Implications of Dark Matter/Dark Energy to the Understanding of Reality

Francis P Xavier SJ, Gasson Professor, Boston College, USA and
Vice President for Academics and Research, JWL, Geneva, Switzerland

Abstract:

It is generally accepted that the universe originated from the 'Big Bang', which occurred when the temperature of a very concentrated matter was about 10^{31} degree centigrade. Today scientists formulate that only about 4.6% of the mass of the universe seems to be of ordinary (visible) matter and about 23% is thought to be composed of dark matter (invisible or virtual). The remaining 72% is thought to consist of dark energy distributed diffusely in space. This paper tries to understand: i. the zero point of Big-Bang, which witnessed the creation of particles and anti-particles and the subsequent disappearance of anti-particles from our Milky Way but existing beyond our universe; and ii. why gravitational force in our universe is attractive while it is repulsive beyond million- and hundred-million light year scale. Presenting the nature of matter and anti-matter, the paper goes further into the origin and existence of dark-matter and dark-energy, which would be eventually taken over by the second law of thermodynamics. An attempt is made to understand the reality from the perspectives of the missing matter (Dark-Matter) in the universe, which is an embarrassment in science and an unsolved mystery in nature. Hope this paper throws some light on Dark Matter/Energy.

Keyword: Dark Matter, Dark Energy, Big Bang, Reality, Universe

Discoveries:

Ptolemy (85 – 165 BCE), in his treatise the *Almagest*, explains that the earth is spherical, motionless, and positioned at the center of the universe. Even in the 1920s, most physicists believed that the universe was static, or unchanging in size.[1] In 1929, American astronomer Edwin Hubble studied, at the Mount Wilson Observatory, exploding stars known as supernovae. He found that nearly all galaxies were moving away from us, and the farther away they were, the faster they were moving.[2] [The galaxies are rushing away from the Earth at about 40,000 Km/sec, that is about 90 million mph.[3]]

In 1933 Fritz Zwicky, a Swiss astrophysicist, inferred (using virial theorem) the existence of the unseen matter, which he referred to as *dunkle Materie* ('dark matter'). He indicated that there was much more estimated mass than was visually observable. This was the first proposition for the presence of 'dark matter'.[4] Zwicky concluded that this non-visible form of matter would provide enough of mass and gravity to hold the visible galaxies in the cluster. Assuming that the visible material makes up only a small part of the cluster, galaxies show signs of being composed largely of a roughly spherically symmetric, centrally concentrated halo of dark matter with the visible matter concentrated in a disc at the centre. Thus most of the galaxies is in fact dominated by dark matter. (Dark Matter is non-luminous or sub-luminous material whose existence could be deduced from its gravitational effect on visible matter.[5])

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[1] S. Hawking and L. Mlodinow, *The Grand Design*, Bantam Books, London, 2010, p.71

[2] https://www.space.com/20929-dark-energy.html

[3] https://www.space.com/15665-edwin-powell-hubble.html

[4] https://en.wikipedia.org/wiki/Fritz_Zwicky

[5] V. Trimble, The World Line of Dark Matter: Its Existence and Nature through Time, In: D.B. Cline (Ed), *Sources of Dark Matter in the Universe*, World Scientific, Singapore, 1995, p.10.

In 1963, Vera Rubin, observing the rotation of galaxies at the McDonald Observatory, discovered an apparent anisotropy in the expansion of the Universe on the scale of 100 million light years (The Rubin-Ford Effect). She uncovered the discrepancy between the predicted angular motion of galaxies and the observed motion, by studying galactic rotation curves. Other astronomers discovered, that the rate at which the stars rotate around individual galaxies is similarly out of sync. Detailed observations have shown that stars far from the center of galaxies are moving at much higher velocities than can be explained by the amount of visible matter that the galaxies contain.[6] This phenomenon came to be known as the galaxy rotation problem, and it became as the evidence of the existence of dark matter, encompassing spiral galaxies. Rubin indicated, through calculations, that galaxies could contain at least five to ten times as much as dark matter as ordinary matter.[7]

