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Dark Matter Revisited

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Abstract

The relationship of dark matter to a creationist perspective of the universe was evaluated in an article in the March 2000 issue of the *Creation Research Society Quarterly*. It is interesting to note that even after seventeen years of intensive searching since that article was published, no one has directly observed dark matter or provided a definitive theory to what it is. Its existence and location were first based on observations of the dynamics of galaxies and galaxy clusters. More recently it has been absorbed into the assumptions by the standard model cosmology for the evolution of the universe. This article provides an updated creationist perspective on dark matter and what is and is not known about it. It addresses galaxies and their flat rotation curves; clusters of galaxies and how their supposed dark matter distribution formed gravity lenses; and how dark matter is related to the large-scale structure of the universe. It investigates the latest searches for a dark matter particle by accelerator experiments and astronomical observations. It also presents a creation-based cosmology and a possible new interpretation of the observations that originally led astronomers to propose the existence of dark matter. This new cosmology and its new interpretation of observations question the need for dark matter in a universe created only 6000 years ago.

Introduction

Of the six mysteries in modern astronomy listed in the introduction to DeYoung's original article on dark matter (DeYoung, 2000), all remain to be solved. Recently, at least six more have been added to the list by astronomers according to an article in *Science Magazine* (Coontz et al., 2012). The additional mysteries they identified include:

- Dark energy (or what drives the expansion of the universe)
- Missing baryons
- How do stars explode?
- What re-ionized the universe?
- Why is the solar system atypical?
- Why is the sun's corona so hot?

These new mysteries plus the six old ones all point to weaknesses in the concordance, or lambda cold-dark-matter model of cosmology (standard model), which is based on the theory of Freidmann and Lemaître. It may be time to promote a creation model that resolves

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all these mysteries, including the dark matter mystery explored in this article.

Dark matter is still considered a major mystery in both modern astronomy and particle physics. Its greatest unknown is why, if it is made of particles, they do not emit, reflect, or absorb electromagnetic radiation. Also, as far as has been determined, they have a negligible cross section of interaction with known particles they pass through or pass through them. According to the current understanding of the universe, it is cold dark matter that accounts for the missing mass that provides enough gravity to explain certain observed astronomical phenomena. In most cases these phenomena are interpreted entirely in terms of the standard model of evolution of the universe. The most recent theories estimate approximately 20% of the mass in the universe is provided by visible material (atomic matter made of baryons and fermions) and the other 80% of the mass is provided by dark matter. No one has explained how such a large percentage of the mass in the universe can remain unidentified.

What Is Not Referred to as Dark Matter

Astronomers observe dark nebulae that can obscure stars located beyond them. But these are clouds of debris and dust made of atomic matter. They appear dark in the visible portion of the electromagnetic spectrum. At other wavelengths, such as infrared and radio waves, stars have been observed through these dark nebulae.

Besides dark nebulae, astronomers also have observed black holes. These are relatively small volumes of space that do not emit radiation from within their boundary. Their gravity is so great that nothing escapes from within them, not even photons. The border of a black hole is called its *event horizon*. Black holes have been inferred from observations of binary star systems where the visible components interact with an invisible mass or black hole. They have also been found at the centers of most galaxies in super-massive form. Astronomers have been able to detect these super-massive black holes by the motion of stars near them. Others that are near enough have been observed by the x-ray radiation emitted just outside their event horizons as atomic matter is being torn apart. Recently scientists claimed that gravity-wave detectors have directly detected the ring-down signature of two stellar-sized black holes joining.

Astronomers have found other objects of atomic matter that are not visible but also cannot be considered dark matter. Some of these objects are dwarf stars/planets that do not emit/reflect enough visible light to be seen, molecular gaseous clouds, and comets/asteroid belts around many stars in most galaxies. Recent data from infrared-detecting satellites have shown that there are 75% more dwarf stars than visible stars in the Milky Way galaxy. A recent study (Gupta et al., 2012) using x-ray absorption data from the Chandra satellite collected by the European Space Agency's XMM-Newton space observatory and x-ray emission data from Japan's Suzaku satellite have allowed the astronomers to calculate that as much as 10–60 billion solar masses are in the form of high temperature gaseous oxygen and hydrogen in a halo around the Milky Way galaxy. Another study (Eckert et al., 2015) found hot baryon gas in the cosmic web structure near the giant cluster of galaxies labeled Abell 2744. Masses of such baryon gases as these may someday solve the mystery of the missing baryons, if sufficient quantity is detected in or between all the galaxies in the universe.

Proposed Dark Matter Locations

Dark matter has been proposed to fill in the missing mass to complete theoretical models for three hierarchical levels of universe structure and their formation. It was proposed to provide the gravity that holds single galaxies together, that holds multiple galaxies in clusters, and that helps balance Einstein's general relativity (GR) equations for the large-scale structure of an expanding universe. To satisfy all three requirements, large quantities must be located both inside, around and between all the visible galaxies. Most of the theoretical models that it completes are based on the standard model of cosmology beginning with a big bang approximately 13.8 billion years ago. The theoretical models for each hierarchical level of cosmic structure that make use of dark matter will be considered in the following sections.

Single Galaxies

Galaxies do not function the same way as stellar systems. In a star system like our solar system, the planets travel faster or slower depending on how far they are from the star. They follow Kepler's third law of planetary motion. However, in the Milky Way galaxy (hereafter Galaxy) the stars outside the central bulge orbit the Galaxy center at nearly a single linear velocity of an average 232 kilometers/second (km/s). This effect is called a flat rotation curve (DeYoung, 2000). Measurements of several nearby galaxies show that a flat rotation curve is typical for spiral galaxies (Worraker, 2002).

