The problem for their detection is the “weakly interacting” nature of WIMPS. However, it is possible that once in a great a WIMP could collide with an atom and knock its nucleus, creating a minuscule vibration in a supercooled crystal detector. So, far the most sensitive of such experiments, the Cryogenic Dark Matter Search (CDMS) located a half mile underground in an old iron-ore mine in Minnesota, has failed to detect any WIMPs. More sensitive experiments are planned. Axions may also be detected directly, though using very different techniques. These hypothetical particles are predicted to interact with a strong magnetic field, to produce radio waves. Experiments such as the Axion Dark Matter Experiments have so far yielded negatives results. Many projects using different techniques for the detection of axions are planned for the near future.

XIV. INDIRECT DETECTION

Indirect detection experiments search for the products of the self-annihilation or decay of dark matter particles in outer space. For example, in regions of high dark matter density (e.g., the centre of our galaxy) two dark matter particles could annihilate to produce gamma rays or Standard Model particle-antiparticle pairs. Alternatively if the dark matter particle is unstable, it could decay into standard model (or other) particles. These processes could be detected indirectly through an excess of gamma rays, antiprotons or positrons emanating from high density regions in our galaxy or others.[122] A major difficulty inherent in such searches is that various astrophysical sources can mimic the signal expected from dark matter, and so multiple signals are likely required for a conclusive discovery.

The indirect searches for dark matter are based on the possibility of observing a unique signature from their decay. Most theories for WIMPS predict that when they collide, they annihilate and produce a shower of high energy particles and radiation. One of the most important programs of NASA’s Fermi Gamma-ray Space Telescope, launched on 11th June 2008, is to search for gamma rays from the annihilation of WIMPs, or from the interaction of axions with strong magnetic fields in the nuclei of galaxies.

Some physicists have proposed that instead of adopting a passive approach of observing dark matter directly in the lab, or in directly through astronomical observations, we should actually create the staff. Since the dark matter particles were presumably created in the first few nanoseconds or so of the Big Bang, when temperatures were of the order of 10^{15} degrees, a particle accelerator that reproduces these conditions might create dark matter. So far the attempts to produce such new particles at the Tevatron Collider at Fermilab have turned out to be fruitless. Currently, the front runner in this category is the LHC at CERN, Switzerland. The goal of LHC experiments is not to produce WIMPs directly, but to produce other particles which might decay into some exotic dark matter candidates. This decay process, although nearly instantaneous, would allow scientists to track momentum and energy changes that would provide indirect evidence for the new particles.

XV. ALTERNATIVES TO DARK MATTER AND DARK ENERGY

There have been a number of conjectures presented as alternatives to dark matter, but nothing yet to rule the day. It all comes down to finding the definitive evidence. In this regard, I have 'tossed my hat in the ring', based on model I was playing around with to help make the concept of spatial curvature more intuitive. To my surprise the model suggested a way to combine the concepts of dark energy with the unexplained gravity, in a way that eliminated the need for dark matter

Although the evidence for dark matter is wide and deep, it is nevertheless in direct, and is based on the assumption that the laws of motion and gravity as formulated by Newton and expanded by Einstein apply. An alternative possibility is that a modification of gravity can explain the effects attributed to dark matter. The basic idea is that at very low accelerators, corresponding to large distances, the usual law of gravitation is modified.

The most studied of these modifications is known as the modified Newtonian Dynamics (MOND). According to this hypothesis, the force of gravity falls off more slowly at low accelerations. With this prescription, less mass is required to explain the observed rotation of the outer edges of galaxies or the pressure of the hot gas in clusters of galaxies than in the Newton-Einstein theory. By adjusting the parameters of the theory, the need for dark matter can be eliminated.

Although MOND has had some success in explaining observations of galaxies, it and other theories that involve modifying the law of gravity have been challenged by observations of the Bullet Cluster (1E0657-56) in 2006. The x-ray observations show that the Bullet Cluster is composed of two large clusters of galaxies that are colliding at high speeds. Using the gravitational lensing technique, astronomers have deduced that the total mass concentration in the cluster is different from that of the hot gas. this separation was presumably produced by high speed collision in which the gas particles collided with each other, while the stars and dark matter were unaffected. It has been shown that the Bullet clusters contains galaxies(2%) , intergalactic plasma (10 %) and dark matter (88%) . it cannot be explained by an altered law of gravity centered on the hot gas particles , and provided direct evidence that most of the matter in the Bullet Cluster is dark matter.

If future surveys of the motions of stars bolster the ESO findings, strongly suggesting there really is no dark matter in our region of the galaxy, then cosmologists may have to scrap all the current theories and begin anew. "To date, a comprehensive relativistic theory alternative to the dark matter paradigm, able to explain the observations on all scales, from galactic rotation to the clusters of galaxies, is not known," Moni-Bidin said.

XVI.CONCLUSION

The dark energy idea is just one component in a recent major overhaul in cosmological theory, based on observations that contradict prior theories. It turns out that only 4% of mass-energy is the conventional kind we see around us. Fully 74% of all mass-energy is now thought to be dark energy, while 22% is believed to be "dark matter", a category of matter that has been hypothesized to account for the observed, anomalous orbital behavior of galaxies. We would like to state that understanding the dark matter and dark energy are the biggest challenges to the present day particle Physics.