In 1970s astronomers generally accepted the idea, persuaded by new evidence that rotating galaxies would fly apart without the stabilizing gravitational attraction of dark matter.[8] In the 1990s, two independent teams (one at Johns Hoskins University) of astrophysicists studied distant supernovae to calculate the deceleration. To their surprise, they found that the expansion of the universe wasn't slowing down, but it was speeding up![9] They assumed that something must be counteracting gravity – This they labeled as dark energy.[10]

In 2005, astronomers from Cardiff University (Wales, UK) claimed to have discovered a galaxy, 50 million light years away in the Virgo Cluster (named as VIRGOHI21), made almost entirely of dark matter. The dark matter component is assumed to have much more mass than the 'visible' component of the universe. Today, according to many scientists, only about 4.6% of the mass of the Universe seems to be of ordinary matter and about 23% is thought to be composed of dark matter. The remaining 72% is thought to consist of dark energy, an even stranger component, distributed diffusely in space. Dark matter/energy seems to pervade all through the universe, though with varying intensity (just like the unconscious pervading our whole conscious system). Dark matter may be present in the form of many undeveloped stars or of already cold compact stellar objects.

In January 2012, Christoph Weniger, a physicist at the University of Amsterdam, discovered a strange type of radiation around the center of our galaxy. He interpreted that the glow could be a signal of dark-matter particles smashing into each other and, in the process, transforming from something invisible to something visible.[11] The detection (on Oct 16th 2017) of gravitational waves created by two neutron stars smashing into each other (about 130 million years ago) confirms dark matter in the universe.[12]

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6 https://news.vanderbilt.edu/2013/06/10/dark-matter/

7 https://en.wikipedia.org/wiki/Vera_Rubin

8 http://discovermagazine.com/2013/julyaug/21-the-possible-parallel-universe-of-dark-matter

9 http://www.pnas.org/content/112/5/1243.full.pdf

10 https://www.space.com/20929-dark-energy.html

11 http://discovermagazine.com/2013/julyaug/21-the-possible-parallel-universe-of-dark-matter

12 https://news.nationalgeographic.com/2017/10/gravitational-waves-discovered-neutron-stars-pictures-science/#/01-neutron-star-merger.jpg

According to Sathyaprakash of Cardiff University, "the violent process in the universe, such as merging black holes and neutron stars, supernovae, and other cosmic phenomena", while studied together with Einstein's theory of gravity, could "solve riddles of dark matter and dark energy."[13]

Perception of Reality:

The perception of reality has gone through many phases of increasing understanding:

1. Initially Aristotle (384-322 BCE) proposed single dimensional world view, through the so called 'Correspondence Principle' (fact/object-reality relationship[14] or cause-effect relationship). What we see here is the reflection of what is there above.
2. Euclid (323-285 BCE), often called the 'father of geometry', made it two dimensional: The world is flat as we could see on a plane.
3. After a long gap of thirteen centuries, Newton (1643-1727 CE) came to enhance the world picture – He made it three-dimensional. He was instrumental in the scientific revolution. His laws, especially the laws of motion and the law of gravitation, still rules the world on a macro scale.
4. The world-view was fine tuned by Einstein (1879-1955 CE), who proposed four-dimensional concept of the universe, adding time to the three-dimensional concept, known as space-time continuum, soon ushering in matter-wave nature of quantum picture of reality. We are familiar with the conflict between Newton's absoluteness of space (deterministic mass and length concept) and time and Einstein's space-time continuum and relativity of mass, length, and time. That light is deflected by gravity was a revelation especially when it was experimentally verified. We are also familiar with the tension between Einstein's world and the world of quantum theory: Einstein did not feel comfortable with the quantum theory concepts of probability, uncertainty principle, non-locality of particles etc.
5. The world picture seems to be still incomplete. Whatever be the reality, what exists is what one perceives! It is the consciousness that gives the fifth dimension to the reality. This becoming conscious of reality goes beyond the deterministic world of Newton as well as the relativistic world of Einstein. What is out there could be only a possibility of various probabilities, depending on one's perception and understanding.