Isaac Newton showed that only the distributed mass within a star's orbit affects its motion around the center of the Galaxy if it follows Kepler's law. This motion is theoretically based on the virial theorem, which is applicable to a gravitationally stable system. A galaxy is considered stable if it does not dissipate or collapse over time. The virial theorem equates the gravitational potential energy within an orbit to twice the kinetic energy of the orbiting star. Astronomers using this equation have calculated that any star in the outer Galaxy that is moving at 232 km/s requires more than 5 times the amount of mass than that visibly observed within its orbit to maintain the energy balance. This energy balance provides the gravitational stability and prevents the stars from eventually exiting the Galaxy or spiraling into its center. Most astronomers have proposed that dark matter provides this invisible or missing mass. At the time of DeYoung's article, a dark matter halo was proposed for a typical spiral galaxy so that the velocity of stars located beyond 40,000 light years (ly) from the center of a galaxy would fit the observed flat rotation curve. A light year is the distance light can travel in one year in a vacuum on Earth or approximately 10 trillion kilometers.

More recently, astronomers have proposed dark matter resides inside the Galaxy within 13,000 ly of Earth. They first found that the density of visible stars within a cylindrical region centered on the solar system was enough to explain the region's orbit around the Galaxy center (Moni Bidin et al., 2012). But in a responding article (Bovy and Tremaine, 2012) the authors showed that such a result was due to the assumption that the mean azimuthal velocity of the stars does not change with distance above or below the galactic plane. They showed that if this velocity change (named azimuthal drift) is left out of the equation, there is an unobserved stellar density falloff with distance from the plane. This density falloff would result in a radial velocity of stars on the galactic plane that violates the assumption of zero radial velocity for the application of the virial theorem. They also showed that with the observed azimuthal drift included in the calculation, the amount of dark matter mass required in the vicinity of the solar system is the same as predicted by several earlier studies.

But another study (Garbari et al., 2012) used measurements of individual velocities and positions of K dwarf stars to determine their density in a volume of space. They used only the faint K dwarf stars because the distance and velocity data from that single type of star is not dependent on their magnitudes. The data for K dwarf stars that were available from a previous survey were also the most complete for any star type. They then determined the density of stars versus distance below or above the Galaxy plane. From this density of baryonic matter, they found that 2.5 times more dark matter was required than had been found in the previous studies for a volume centered on the solar system. They suggest this increased density of dark matter could be attributed to a more oblate rather than spherical distribution, and it may even point to only a disc of dark matter centered within the Galaxy disc of visible stars. From such conflicting results, which are all based on the virial theorem, it is obvious that the amount and location of dark matter near the solar system and in the whole visible disc of the Galaxy remains unresolved.

The flat rotation curve is apparently typical of spiral galaxies. However, it is difficult to apply such a curve to elliptical and lenticular (irregular) galaxies. These two types of galaxies have a majority of their stars moving in random directions and velocities. This makes it difficult to obtain galaxy rotation rate data.

Modified Newtonian Dynamics. The flat rotation curve around the center of the Galaxy of the stars outside the bulge has also been explained without dark matter. Theorists have proposed that a new law of gravity is required for galaxies. One new law developed for spiral galaxies is an ad hoc modification of Newton's law of gravitation that meets the requirements of the virial theorem and fits the measured flat rotation curves. This new theory called modified Newtonian dynamics (MOND) would be applied only when accelerations are very low due to the distance between gravity sources (masses). It sets a single universal value for the minimum acceleration of gravity at 1.2×10^{-10} ms^{-2} (Worraker, 2002). With this additional constant acceleration term, the galaxies are shown to be stable over the billions of years as required by the standard model cosmology. Many spiral galaxy rotation curves have been calculated using MOND and successfully compared to observation data. One objection that has been raised to MOND is due to Einstein's general theory of relativity (GR), which does not include such an additional acceleration term. Since the acceleration term is small, it is not involved in many of the tests that have been performed to verify GR.

Verlinde Law of Gravity. Another new law of gravity is based on a theory proposed by Erik Verlinde (Verlinde, 2011). He assumed space and gravity are emergent quantities in a quantum gravity and holographic scenario. In this scenario gravity is explained as an entropic force caused by changes in the information associated with the positions of material bodies. The relativistic generalization of this concept leads to Einstein's equations. A black hole is the clue that leads to using the holographic principle in this scenario. The mass of a black hole is related to the surface area of its event horizon, and not to its density or volume. In holography with light, a three-dimensional image is produced from a two-dimensional record (hologram) of the object. The inverse process is used to make the hologram.

In Verlinde's original theory, the gravitational potential energy at a point on a surface that acts as a holographic screen to the Galaxy's stars behind it changes as the acceleration of the individual stars cause changes in their position relative to the screen. The change in potential energy is equal to a change in entropy of the entire system behind the screen. The coarse-grained average of the changes in the acceleration of the stars leads to the value of the force of gravity at that viewing point in space.

He provided a more detailed description of his theory named emergent gravity (EG) as related to the observed universe based on assumptions found in the standard model of cosmology (Verlinde, 2016). He utilized insights from string theory, black hole physics, and quantum information theory. In this version, he replaced the idealized empty anti-de Sitter space and point sources with the galaxy-filled Minkowski space of GR and the big bang theory. One noted exception to the standard model is the absence of dark matter. He replaced dark matter by the force of quantum entanglement in his EG theory. Quantum entanglement is a property of quantum particles (photon, electrons, etc.) and as far as is known does not depend on the particle mass. In the EG theory the total energy potential ends up with an added constant term from entanglement that leads to a force equal to the MOND theory constant acceleration found at galactic and intergalactic distances. He makes another assumption that differs from the standard model cosmology, where dark energy was displaced by baryonic matter when it formed after the big bang. The elimination of the dark matter is compensated by the reduction of the amount of dark energy required to model the forming universe.

A first test of EG theory has been reported (Brouwer et al., 2016). They reported on weak lensing measurements of the apparent average surface mass density of 33,613 isolated central galaxies. They compared their measurements to EG predictions and found that they are in good agreement.

Another recent study by astronomers (McGaugh et al., 2016) pointed to a direct relationship between galaxy rotation rate and its baryon mass distribution. The measurements were made on rotationally supported (spiral and irregular) galaxies. If the flat rotation curves of these types of galaxies are supported directly by their baryon mass distribution, then any dark matter and its motion must be correlated with the baryons. Since this correlation is highly unlikely for most models, the authors claimed that a new law of gravity may be the only solution.

