

# MOLECULAR DIFFUSION MODEL AS AN ALTERNATIVE TO DARK ENERGY

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## ABSTRACT

Dark energy is rightfully considered to be the reason for causing the accelerated expansion of the universe. Universe expanding at an accelerated rate instead of slowing down or coming to a stop seems extremely uncanny. The Big Bang theory is strongly favoured and the most accepted theory for the origin of the universe. On the other hand the competing Steady State theory also has an equal importance. In this paper I present a theory that bridges the gap between the Big Bang theory and the Steady State theory. The molecular diffusion model has been introduced in this manuscript as an alternative to dark energy in order to explain the mysterious accelerated expansion of the Universe.

**Key words:** Big Bang theory - Steady State theory - dark energy - accelerated expansion.

## 1 INTRODUCTION

The Universe is expanding towards the infinity and beyond at an accelerated rate instead of slowing down or even coming to a halt. A mysterious energy rightfully termed as dark energy is considered for causing the Universe to expand at an accelerated rate. Dark energy introduced itself 5 billion years ago (Frieman, Turner and Huterer 2008) and since then the Universe has continued to expand at an accelerated rate; before this time the expansion of the Universe was decelerating due to the gravitational attraction of matter. The accelerated expansion of the Universe was discovered independently by the High-Z Supernova Search Team in the 1998 (Riess et al.) and by Supernova Cosmology Project team in the 1999 (Perlmutter et al.) by measuring the distance to Type IA supernovae from their brightness (standard candles) and then comparing this distance with the supernovae's cosmological redshift. Dark energy fills the entire Universe just like the Cosmic Microwave Background Radiation (CMBR), but unlike the CMBR whose energy density decreases with time as the Universe expands; the energy density of dark energy remains constant.

The Big Bang theory is the most accepted theory regarding the origin of the Universe. The theory was first developed in 1927 by Sir Georges Lemaître after which the theory was revived and revised by Sir George Gamow in 1946. CMBR is the strongest proof regarding the origin of the Universe from the Big Bang explosion that takes us back into the past 13.8 billion years from the present date. The CMBR was discovered in the 1964 (Penzias and Wilson) at the Bell Telephone Laboratories, America. This relic radiation was extremely hot billions of years ago and at present it has cooled down ( $T \propto 1/\sqrt{t}$ )

and ( $\rho \propto T^4$ ) to a temperature corresponding to  $2.7260 \pm 0.0013$  K (Fixsen 2009). The energy density  $\rho$  of CMBR has also decreased due to the expansion of the Universe. This makes the CMBR to be of vital importance in cosmology, it basically shows that the Universe was once very hot and dense and has evolved into the Universe that we know today (evolving Universe). The presence of CMBR suggests that only a super-dense explosion in the past could have given rise to this relic radiation which at present can be detected as a faint glow covering the entire sky by using a very sensitive radio telescope; the CMBR falls within the microwave region of the electromagnetic spectrum and is a black-body radiation.

All large-scale celestial objects receding away from each other is another strong proof regarding the origin of the Universe from the Big Bang explosion. All such receding objects are analogous to fragments from an explosion, flying away from the primordial origin into the cosmic wilderness. If we were to rewind the receding nature of the celestial objects we would observe that the celestial objects were once closer to each other in the past as compared to the distance at which they are according to the present day scenario. In fact, if we continue to rewind further back in time, all celestial objects would disintegrate into gas clouds from which they were formed and all this would eventually converge into an infinitely dense singularity, and this singularity would be the ground zero of the Big Bang explosion.

The synthesis of light elements (Hydrogen, Helium, and Lithium) would have only been possible if the temperature in the past was extremely high, this is another proof that points towards the origin of the Universe from the Big Bang explosion.

However, there are some scientists who believe that the Universe has no beginning and it has no end, the Universe appears the same at all points in space and at all times, furthermore, according to this theory matter is created at a constant rate throughout the Universe at a rate of about  $10^{-10}$  nucleon  $\text{m}^{-3} \text{y}^{-1}$  as a property of space. This caused the emergence of the so called Steady State theory that was first proposed in 1948 by Sir Hermann Bondi, Sir Thomas Gold and Sir Fred Hoyle.