Hence, the perception of the world, physically or conceptually, is a possibility of probability – a spectrum of possibilities. [Probability: Everything we hear is an opinion, not a fact. Everything we see is a perspective, not the truth – Marcus Aurelius.]

In fact, the conflict between Einstein's world and the quantum world comes out in a strong way when we consider his theory of general relativity. *General relativity* is the theory of the very large while *quantum theory* is the theory of the very small. Normally there is no overlap between the two and there comes in conflict especially at the birth of the universe. If we are going to find *a better description of reality* then we need the combination of the two, that is, the *quantum theory of gravity*.

The incompatibility between general relativity and quantum theory comes from the fact that general relativity, like classical mechanics, is the recipe for predicting the future with certainty.

[13] https://www.cardiff.ac.uk/news/view/201214-space-time-ripples-detected-for-the-very-first-time

[14] https://plato.stanford.edu/entries/truth-correspondence/

All things are predictable with certainty. Quantum theory, on the other hand, is the recipe for probabilities. With quantum theory we can only predict the probable position and probable path with uncertainty. Quantum theory, therefore, undermines the very foundation stone of general relativity. Now researchers are trying to combine quantum theory and general theory of relativity by using a number of approaches. One such approach is the superstring theory, which views the fundamental building blocks of matter not as point-like particles but as ultra-tiny pieces of strings.

But our life-journey of understanding the reality, as it is, is not over: In this paper an attempt is made to explore the missing matter and missing energy, namely dark matter and dark energy. The concept of dark-matter and dark-energy seems to explain, to certain extent, the origin of 'Big Bang', namely where from did the 'matter' and 'energy' come for the 'Big Bang' to take place and how the Big Bang actually occurred.

Origin of the Universe:
In the beginning of the time, most scientists believe, there was a 'Big Bang'. About 13.7 billion years ago our universe was only a few millimeters across[15]; and the temperature of the universe, at about one-hundredth of a second, was about 10^{31} degrees of Centigrade (At that point of time, the entire universe would have acted as a nuclear fusion reactor). We do not know how much matter (visible) was present but we could see there was enormous amount of energy (using, Energy E = kT, with T as the initial temperature and k, Boltzmann's constant).

Universe loves as well as keeps up balance and symmetry. According to the Yin-Yang principle of ancient Chinese Philosophy (3rd century BCE), things exist as inseparable and contradictory opposites, such as female-male, dark-light, positive-negative etc. The two opposites attract and complement each other and a correct balance between the two would result in harmony. According to this mythology, yin and yang were born from chaos when the universe was first created and they were believed to exist in harmony at the center of the Earth.[16] We could compare it with the creation story depicted in the book of Genesis: 'Now the earth was formless and empty, darkness was over the surface of the deep, and the Spirit of God was hovering over the waters' (Gen 1:2). From this void came all that came to be: God created or it came to exist by itself (by a Grand Design?). If we believe that God created, it is fine, then we believe that 'in him we live and move and have our being' (Acts 17:28). We could also take the Big Bang as the origin of events in the universe.

Initially, if symmetry were to hold good, there were particles and anti-particles. Anti-particle is literally the mirror image of normal matter/particle, ie. with same mass and spin but with opposite electrical charge. When a particle encounters an anti-particle the result is mutual annihilation with the release of energy (mainly γ radiation) as shown below:

Particle + anti-particle → annihilation + radiation.

They, particle and anti-particle, when brought together, disappear and their kinetic energy and rest-mass energy could be converted into other particles.

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[15] S. Hawking and L. Mlodinow, *The Grand Design*, Bantom Books, London 2010, p.230.