Satellite Galaxies, Globular Clusters, Star Streams

Further evidence concerning the distribution of dark matter in the Galaxy has been found in the proposed dark matter halo surrounding the visible stellar disc. Astronomers have found that the uniform spherical distribution of dark matter in the Galaxy halo predicted by the standard model of galaxy formation cannot be confirmed. A recent analysis (Pawlowski et al., 2012) of the position of satellite galaxies, globular clusters, and star streams relative to the orientation of the Galaxy poles and visible disc indicate a significant asymmetry in mass distribution.

The authors analyzed the motion of 24 satellite galaxies (SG) and 137 globular clusters (GC) within the proposed dark matter halo connected with the Galaxy. SGs are compact groups of stars (mostly dwarf galaxies) that are not within the basic structure of the Galaxy. The Large and Small Magellanic Clouds are the largest of these satellites with approximate diameters as viewed from Earth of 35,000 ly and 15,000 ly respectively. Their analysis showed that all 24 SGs orbit in a disc that is nearly perpendicular to the visible plane of the Galaxy. In the first half of 2015, detection of 20 more SG candidates were announced, and so far, fourteen have been confirmed. These fourteen also orbit in the same plane as the other SGs within 9 degrees of the original defined satellite disc polar orbit (Pawlowski et al., 2015).

GCs are smaller clusters of stars (typical diameters < 30 ly) than the SGs, and most are located within the basic Galaxy structure. The authors placed the GCs into three categories based on their location (inside or outside the visible disc and bulge) and color (blue for young or red for old). Their analysis showed that the 30 blue outside GCs orbit the Galaxy center in the same polar disc as the SGs. The 70 red outside GCs and 37 inside GCs orbit with the visible plane of the Galaxy.

They also analyzed the orientation of 14 star streams that have been located in the proposed dark matter halo outside the visible disc. The normal to seven of the star streams point in the same direction as the normal to the polar disc of SGs. The remainder point in a direction somewhere between the normal of the visible galactic plane and that of the polar disc of SGs.

The results of these analyses of SGs, GCs, and star streams all indicate that there is a large asymmetry in the visible mass distribution within the halo region that extends 32,000 ly to over 800,000 ly from the center of the Galaxy. A spherically uniform dark matter distribution as required by the standard model of galaxy formation cannot explain these observational data.

These results are also supported by observations of the Andromeda galaxy (M31). In a recent article, McGaugh and Milgrom (2013) reported 17 satellite galaxies that orbit the galaxy center in a disc not in the same plane as the majority of the visible stars. They went on to show that using MOND theory they could predict the dispersion of these satellite galaxies without requiring dark matter.

The authors of these articles attempted to explain formation of spiral galaxies with such an asymmetric mass distribution by attrition during one or more collisions with other galaxies. But according to the author of a recent article in *Scientific American* (Libeskind, 2014), there is not enough evidence to support collision theories for spiral galaxies. He suggested that the abnormal amount of satellites and star clusters that are out of the visible plane of a galaxy is due to the web of dark matter that supposedly formed the large-scale structure of the universe. This large-scale structure was recently described in a *National Geographic* article (Ferris and Clark, 2015).

Galaxy Clusters and Beyond

The next level in the hierarchical structure of the universe where dark matter has been proposed is in galaxy clusters. Many of these clusters contain several hundred to over a thousand galaxies in a relatively compact volume. Examples given by DeYoung (DeYoung, 2000) are the Coma, Virgo, and Abell 1060 clusters. Astronomers have detected visually 10% or less of the mass required for these clusters to be gravitationally bound in a stable configuration. The remainder (over 90%) is missing, of which the majority has been assumed to be dark matter.

Since 1933 astronomers have measured the average relative velocities of individual galaxies within clusters and then used the virial theorem to calculate the missing mass to support their assumption that the clusters are stable. The average velocity data are obtained by measuring the redshifts of the individual galaxies in the cluster. This method actually provides only the velocity data in a single dimension, and an assumption has to be made that the galaxies in a cluster move the same average amount in the other two dimensions. Also, all the velocity measurements have the Hubble law redshift for the center of mass of the system (obtained from their average redshift) subtracted to obtain each galaxy's velocity from the residual Doppler redshift. These measurements showed that the galaxies are moving relative to each other at velocities that would have disrupted the clusters in much less time than the assumed 13 billion years since galaxy clusters supposedly formed after the big bang.

For example, in the Virgo cluster, the dark matter required is 50 times the visual matter that has been detected. Most of this extra matter must be located between the galaxies since only 5 times the visual matter within a galaxy is required for typical spiral galaxies to be stable. If dark matter exists in dense halos around the galaxies in the clusters, the question becomes how those dark matter halos move with the galaxies without colliding and being distorted as galaxies pass each other.

Beyond single clusters, astronomers have found clusters of galaxies aligned in strings that form what they have named filaments in the large-scale structure of the universe. An artist's concept drawing of this structure in a two-dimensional section of the universe is shown in Figure 1. Each point of light in this structure represents visible magnitude and average redshift measurements of a galaxy of billions of stars. Astronomers have proposed that dark matter surrounds each galaxy and aligns along the strings of galaxies as structure for the filaments. The large-scale structure that includes the Virgo Cluster and our Milky Way galaxy is a super-cluster containing 100,000 galaxies that has been named Laniakea.