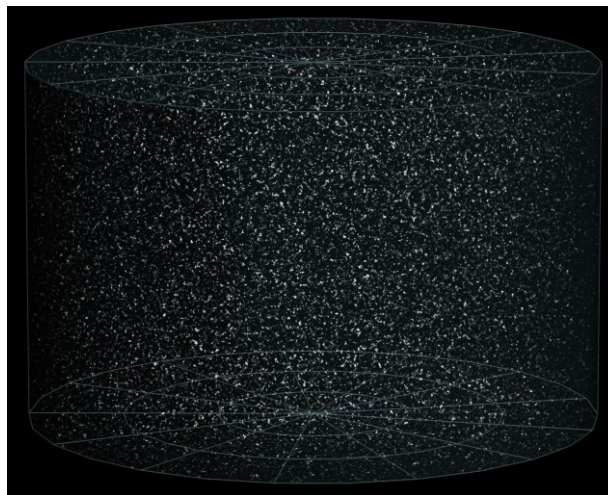
During this regime the observational methods were not efficiently developed. The value of the Hubble constant  $H$  derived during this period was not accurate. Since, the reciprocal of the Hubble constant  $H$  provides us with the age of the Universe, therefore, the age of the Universe obtained from an inaccurate value of the Hubble constant  $H$  was found to be less than the age of fossils found on earth, or we can say that the age of the Solar System was found to be more than the age of the Universe. This observation accelerated a necessity to chalk down the Steady State theory. Though the steady state theory may seem quite persuasive, however, the theory is unable to provide strong evidences as the Big Bang theory provides; evidences such as the presence of the omnipresent CMBR, large-scale structures receding at an accelerated rate away from a common centre, that is, the accelerated expansion of the Universe (a proof of violent explosion in the past) and the synthesis of light elements. The Big Bang theory is more successful and widely accepted theory for the Universe's origin, whereas the Steady State theory on the other hand is not.

## 2 STEADY STATE OR BIG BANG ?

I believe that both theories are equally credible. If the Universe or more precisely the empty space is infinite, then the Big Bang cannot be termed as an event that has caused the Universe or more precisely the infinite space to come into existence. An infinite space suggests that it existed eternally forever and is not expanding. This introduces a paradoxical situation since the Big Bang event would not be able to create an infinite Universe as the big Bang event occurred at a particular or finite time in the past. In order to bridge this paradoxical gap between the two theories it would be much better to consider that the empty space or the infinite void existed eternally forever (Steady State) and most probably the Big Bang event occurred 13.8 billion years ago within this infinite void under certain favourable conditions (Steady State - Big Bang). The Big Bang event within an infinite and eternal void has therefore given rise to the so called "observable Universe", whereas everything present beyond this observable Universe within which the large-scale celestial objects are accelerating into is the part of the infinite and ever existent or the eternal Steady State void. This will be proved to be true if the presence of the CMBR is found to be limited only within the observable Universe and not beyond it.

Now, if the space is already infinite then it would not be expanding, therefore, most probably it is the accelerated recession of celestial objects causing the distance between them to increase with time. Recession of celestial objects upon a stationary space-time continuum should produce a feeble gravitational wave in their wake. The molecular diffusion model has been introduced to explain the accelerated recession of celestial objects.

## 3 MOLECULAR DIFFUSION MODEL



**Figure 1.** Large-scale structures within the "observable Universe". When compared to the infinite size of the Universe, the large-scale structures can be considered as molecules within a vacuum chamber. Cosmic structures possess diffusion energy and therefore they diffuse or recede into the empty space at an accelerated rate just like molecules that diffuse in an ultra-high vacuum chamber.