[16] ttps://www.ancient.eu/Yin_and_Yang/

But the symmetry between particles and anti-particles were somehow broken in order to make way for the evolution of life to appear on the face of our universe. We can have a glimpse of it as we analyze the building block of matter, namely atom. An atom is made up of positively charged nucleus as the core (containing positively charged protons and neutrons with no electrical charge) with a periphery containing clouds of negatively charged electrons (and the number of positive charges and negative charges would be equal). Still neutron with no charge is influenced by magnetic field since it exhibits magnetic moment – This is, according to Yukawa, since neutron is a combination of positively charged proton coexisting with a negatively charged π-meson (That explains why the neutron mass is slightly higher than that of the proton). This can be depicted as follows:

$atom^{o} = nucleus^{+} (protons^{+} + neutrons^{o}) + electrons^{-}$ with

$neutron^{o} = proton^{+} + pi\text{-}meson^{-}$ (the superscripts +, - , and o indicating positive, negative, and neutral electrical charges).

And now theories are formulated that a proton might be made up of three quarks! And Einstein's $E = mc^2$ explains the equivalence of mass and energy, ie. mass is the concentrated form of energy. Given the fact that our universe is filled with life, right now our universe (meaning the Milky Way) has very little anti-particles whereas distant galaxies have more of these. Comparing $E = mc^2$ and the fact of enormous amount of energy, causing the 'Big Bang', we need some explanation for the imbalance between the two, namely mass and energy.

Interpretation of Second Law of Thermodynamics:

The imbalance between mass and energy could be analyzed thermodynamically. The first law of thermodynamics establishes the conservation of energy, namely the amount of energy in the universe is constant and hence energy can be neither created nor destroyed but could be transformed. But in the process of transformation, certain amount of energy is permanently lost and is termed as 'entropy'. Therefore the available energy, according to the second law of thermodynamics, continuously decreases (which means the entropy is on the increase). When entropy reaches the maximum, nothing can exist and hence the heat-death of the universe is the result. But the question is: where did the energy initially come from for the 'Big Bang' to occur? There might have been a tremendous dense source of energy, given the relatively small amount of mass, building pressure and temperature ($PV = RT$) finally leading to explosion ($E = kT$). As $E = mc^2$ and $E = kT$ may not balance each other, we tend to believe in the existence of unknown-energy, labeled dark-energy (and hence dark-matter), that caused the Big Bang. The dark matter is invisible to us!

Matter and Anti-Matter:

Antimatter is an extension of the concept of anti-particle to matter. In general,

a. Our immediate universe (ie. earth, solar system, Milky Way) is mostly made up of matter with very little of anti-matter (Milky Way is a flat disk of stars with a diameter of 80,000 light years and a thickness of 6,000 light years); and
b. Anti-matter comes from anti-region (which is a region of powerful flux of gamma-ray radiation).

Antimatter is also produced in some radioactive decays (eg. carbon and neon) as indicated below:

^{14}C: One neutron decays into proton + electron + anti-neutrino.
^{19}Ne: One proton decays into neutron + positron + neutrino.
And also these conversions are reversible as indicated below:

Anti-neutrino + proton ↔ positron + neutron and

Neutrino + neutron ↔ electron + proton.

And it is interesting to see how these matter/particles have been predicted and discovered.

Let us consider the derivation of Einstein's Mass-Energy equation.[17] The kinetic energy (K) of a body is equal to the increase in its mass as consequence of its relative motion multiplied by c^2.

$$K = mc^2 - m_oc^2, \text{ where } m_o \text{ is the rest mass.}$$

Rearranging the equation we have,

$$mc^2 = m_oc^2 + K$$

If the kinetic energy is decreased so as K = 0, then the body will be at rest. However, it will still have energy m_oc^2. In other words, the body contains energy E_o when stationary relative to its frame and will have mass m_o, known as the rest mass. This is shown as:

$$E = E_o + K, \text{ where } E_o = m_oc^2.$$

For a moving body the energy E is:

$$E = mc^2 = m_oc^2/\sqrt{(1-v^2/c^2)}$$

1928 Paul Dirac presented $E = mc^2$ as $E = \pm mc^2$ (implying energy and dark-energy).
1930 Paul Dirac proposed the existence of positron as anti-particle of electron.
1932 Carl Anderson discovered positron in the cloud chamber experiment.
1955 In Berkley (USA), anti-proton was discovered.
1998 CERN produced anti-atom (which survived for 40 nano-sec).
In 2012, Higgs Boson, known as 'God Particle' was discovered.[18]
[In CERN, Conseil Européen pour la Rechereche Nucléaire, using the atom-smasher (particle accelerator and collider) temperature of the order of big-bang temperature (ie. ~10^{31}C) was created and the collision of particles was carried out and studied using cloud chamber.] The Higgs particle may be responsible for the mass of fundamental particles such as quarks, but quarks alone can't account for the mass of most of the visible matter in the universe—that's everything we see and sense around us.[19] So there could be other sources of matter!