Gravitational Lenses

Another method used to measure the mass of galaxies and galaxy clusters is the strength of their gravitational lenses. These lenses are formed by gravity of a closer galaxy or cluster that bends the path of light from quasars or galaxies farther away as it passes by and through them. There had been approximately 500 galaxy lenses identified as of September 2015, and more have been found since. A lens formed by gravity bends all wavelengths of electromagnetic radiation the same amount, which makes them different from refractive or diffractive lenses. A conceptual drawing of the two images of a quasar (quasi-stellar radio object) that is beyond a galaxy is shown in Figure 2. A gravity lens is labeled strong if it produces multiple images of a background source that is recognized as a single galaxy or quasar by the observer through a telescope. If they just distort background sources' shape or orientation by an amount not recognizable to the observer, they are labeled weak lenses. Gravity lenses are based on Einstein's GR theory. The measurement of

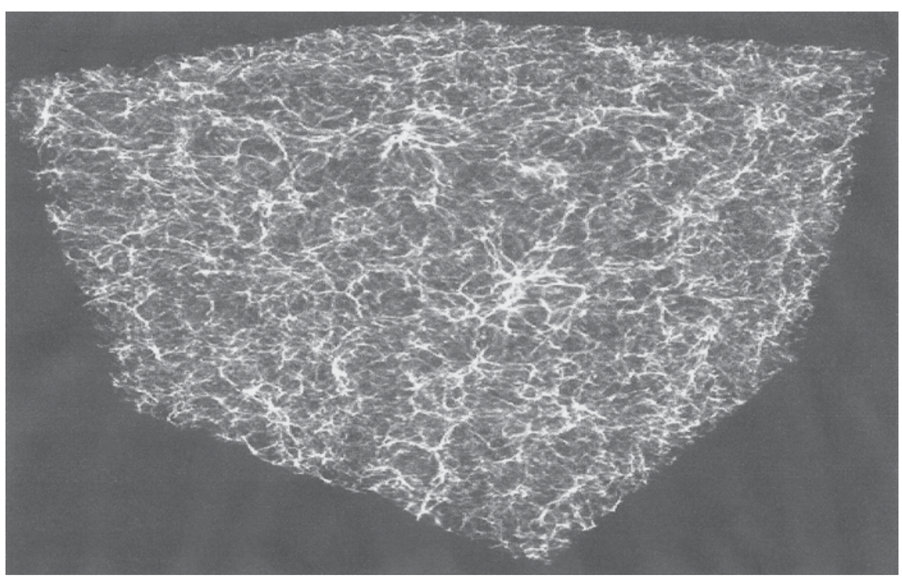

Figure 1. An artist's concept drawing of the large-scale structure of the universe in a two-dimensional quadrant as it would appear from Earth. Each point of light represents a galaxy.

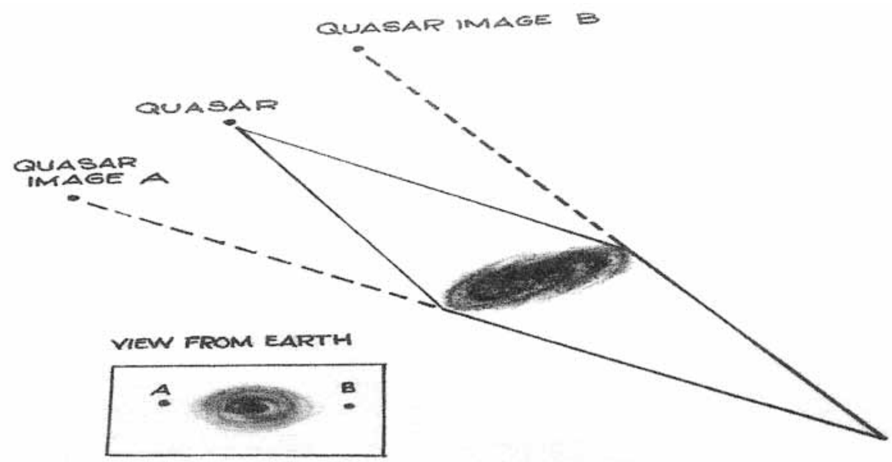

Figure 2. An artist's concept drawing that shows how two images of a single quasar are formed by a galaxy gravity lens. Inset shows the view from Earth.

the bending of light by the gravity of the sun was one of the original methods used to verify his theory. Theorists have shown that the MOND theory of gravity can be applied to lenses without the need for dark matter (Bekenstein et al., 1999).

Gravity bending of light by a star or stellar system within the Galaxy is called a micro-lens, and as far as can be determined they do not involve dark matter. In DeYoung's original article, he mentioned micro-lens events that could not be explained by ordinary matter. Since that time improved telescopes have shown that red and brown dwarf stars (visible only in the infrared spectrum at their distances from Earth) outnumber the visible stars and most likely caused these events. Because astronomers have not observed micro-lenses made of only dark matter, most astronomers now believe that dark matter does not form clumps.

Single Galaxy Lenses. Galaxies that form lenses for sources of light beyond them have been found throughout the universe. A collaboration of scientists from the University of Arizona and Harvard-Smithsonian Center for Astrophysics has compiled a list of 118 single galaxy lenses (Kochanek et al., 2013). This list is named CASTLES for CfA-Arizona Space Telescope Lens Survey. In this survey, the redshift of the lens galaxy varies from z = 0.11 to 1.01 or estimated distances from Earth of approximately 1.5 to 8.5 billion light years (bly). All the distances provided were calculated from the redshift data using a medial value of 21.5 km/s/mly as the Hubble constant. The source object redshift varies from z = 0.48 to 4.5 (6 to 12.4 bly). Recently a giant elliptical galaxy was found in a cluster at z = 1.62 (9.6 bly) that is presently the farthest known lensing galaxy. It provides an image for a tiny spiral galaxy at z = 2.25 (10.7 bly) (Wong et al., 2014).

One item that is not listed in the CASTLES survey is the estimated amount of dark matter required by the galaxy lens. According to DeYoung's original article, there is 5–10 times more dark matter in galaxies than visible matter. The observation of the images indicates that the dark matter is distributed throughout the galaxy lens and not only in a halo around it. As the search for gravity lenses continues, astronomers predict more sources will be found that are closer to the predicted limit of visibility (13.4 bly) in the early universe.