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REFERENCES

[1]. Hubble snaps dark matter warping space-time. Rik Myslewski, The Register. 14 Oct 2011.
[2]. "Dark Energy, Dark Matter". NASA Science: Astrophysics. 5 June 2015.
[3]. Francis, Matthew (22 March 2013). "First Planck results: the Universe is still weird and interesting". Arstechnica.
[4]. Freese, Katherine; Fields, Brian; Graff, David (2000). "Death of Stellar Baryonic Dark Matter Candidates". arXiv:astro-ph/0007444 [astro-ph].
[5]. Ferris, Timothy. "Dark Matter". Retrieved 10 June 2015.
[6]. Bertone, G.; Merritt, D. (2005). "Dark Matter Dynamics and Indirect Detection". Modern Physics Letters A. 20 (14): 1021–1036. arXiv:astro-ph/0504422 Bibcode:2005MPLA...20.1021B. doi:10.1142/S0217732305017391
[7] "A history of dark matter". Ars Technica. Retrieved 2017-02-08.
[8] "Quantum Dots". Nanosys – Quantum Dot Pioneers. Retrieved 2015-12- 04.
[9] Silk, Joseph (6 December 2000). "IX". The Big Bang: Third Edition. Henry Holt and Company. ISBN 978-0-8050-7256-3.
[10 Vittorio, N.; J. Silk (1984). "Fine-scale anisotropy of the cosmic microwave background in a universe dominated by cold dark matter". Astrophysical Journal Letters. 285: L39–L43. Bibcode:1984ApJ...285L..39V. doi:10.1086/184361.
[11] Rosenberg, Leslie J (30 June 2014). Status of the Axion Dark-Matter Experiment (ADMX) (PDF). 10th PATRAS Workshop on Axions, WIMPs and WISPs. p. 2.
[12 Peter, A. H. G. (2012). "Dark Matter: A Brief Review". arXiv:1201.3942 [astro-ph.CO].
[13] "The Hidden Lives of Galaxies: Hidden Mass". Imagine the Universe!. NASA/GSFC.
[14] Bertone, G. (2010). "The moment of truth for WIMP dark matter". Nature. 468(7322):389393. arXiv:1011.3532 . Bibcode:2010Natur.468..389B. doi:10.1038/nature09509. PMID 21085174
[15] Olive, Keith A. (2003). "TASI Lectures on Dark Matter". p. 21
[16] Gershenfeld, Neil; Chuang, Isaac L. (June 1998). "Quantum Computing with Molecules" (PDF). Scientific American.
[17 Freese, Katherine (4 May 2014). The Cosmic Cocktail: Three Parts Dark Matter. Princeton University Press. ISBN 978-1-4008-5007-5.
[18] "First test of rival to Einstein's gravity kills off dark matter". 15 December 2016. Retrieved 20 February 2017.
[19] Phillip D. Mannheim (April 2006). "Alternatives to Dark Matter and Dark Energy". Progress in Particle and Nuclear Physics. 56 (2). arXiv:astroph/0505266 . Bibcode:2006PrPNP..56..340M. doi:10.1016/j.ppnp.2005.08.001.
[20] COSMOS - The SAO Encyclopedia of Astronomy. "Baryonic Matter". Swinburne University of Technology. Retrieved 9 April 2018.
[21] "Dark Energy". Hyperphysics. Retrieved January 4, 2014.
[22] Kragh, H. 2012. Preludes to dark energy: zero-point energy and vacuum speculations. Archive for History of Exact Sciences. Volume 66, Issue 3, pp 199–240
[23] Harvey, Alex (2012). "How Einstein Discovered Dark Energy". arXiv:1211.6338
[24] Overbye, Dennis (20 February 2017). "Cosmos Controversy: The Universe Is Expanding, but How Fast?". New York Times. Retrieved 21 February 2017.
[25] Peebles, P. J. E.; Ratra, Bharat (2003). "The cosmological constant and dark energy". Reviews of Modern Physics. 75 (2): 559–606. arXiv:astroph/0207347 . Bibcode:2003RvMP...75..559P. doi:10.1103/RevModPhys.75.559
[26] Turner, Christina (February 14, 2006). "The Early History of Gravitational Lensing" (PDF). Archived from the original (PDF) on July 25, 2008.
[27] "A brief history of gravitational lensing — Einstein Online". www.einstein-online.info. Retrieved 2016-06-29.
[28] Schneider Peter; Kochanek, Christopher; Wambsganss, Joachim (2006). Gravitational Lensing: Strong, Weak and Micro. Springer Verlag Berlin Heidelberg New York Press. p. 4. ISBN 978-3-540-30309-1.
[29] "Most distant gravitational lens helps weigh galaxies". ESA/Hubble Press Release. Retrieved 18 October 2013.
[30] Jog, C. J. (2002). "Large-scale asymmetry of rotation curves in lopsided spiral galaxies" (PDF). Astronomy and Astrophysics. 391 (2): 471–479. arXiv:astro-ph/0207055
[31] Siegfried, T. (5 July 1999). "Hidden Space Dimensions May Permit Parallel Universes, Explain Cosmic Mysteries". The Dallas Morning News.

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