Dark Matter-Energy:
Some physicists would agree that even seemingly solid matter is mostly empty space. Take an example of an atom: The distance between the centres of the atoms is so vast compared to their actual size – Still interesting, even the inside of an atom is mostly of empty space with core nucleus and electron cloud constantly in motion! If an atom could be blown-up to the size of our planet earth, then the electrons would be visible to the naked eyes. What is more important is the vibrational frequency, due to particles in motion, which is energy. Dark-Matter is a kind of blank-state: It is an embarrassment in science and an unsolved mystery in nature. What it is and how/why it was generated are not clearly known.

[17] http://www.emc2-explained.info/Emc2/Deriving.htm#.Wcq8Wzlrx-U

[18] https://www.nbcnews.com/science/science-news/god-particle-new-cern-experiments-shed-more-light-higgs-boson-n419926

[19] https://phys.org/news/2012-08-quark-higgs.html

Dark matter does not interact with the electromagnetic force – That is, it does not absorb, reflect, or emit light. Hence, it is extremely difficult to spot it. But 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. Dark energy appears to be associated with the vacuum in space. It is assumed that it is evenly distributed throughout the universe, not only in space but also in time – That is, its effect is not diluted as the universe expands. The even distribution implies that dark energy does not have any local gravitational effects, but rather a global effect on the universe as a whole. This brings in a repulsive force, which tends to accelerate the expansion of the universe.[20]

It is believed that the visible matter in the universe accounts for only 4.6% of the total matter (ie. mass and energy) – This is called 'well behaved ordinary matter'; while 24% of the universe-matter is invisible matter (known as 'dark-matter') and there is no clue regarding what it is. And the rest, ie. 71.4%, would be of dark-energy.[21] This explains why there was a Big Bang with relatively smaller amount of mass in the beginning of the universe. Further, this was, as S. Weinberg would put it, "not an explosion like those familiar on earth, starting from a definite centre and spreading out to engulf more and more of the circumbient air, but an explosion which occurred simultaneously everywhere, filling all space from the beginning, with every particle of matter rushing apart from every other particle".[22] Today the universe is extended over 476 million light-years apart.[23]

Another argument in favour of the dark-matter is: The amount of matter visible in the cosmos is not nearly enough to account for the movement of the stars and galaxies that we observe. They behave as if huge amounts of invisible matter are pulling them about. Galaxies, like our Milky Way, contain about 10 times as much matter as is visible in stars. This invisible matter is known as the 'dark-matter'. The dark-matter holds the stars in their orbits and stops them from flying off into intergalactic space and at the same time causes expansion.

Inflation Theory:
The universe, initiated by the 'Big Bang', started to expand. The universe 'inflated' during its first split-second of explosion due to the phenomenally violent expansion. What drove the expansion was a peculiar event that took place in the vacuum of empty space. The 'inflation' is understood as any two marked dots, growing in distance, on an ever expanding balloon (a concept of Arthur Eddington at Cambridge University in 1931[24]) – Thus objects were flying apart from each other. And this exploding-expansion was very much necessary to keep off particles from anti-particles lest they would destroy each other. With inflation theory plus the dark matter tagged on, the big-bang theory is better understood. In fact, when the scientists talk about Big Bang they mean:

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[20] https://home.cern/about/physics/dark-matter

[21] https://map.gsfc.nasa.gov/universe/uni_matter.html

[22] S. Weinberg, The First Three Minutes: A Modern View, Basic Books, New York, 1977, p.5.