Galaxy Cluster Lenses. Astronomers have searched the distant universe (using the Hubble Space Telescope) for large clusters of galaxies that contain multiple images of galaxies and quasars indicative of strong lensing. Two examples of such clusters are MACS J1149.5+2223 and MACS J0416.1–2403. Both clusters were discovered by the Massive Cluster Survey (MACS) (Ebeling et al., 2010). Other astronomers have searched for weak lenses in clusters of galaxies using the Subaru telescope (Okabe et al., 2013). They have used the data to determine the average dark matter distribution within 50 massive galaxy clusters. Weak lenses have also been used to detect a dark matter bridge between adjoining clusters Abell 223 and Abell 222 (Dietrich et al., 2012).

Observations of cluster J1149 located at z = 0.544 (~ 6 bly) revealed 33 multiply lensed images in its central 6400 ly diameter region (Zitrin & Broadhurst, 2009). The authors used a standard model-based simulation, where the mass density $\Omega_{m0} = 0.3$, dark energy density $\Omega_{\Lambda 0} = 0.7$, and the normalized Hubble constant h = 0.7, to determine a uniform surface mass distribution of 0.5 g/cm^2 within that region. They estimated that all but 5–15% that is baryon matter must be dark matter. They estimated that fainter source galaxies in the background range from z ~ 1.5 to 2.5 (9 to 11 bly).

Cluster J1149 is unusual because of its uniform distribution of mass over its central region. This uniformity is demonstrated by five images of a spiral galaxy located along a line of sight near the center of the cluster at a redshift of z = 1.2. These images have very little distortion of the estimated 0.9 arcsecond diameter of that background galaxy and lead to a calculated magnification of this source of 200 times. Multiple images are matched to a single source by spectroscopy that determines that they have the same redshift. This is a safe assumption since a gravity lens bends all the wavelengths of electromagnetic radiation from the source the same amount.

Cluster J0416 is unusual because of the 194 images that have been identified of 68 galaxies located beyond the cluster (Jauzac et al., 2014). This cluster is located at z = 0.397 (~ 5.5 bly), and it is elongated in one direction. Because of the elongation, this cluster is considered to be a merging system evidenced by its double-peaked surface brightness of x-ray emission. The images are attributed to 68 source galaxies with redshift varying from z = 1.1 to 5.9 (8 to 12.6 bly). The astronomers calculated that a projected mass within an area of 650,000 ly across totaled 160 trillion suns to 1% accuracy. They assumed that dark matter was distributed in two cluster-scale halos and 98 galaxy-scale halos within the cluster.

An international team of astronomers led by Okabe (Okabe et al., 2013) analyzed images for weak lenses of 50 galaxy clusters of similar mass from a Subaru telescope survey. They determined from the distortion of background sources where the mass is concentrated in each galaxy cluster lens. The distribution of dark matter in each cluster is than described by its cluster mass and a concentration factor. By aligning the centers of the visual clusters and then stacking the fifty galaxy clusters on top of each other virtually, they determined a root mean square (RMS) dark matter density distribution. The RMS density distribution demonstrated that the dark matter was peaked at the center and decreases toward the edge of the combined clusters. Because the mass density distribution of the individual clusters varied significantly, they concluded that the standard model best describes the dark matter distribution in galaxy clusters.

Dark Matter Filaments. Using the standard model, astronomers have predicted that galaxy clusters occur at the intersection of large-scale structure dark-matter filaments. According to their theory, the filaments contain high concentrations of cold dark matter, and they cause the clusters to form in strings that are observed. Jorg P. Dietrich and his collaborators believe they have detected the weak lensing of such a dark matter filament between the clusters Abell 222 and Abell 223 (Dietrich et al., 2012). They claim a 4.1σ significance level just short of the 5σ required for declaring a discovery. In their best-fit models, they used elliptical clusters with the filament between them. The average redshift of the super-cluster that the clusters form is z= 0.21 (or a distance of 3 bly). They determined that the redshift measurement resolution in the distance dimension limits the significance level calculation. They also used x-ray emission data from hot gases in the super-cluster to help determine the relative positions of the Abell clusters and the orientation of their filament connection.

What Could Dark Matter Be?

In the standard model of cosmology, cold dark matter is assumed to be made of particles that have not yet been identified. Out of the many proposed candidates, five candidates have been researched more than the others. None have been found in significant quantity and/or have all the required characteristics. The leading candidate for the hypothetical particle has been named a weakly interacting massive particle (WIMP). Two other candidates that particle physicists have proposed are the axion and the sterile neutrino. Two candidates that have been nearly eliminated for consideration are the massive astrophysical compact halo object (MACHO) and a Kaluza-Klein particle that hides itself in a fifth dimension. Both of these should have been easy to detect, but neither can be found. Each of the remaining candidates has at least some of the characteristics that the standard model requires to explain observations from particle accelerator experiments and/or astronomical phenomena. All three candidates appear to be outside the standard model of particle physics and may also be eliminated in the near future by in-process experiments.

WIMPs. In Earth-bound laboratory experiments, the search for a dark-matter particle has not produced a single confirmed detection. WIMPs have eluded detection so far in five different lab experiments set up to detect them. The lab experiments, two in deep mine shafts in South Dakota and Minnesota plus three beneath Gran Sasso Mountain in Italy, have not generated consistent data between the five different methods used for detection. Also, many WIMP-type particles should already have shown up in the data produced at the Large Hadron Collider (LHC) with its energy range of 50 to 13000 giga electron Volts (GeV). All the known elementary particles except the Higgs boson had been found in even less energetic accelerators. This range of energy also rules out the neutralino, the hypothetical lowest energy super-symmetric (SUSY) particle. Neglecting the three types of neutrinos and their antiparticles, which have almost no mass, all the elementary particles and their antiparticles have been found in the energy range from 0.5 mega electron Volts (MeV) of the electron to 173 GeV of the top quark. The Higgs boson also falls into that range at 126 GeV and was the only new elementary particle found so far by the LHC.

Axions. Because of the failure to detect dark-matter particles in the expected energy range that has been searched, several new and unique candidates other than WIMPs have recently gained publicity. The axion is one hypothetical particle that has been searched for but not yet found at lower energy. It was first postulated by Peccei and Quinn as a solution to the strong force charge-parity (CP) symmetry problem (Peccei and Quinn, 1977).

According to their theory, axions should be formed from photons in a strong magnetic field such as in the cores of the sun and stars. Theorists expect axions to be detectable because they should turn into radio-wave photons in a strong magnetic field in a laboratory. They would exist as dark-matter particles only between the originating magnetic field and the detection field. Their energy is predicted to be between 10^{-6} to 10^{-3} eV, and they would have minimal interaction cross section with all ordinary particles. An experiment named Axion Dark Matter Experiment (ADMX) has been running since late 2013 at the University of Washington. Its investigators predicted that they would detect these elusive particles or prove they do not exist by the end of 2016 (Cho, 2013), but neither goal has been announced.

Sterile Neutrino. Other scientists are searching for a fourth type of neutrino designated a "sterile neutrino" because it would be its own antiparticle. Such a particle would be an example of a Majorana fermion, first hypothesized by Ettore Majorana (Majorana, 1937). So far, the experimental evidence for this new type of neutrino is insufficient to claim discovery. An experiment located at INFN Gran Sasso National Laboratories in Italy, named Cryogenic Underground Observatory for Rare Events (CUORE), has been set up to detect this particle. They are searching for the rare event of a neutrino-less, double-beta decay in tellurium-130. Normal double-beta decay in a tellurium nucleus emits two anti-neutrinos. A neutrino-less decay would signal that one of the anti-neutrinos transformed into a neutrino and they annihilated each other. The expected energy released as photons by the annihilation would be 2.528 MeV (Lawrence Berkeley National Laboratory, 2015). Neutrinos are neutral particles and therefore rarely interact with known particles.

All the hunters of dark matter are looking for particles that can provide the mass or energy that generates the gravity their theory requires. If the mass of each particle is small, there must be a large quantity, or each particle must have a high velocity. If their mass is large, they must not move at high velocities or they would interact frequently with each other. In the standard model, most cosmologists assumed WIMPs of cold dark matter exist. Their favorite WIMPs would be super-symmetric versions of the known elementary particles. But they have a difficult time justifying cold matter of any kind at energies above those reached by the LHC (13000 GeV), where no detection has surfaced.

If dark matter consists of axions or sterile neutrinos, it would be considered hot matter. They would be moving at high velocities at, or near to, the speed of light. A very high density would be required of such high-velocity particles to provide the energy for gravity 5–10 times that supplied by the visible matter in galaxies. This would tend to cause them to interact with ordinary matter or each other, and such an interaction should provide a detectable signal. There have been reports of detecting such a signal (i.e. Geringer-Sameth et al., 2015; Davis and Silk, 2015), but determining whether it results from dark matter or not still requires further research. At the present time, the energy for hypothetical dark-matter particles that have been eliminated ranges from below 10 eV and to above 200 GeV. These are extremes as far as explanations for the characteristics of dark-matter particles where both laboratory experiments and astronomical observations are concerned. A Dark Sectors workshop held in April 2016 provided a summary of the results from the search for dark-matter particles and where the search is still ongoing (Alexander et al., 2016).

A Creationist Perspective on Dark Matter

As pointed out above, the recent standard model proponents have assumed dark matter particles existed as far back as the big bang, and they have required them to be widely distributed throughout the universe. How they were distributed without interaction with baryons and photons remains a mystery. The reason the proponents presented was that the galaxies, their clusters and the whole universe itself are held together by gravity in a stable configuration that cannot be explained by the mass of detected baryonic matter. The question that evolutionists and old-universe creationists must face is this: What if dark matter does not exist? It then becomes obvious that the universe could not have evolved as presently explained by their standard model and its big bang theory.

Scientists who believe in a young world by special creation not much greater than 6000 years ago have seldom included dark matter in their models. Some even claim it does not exist and it is just a philosophical issue (Hartnett, 2015). If dark matter is discovered in the future, the young-earth creationist would say it was created with everything else in the universe sometime in the first four days. On which day it was created would depend on the person's interpretation of the events described by Genesis 1:1–19. For example, one interpretation is that God created all energy and matter at the beginning on the first day (Dobberpuhl, 2011). Another interpretation is that God created the planet Earth on the first day but the galaxies of stars among which dark matter supposedly resides on the fourth day (Hartnett, 2007). The difference in the interpretations is based on the definitions the authors used for the Hebrew words for "earth" (*'ereṣ*), "water" (*mayim*), "light" (*'ôr*) and "he made" (*'āśāh*) used in the first chapter of Genesis. The differences in these definitions between the two interpretations are shown in Table 1.

According to Hartnett's definitions, the planet Earth was created on the first day and the sun, moon, and galaxies of stars were made from nothing on the fourth day *in situ*. Since the dark mat-

Table 1. Two authors' definitions of Hebrew words in Genesis 1.

	Dobberpuhl	Hartnett
earth (*'ereṣ*)	All energy and matter combined	Planet Earth
waters (*mayim*)	Liquid earth material	Molecular water (h_2o) only
light (*'ôr*)	All electromagnetic radiation wavelengths	Visible wavelengths only
he made (*'āśāh*)	God made from existing material	God made from nothing (created)

ter, if it exists, resides in and around the galaxies, it also would have been created on that day. If Dobberpuhl's definitions are used, dark matter would have been created and separated from light photons on the first day with all the atomic matter. On the second day, it would have been spread out into the expanse and positioned where it is found along with the atomic matter. A portion of it could have been included in the formation of the galaxies of stars. Then on the fourth day, God only initiated the fission and fusion processes that turned the sun and stars into the light providers of the universe that made the heavens visible.