[23] R. Panek, *The 4 Percent Universe*, Houghton Mifflin Harcourt, New York, 2011, p.210.

[24] S. Hawking and L. Mlodinow, *The Grand Design*, Bantom Books, London, 2010, p.160.

dark energy
Big-Bang → Inflation with Matter + Dark-Matter.

Characteristics of Dark-Matter:
Dark-Matter is the universe's missing matter (ie. *terra incognita*). Physicists believe that the dark matter is composed of some novel subatomic particle *axion*, a hypothetical elementary particle postulated in 1977. It has little mass and interaction with other matter; and it has no electric charge and no spin and no kinetic energy. In analogy, to understand, we could think of

i. Photon which has zero mass and zero electric charge but it is real nonetheless since it possesses definite momentum and energy; and
ii. Neutrino with no charge, extremely small mass, spin (1/2), and interacting feebly with matter but possessing energy and velocity more than that of light. A neutrino could easily pass through without interaction with matter.

Richard Massey (at CalTech) formulated that dark matter, though invisible and transparent, has gravity. Dark matter has been created abundantly during the Big Bang but we do not know what it is but we could spot where it is. It is, like any object, affects light or other radiation that passes through it or nearby (Cf Nature: Dark matter mapper, 7 Jan 2007). According to Eric Linder (at Lawrence Berkeley National Laboratory), cosmologists can map a concentration of the universe's unseen mass through the gravitational deflection of light coming from sources behind it. In 1977, it was postulated that the possible deposit of anti matter was near the centre of the galaxy.

Dark matter appears to form the scaffold (like DNA in biology) upon which the visible matter of the universe, the galaxies, is assembled. Visible galaxy clusters seem to be embedded in vast clumps of dark matter connected by titanic bridges of dark matter called filaments. Cosmologists now suspect that early on in the formation of the universe the dark matter formed a framework around which 'normal' matter could coagulate.

Dark-Matter *vs* Dark-Energy:
Are dark-matter and dark-energy the same or equivalent? It is believed that dark matter and dark energy need not be necessarily related. According to Robert Scherrer (at Vanderbilt University) the density of dark matter decreases as universe expands but density of dark energy stays constant even as universe expands – This may be, as per the Steady-State-Model of the Universe, that new matter is continually created to fill up the gaps between the galaxies created by expansion of the universe racing out at an ever-increasing faster space (as confirmed by the Hubble Space Telescope). Hawking would explain, based on supersymmetry model of the universe, that there are 'force particles and matter particles' as 'two facets' of reality.[25]

Continuing Creation:[26] If 'creation out of nothing' implies transcendence of God, the 'continuing creation' brings in the immanence of God. But we do not consider transcendence and immanence mutually exclusive affirmations about God. Theology has traditionally held the doctrines of creation out of nothing and continuing creation to be interrelated on the view that they are complementary aspects of God's creative involvement with the physical universe. The

[25] S. Hawking and L. Mlodinow, *The Grand Design*, Bantom Books, London, 2010, p.146.

[26] F.P. Xavier, God of the Atoms, LIFE/ISPCK Pub, Delhi (2006), p. 81f.

creatio ex nihilo concept was formulated and defined at a time when the universe was believed to be static. But today we believe in a dynamic universe and hence there should be the concept of continuing creation (*creation continua*). Barbour, clarifies this view in his words as:

> Today the world as known to science is dynamic and incomplete. Ours is an unfinished universe that is still in the process of appearing. Surely the coming-to-be of life from matter can represent divine creativity as suitably as any postulated primeval production of matter 'out of nothing'. Creation occurs throughout time.[27]

Dark energy is a strange force field, first formulated by Einstein, which permeates all of space, creating repulsive force that seems to be causing the universe ever to expand. [Once **Einstein** knew the universe was expanding, he discarded the cosmological constant as an unnecessary fudge factor. He later called it the "biggest blunder of his life," according to his fellow physicist George Gamow.[28]] Physicists agree that this repulsive force stops the galaxies from falling into each other due to their mutual gravitational attraction – It is a force field against the universal gravitational force ($F = Gm_1m_2/r^2$, with m_1 and m_2 the masses of objects 1 and 2, r the distance between the two masses, and G the gravitational constant). As dark matter is essential to hold galaxies together, dark energy keep off particles from anti-particle lest there should be mutual annihilation and radiation.

Competing Forces in the Universe:

Assuming dark energy as the origin of Big Bang leading to cosmic explosion, the expansion of the universe set in, according to the inflation theory. From the Big Bang, the whole universe exploded from an intensely hot body and as the various pieces were flung outward, the spinning pieces became parts of the universe. But now there are two forces, which are competing with each other, namely, the velocity (v) with which the universe is expanding and the gravitational force (g) which tries to attract everything closer together. At present,

$$v > g$$

that is, the universe is still expanding. But the difference between v and g is slowly but steadily decreasing. That means there will come a time when

$$v = g$$

and then onwards it would be

$$g > v$$

that is, the gravitational force will begin to take over. Then the implosion of the universe will begin. The universe will fold, so to say, on itself and as the size of the universe becomes smaller and smaller, the density of the universe will increase and the temperature will rise enormously. This is the beginning of black-hole from which nothing, not even light, will escape – This would be the Big Crunch. And at this stage, it is probable (as the volume of matter condenses and pressure within increases as the temperature rises high, according to PV = RT) that there will be another explosion (Big Bang), which will be the birth/rebirth of another/same universe.[29]

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[27] M.W. Worthing, God, Creation and contemporary Physics, Fortress, Minneapolis, 1996, p.112.

[28] http://hubblesite.org/hubble_discoveries/dark_energy/de-did_einstein_predict.php

[29] F.P. Xavier, God of the Atoms, LIFE/ISPCK Pub, Delhi (2006), p. 20.

But the interaction of v with g is valid only in our universe where gravitational force is attractive but beyond Milky Way and further the gravitational force, due to dark energy, is repulsive keeping particles and anti-particles apart. That is, dark energy supersedes gravity beyond our system. Thus dark energy continues, at larger scale of millions of light years, with cosmic expansion. Ultimately, the second law of thermodynamics would become operative. Hence, the role of dark energy is to delay the gravitation-caused-implosion on the larger scale of the universe.

Characteristics of Dark-Energy:[30]
The following are some of the characteristics of Dark-Energy:

1. It makes up 72% of the universe: 4.6% normal matter (all atoms, molecules, etc); 23% dark matter (which doesn't interact with the universe, except with gravity); 72% dark energy. [Analogy: 60% weight of a grown up adult or an animal is made up of water[31], while it could go up to 95% for plants.[32]]
2. It is an impulsive force that pushes against space-time: As the universe expands, the fabric of space is filled with dark energy, further pushing space-time outward. It causes the acceleration of the universe, providing an impulse pushing things apart causing more expansion.
3. It is smooth and persistent throughout the universe: It is assumed to be everywhere (more or less homogeneous) and the density remains the same as the universe expands.

Consequences of Dark-Energy:
Applying $E = mc^2$ (mass-energy equivalence) the following are the characteristics of dark energy:

a. Every cubic meter of the universe contains energy equivalent to 10^{-16} kg (ie. a handful of H_2 atoms in weight). Dark energy in our solar system would amount to the mass of a small asteroid but dark energy is everywhere (though the intensity varies).
b. Dark energy determines the expansion rate of the universe and at the same time acts as 'matrix' (or 'scaffolding') on which the galaxies are hung.
c. Dark energy has negligible effect on anything smaller than the super cluster scale. For example, in our system (ie. within a scale of thousands of light years) gravity is dominant. Beyond that, ie. over million- and hundred-million light year scale, effect of dark energy is dominant, with the consequence that the star formation seems to have slowed down.
d. According to some astronomers, dark energy is the cause of apparent cosmological evolution.