The questions that DeYoung asked in his "A Creationist Response" section remain relevant. But recent developments from theory and observation may have modified some of them. For example, the first question on whether the laws of nature are universal depends on mankind's understanding of those laws. One argument for assuming missing mass within a galaxy was found in their flat rotation curves. Other astronomers proposed an alternative to missing mass with the MOND and EG theories of gravity. Still others assumed a different metric than the standard model metric based on Friedmann-Lemaitre-Robertson-Walker (FLRW) cosmology. FLRW assumed that the universe is both homogeneous and isotropic. In that universe model, the relationship between redshift and distance was defined as the *Hubble constant*. More recently, observation data showed that the Hubble constant has changed with time. In the 1990s, Moshe Carmeli derived a different metric that allowed the Hubble constant to change with a time constant (Carmeli, 1996). His universe was based on five dimensions instead of the four dimensions of space-time in GR. He added a velocity dimension to GR and named it the *spacevelocity* model. Hartnett (2007) expanded on Carmeli's work to show in spacevelocity there was no requirement for dark matter in spiral and elliptical galaxies and it provided the theoretical basis for MOND. The question becomes, which law of gravity does the rotation of galaxies follow: MOND, Verlinde's EG, or Einstein's GR with the FLRW or Carmeli's metric? These laws of gravity also depend on a yes answer to the second question: Are galaxies stable with respect to the virial theorem?

Does a creation scientist have any more information about the Galaxy from the Bible? First a scriptural reason was given for the stars in the local region around the solar system to have the same linear velocity. This was reported in Genesis 1:14. We can infer from this verse that all the stars in the constellations visible to the naked eye (which are stars less than 6000 ly from Earth) were positioned and put into motion on the fourth day. With nearly the same linear velocities, the stars retain their resolvable relative locations so that their constellations remain as perpetual signs. This means that constellations change only very slowly with time, and the change would not be noticeable, at least to the naked eye in a human lifetime.

Let us assume that the same relative positioning is true for most of the stars in the Galaxy, since by its symmetry it is logical that they were made at one time. We look especially at those stars that are at the outer edge of the Galaxy's visible disc. They will remain in the Galaxy for many years because most of their initial velocity was tangential and not radial when God fixed their motion on the fourth day (Genesis 1:17). For example, a star at 50,000 ly from the center of the Galaxy that is traveling at 232 km/s of the flat rotation curve and not gravitationally bound will have moved a distance of 1 ly from the Galaxy center while traveling 316 ly in the tangential direction as depicted in the conceptual drawing of Figure 3. In the 6000 years since Creation, stars traveling at that initial velocity would have moved less than 5 ly in the radial direction. If any gravity supplied by the baryonic matter in the disc is taken into consideration, the ra-

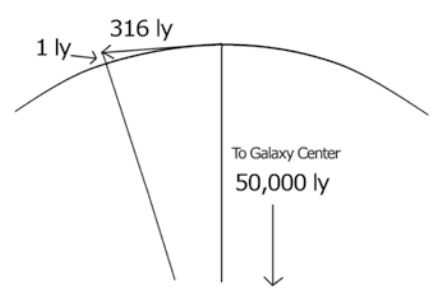

Figure 3. An artist's concept drawing (not to scale) of the motion of a star 50,000 ly from the center of the Milky Way galaxy as it would have traveled at 232 km/s without gravity. It would travel a distance of 316 ly in the tangential direction for every 1 ly in the radial direction.

dial movement would be even less. Such a small radial motion at 22,000 ly from Earth would not be detectable even with modern telescopes. Another factor to consider is that the solar system and Earth may also be moving slowly away from the center of the Galaxy, reducing the relative change even more.

DeYoung used essentially this same argument to answer his third question about galaxy clusters. If God created the galaxies in a cluster and set their motions at the beginning, they would not have moved far enough in 6000 years to have disrupted their clusters. The answer to the questions would be that they may not be stable, and the virial theorem does not hold for both galaxies and their clusters. Evolutionary astronomers claim the universe is expanding at an ever-increasing rate, so why couldn't the galaxies and their clusters also expand at a much slower rate? In fact, Carmeli and Hartnett's theory predicts such a motion (Hartnett, 2007).

One question that DeYoung did not ask but remains for creationists to answer is this: How were gravity lenses formed by galaxies and their clusters without dark matter? As believers in Creation know, the Creator was involved in the forming of the heavens and all natural processes. Scientists have not yet determined the relationship between gravity and photons at the most basic level. Newton defined gravity as the attractive force between two masses. Einstein defined gravity as the curvature of space-time caused by mass. He proposed that photons propagate along a geodesic of that curvature. But according to Verlinde's EG theory, there is a hidden force at the quantum level that interacts between photons and gravity, and it sets a lower limit on gravity. This may indicate some hidden physics connecting photons, space-time, and mass/energy that GR does not include. It could be the cause of the difficulty in combining gravity and the three other forces into a theory of everything.

A New Genesis Cosmology without Dark Matter

A new cosmology based on the Genesis creating-and-making account was proposed in the book *The First Four Days* (Dobberpuhl, 2011). The main premise of that book was that God recorded the miracles He performed during the first four days, which explained the creating and making of the physical universe in preparation for mankind's habitation. The following paragraphs provide a summary of these miracles and how they relate to a universe without dark matter. It is assumed that dark energy was God's hand in forming the stretched-out heavens. More details can be found in the book on each of the miracles that God performed.

In the beginning, God created the heavens and the earth. In this interpretation of Genesis 1:1, the heavens were a four-dimensional space-time and the earth was all the energy and matter now found in the universe. The definition of earth was obtained from Genesis 1:10, where God named dry ground "earth." Dry ground contains atomic matter, electromagnetic energy, and gravitational energy. If this interpretation is true, the originally created earth material would also have contained dark matter if it exists. From Genesis 1:2 it can be inferred that the heavens were empty except for the earthen material that was in liquid form. The liquid did not emit light (electromagnetic waves or photons), and therefore it could not have been composed of atoms. It is possible that this was a unique form of matter and energy that does not exist after the first day.