Understanding of the Reality: Wonders of the invisible World
A galaxy consists of billions of stars and their solar systems. In our galaxy, Milky Way, sun is one of 200 billion stars (and no other solar system has been discovered). According to astronomers, there could be 100 billion galaxies (It could be 200 billion). And the distance from earth to the edge of observable universe is 46.5 billion light years (ie. 4.4×10^{26} m).

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30 http://www.everyjoe.com/2008/03/25/technology/six-characteristics-of-dark-energy-191/

31 https://en.wikipedia.org/wiki/Body_water

32 https://www.slideshare.net/syedtaimurrahim/water-in-animal-nutrition

At the singular point of the universe, it is assumed, there was neither mass nor energy – There was void. Then in the beginning of the Big Bang, matter was created from dark energy, each particle along with its anti-particle. Due to misalignment (or pre-determined) mechanism, very little anti-matter was left out in our galaxy. Matter and dark matter began operating at different scale: Matter within our galaxy, ie. the Milky Way, was dominant giving rise to life (with attractive gravity in the near absence of anti-matter), while dark matter became dominant, beyond the scale of millions of light years, with repulsive gravity keeping matter from anti-matter.

Physics laws, we could assume, operate differently depending on dimensions and scales: Within the nucleus like-charges (ie. protons) attract each other but outside of it like-charges repel each other. Atom, which is the building block of matter, is made of core positive charge with the periphery of negative charge. Conversely cell, which is the building block of biosystem, comprises of negatively charged inner core and positively charged protoplasm (periphery). While an atom has rest mass energy, with increase in mass as the velocity increases, a cell possess energy revealed through the characteristic vibrational frequency.

Probability principles apply to micro world of subatomic particles, while Newton's laws hold good for the macro world. And Kepler's laws govern planetary motion. Gravitation itself seems to vary from attractive to repulsive depending on the dimension of the universe. In the realm of dark matter the possibility of life is little given the detected background radiation of 3 K, discovered by Robert Wilson in 1964, from outer space (in which condition life cannot originate and survive).

Within our galaxy the cycle of big bang and big crunch, termed as explosion and implosion, would result in exhaustion of mass and energy eventually leading to heat-death of our galaxy. On the other hand, if the dark energy's repulsive force, at some point, begins to decrease in strength with time, the universe might eventually reverse course and collapse. Entropy will begin to act finally on dark matter and dark energy with final result of ultimate heat-death of the universe. At that point, when repulsive gravity fails, union of matter and dark-matter would result in the ur-energy (or ultimate energy) and that would be, in Teilhard de Chardin's term, the culmination in the Omega Point.

Implication of the Dark Matter/Energy:
Dark matter/energy seems to pervade all through the universe. Dark matter does not interact with the visible matter nor with electromagnetic force – That is, it does not absorb, reflect, or emit light (except through gravitational effect). Though invisible and transparent, it has gravity. Dark matter seems to outweigh visible matter roughly six to one.

Dark matter appears to form the scaffold (like DNA in biology) upon which the visible matter of the universe, the galaxies, is assembled. It is the matrix for the universe – The dark-matter holds the stars in their orbits and stops them from flying off into intergalactic space and at the same time causes expansion. At the creation or at Big Bang particles and anti-particles would have been created. The anti-particles have been forced outside of our Milky Way, where the gravitational force is repulsive.

It is believed that dark matter and dark energy need not be necessarily related. The density of dark matter decreases as universe expands but density of dark energy stays constant even as universe expands. The dark energy is propelling the expansion of the universe sustaining the stability of the universe at the same time. As dark matter is essential to hold galaxies together, dark energy keep off particles from anti-particle lest there should be mutual annihilation and radiation

Given the multi-reality, one wonders at the possibility of another universe. Our universe may be one of the many, physicists say. The scientists are now looking into the question of: Universe or Multiverse?[33] The possibility of a multiverse is raised by the theory of cosmic inflation. However, science, especially the laws of nature, would tell us *how* the universe behaves, but would not answer the *why* questions. Science may understand and explain the universe as a Grand Design but science may not indicate who the Grand Designer is. And science has not said the final word!

- Gasson Lecture at Boston College, USA
01st Nov 2017

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