God commanded light to exist at dawn of the first day (Genesis 1:3–5). It is reasonable to assume that He formed light from the dark earthen material that He had created. God claims to form light and create darkness in Isaiah 45:7. It is also reasonable to assume that He formed atomic matter at the same time as the perpetual source for light. He allowed a portion of the light from the earthen material to propagate into empty space for daylight on that day. The remainder of the earthen material was made of a mixture of baryonic matter and electromagnetic radiation, possibly in the form of very hot plasma. There is no physical reason to believe that dark matter existed at a time shortly after the big bang in the standard model, much less in this model.

According to this interpretation of Genesis 1:6, God divided this remaining earthen material into ultra-massive black holes at the beginning of the second day. He utilized gravitational energy for the first time. Each ultra-massive black hole contained at least one galaxy worth of atomic matter and electromagnetic radiation. Psalm 104:3 could refer to these as dark clouds that God made into His chariots to carry the physical hosts of heaven to their destinations. He dispersed these black holes out into the universe near to the positions where galaxies are now found. He performed this action supernaturally in less than a half day. His actions eliminate the requirement for both the unknown initial energy for inflation and the dark energy that is now causing the expansion of the universe in the standard model.

According to this model, God made the expanse that must have included the celestial bodies, or He would not have named it the heavens. He stretched out the gravitational fields between the masses of the black holes, forming the large-scale structure or fabric of the heavens. All the movement of these masses took place at superluminal speeds (faster than the speed of light now measured in a vacuum). The dispersion to their final positions may have continued until the fourth day as described below.

Then in the second half of the same day God formed holes in the event horizons of the ultra-massive black holes to release masses of atomic matter. They formed masses made of the chemical elements that had formed within the black holes and are found in all the celestial bodies. In this manner, God spread out the earth (Isaiah 42:5) that formed the masses of all the celestial bodies and gas clouds found in each galaxy. In a spiral galaxy, the outpouring of the masses was wound up into the galaxy around the resulting super-massive black hole. First to exit would have been the satellite galaxies and globular clusters that formed the satellite disc perpendicular to the visible disc. Then the black hole could have been shifted 90 degrees to begin ejecting the liquid masses of the celestial bodies that later formed the visible disc. The celestial bodies were formed into spheres by their own gravity if they contained enough material.

In the Galaxy, the solar system was formed including the planet Earth. The star was led out by God (Isaiah 40:26) to a position located approximately 28,000 ly from the black hole in less than half a day. The hole in the event horizon that ejected the Earth could have provided the daylight for this day. God would have performed all these actions at superluminal speeds. With God's design and guidance, there would be no requirement for the universe to be homogeneous and isotropic as required by the standard model or even just isotropic as required by the Carmeli model.

On the third day, God first commanded sea water (molecular water and many other chemical elements) from pockets within the solidified crust to burst forth and cover the surface of the Earth. He then commanded the dry ground to rise above sea level (Job 38:8–11). When God gathered the water on the surface, escaping molecular gases could have formed an atmosphere. When God raised solid ground in a very short period of time, the rushing water runoff formed the surface sediment structure. The ground dried quickly before God planted the vegetation. The account reports that trees were mature and bore fruit in less than 24 hours. This indicates that vegetation growth rate was much faster than what is considered normal today. Only if all the natural rates of the processes involved were accelerated by God could everything have taken place as described for this one day.

We inferred that God also provided a protective magnetic field for Earth. He could have provided light for the second half of the third day by particles impinging on the magnetic field forming an ultra-bright aurora effect that surrounded the planet. If the galaxy was still winding up the particles and even daylight may have been provided by the hole in the event horizon at the other end of the bar at the Galaxy center as it rotated past the direction to the solar system.

Finally, on the fourth day God finished the heavens by lighting the stars in all the galaxies. He provided the Doppler redshift for them and caused the supernovae and gamma ray bursts that are observed today. The redshift of the galaxies was provided by the difference between the rate the galaxy was receding from Earth and the speed of light at the galaxy's position in space (both much faster than c at that point). In the standard model, redshift was assumed to be caused by space expansion based on the cosmological principle that the universe has no center or edge and is homogeneous and isotropic. We assumed God placed Earth near the center of the universe and provided redshifts that are quantized as a result. The supernova and gamma ray bursts observed today can be explained as a slow-motion view of what took place in one day at accelerated rates due to the one-way slowing of the propagation speed of light.

God also fixed the motions of nearby stars in the Galaxy to form the constellations that provide perpetual signs. He set the rotation of the Earth, the orbit of the moon, and their combined orbit around the sun for mankind to tell time. Until this point in Creation Week, God was the only time keeper. How God treated space-time during the first four days may always remain a mystery to us. But some knowledge from the results of His miracles can be gained that may provide some clues.

For example, on the fourth day the light from stars visible in all the constellations started and arrived on that same day. This means that light leaving stars up to 6000 ly from Earth traveled the distance in twenty-four hours or less. It would have traveled over 2,000,000 times faster than light travels now. Another indicator of what light speed was during that time would be at the Galaxy level. If it is symmetric as observed by mankind, it must have formed all at the same time. Electromagnetic radiation from the other side of the Galaxy that is now observed could not have arrived in 6000 years since Creation at its present speed. So, the assumption that the speed of light in a vacuum was always a constant could not be true for the first four days. If the constant-speed-of-light assumption is wrong, other process rates such as atomic decay rates and atomic material cooling rates also may have been accelerated the same amount.

Conclusions

In conclusion, what dark matter is and where it is located both are still mysteries. Its proposed existence was based on assumptions that may not be true. All cosmologies based on GR and the FLWR metric have now assumed that it exists, and it will be found. They also assumed that the speed of light has always been a constant. Another cosmology by Hartnett and Cameli based on a different metric that replaced empty space with a fabric and added a velocity dimension has already removed the requirement for dark matter. But their ad hoc assumptions may still hide unknown processes that relate time, space, and matter/energy during the first four days. Only a cosmology based on the correct interpretation of what God provided in His Word can hope to meet all the requirements. That cosmology may never be developed or understood by mankind. So, unless dark matter is located and identified, the question of whether it actually exists within our universe will remain unanswered.

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