Diffusion is the flow of molecules from the region of their higher concentration to the region of lower concentration in the presence of a gradient which can be a concentration gradient, a pressure gradient, a thermal gradient or a combination of these. Diffusion ceases only when the system has reached a homogenous state or a state of dynamic equilibrium. The celestial objects distributed within the observable Universe are therefore just diffusing out at an accelerated rate. Such diffusion will only cease when the Universe would have achieved a homogenous distribution of matter throughout its empty space.

All large-scale structures (galaxies, galaxy clusters, superclusters, etc.) when compared to the gigantic volume of the infinite Universe resemble microscopic particles, almost like gas molecules in an infinite and ultra-high vacuum chamber. Therefore, the celestial objects are simply diffusing out into the infinite realm (diffusion of gas molecules in an ultra-high vacuum chamber will be faster as compared to the diffusion of gas molecules inside a pressurized chamber; pressure affects the mean free path of gas molecules, that is, a lower pressure increases the mean free path of the molecules and decreases the collision probability between them, whereas a higher pressure reduces the mean free path and increases the collision probability between the molecules).

In the past, the distance between celestial objects was less, or we can say that the mean free path was less, therefore, the collision probability between structures was significantly higher; structures readily collided and merged to form bigger structures. As time progressed the distance between structures increased, that is, the mean free path of gravitationally bound structures increased gradually according to the low pressure of the surrounding space; increased mean free path has reduced the collision probability between the structures at present. The distance between cosmic structures still increasing suggests that the structures are still in the process of adjusting their mean free path according to the

extremely low deep-space pressure. Gravity being the only force between the large-scale structures is not enough to retard the accelerated recession. With passage of time the diffusion or the recession of large-scale structures accelerates due to increasing distance between them causing the gravitational force between such large-scale structures to weaken; diffusion force that was previously suppressed by gravity begins to dominate gradually and gradually by out powering the gravitational force with increasing distance between the distant large-scale structures. Such diffusion forms an accelerated chain reaction and gives rise to accelerated recession over time.

A large-scale structure such as galaxy cluster harbours more atoms throughout its volume. When compared to the colossal size of the infinite Universe we can consider such large-scale structure as a single molecule since it is an ensemble of many atoms all gravitationally bound due to the resultant mass of the ensemble. Therefore, the more the atoms enclosed within a gravitationally bound system, more will be its total energy (sum of energy of all the atoms constituting the system) and therefore more will be its recessional velocity (diffusion of molecules occurs due to the energies of the diffusing molecules; energy possessed by the molecule propels the molecule). In case of a large-scale structure, its total energy is the sum of the energies of all the atoms constituting that particular celestial object. Likewise, the energy of the celestial object could also be given by Sir Albert Einstein's mass-energy equation  $E = mc^2$ , as an object possesses an intrinsic energy corresponding to its mass. Now, since the atoms that make up a large-scale structure are gravitationally bound to such structure, therefore, individual atoms do not diffuse out of such large-scale structure; instead, the entire cluster diffuses or accelerates as a single molecule. At present moment if gravity vanishes all of a sudden, all gravitationally bound large-scale structures will disintegrate into gas clouds which would eventually diffuse out into the cosmos (when structure formation initiated within the young Universe, much of the matter that was unable to form gravitationally bound structures simply diffused into the cosmos, such matter has been distributed or has been diluted to such an extent that it cannot be detected).

In case of molecules which are just about to diffuse, if the molecular attractive force between the molecules is increased somehow, then such force will out power the energy that causes the molecules to diffuse, in such case the molecules would clump together instead of diffusing out. The molecular attractive force is analogous to gravity on large-scales. The structures that cause its constituents to orbit are bound strongly by gravity, and the diffusing ability is out powered by such gravitational force (star causes planets to orbit around it, galaxy causes stars and gas clouds to orbit around it, and, galaxy cluster causes galaxies to orbit around it). Therefore, planets do not diffuse or recede out of a planetary system, stars do not diffuse out of a galaxy, and galaxies do not diffuse out of the cluster; such structures do not expand. On the other hand, the gravitationally self-bound large-scale structures which do not seem to orbit around any other large-scale structures (suggesting that they are

not bound strongly by mutual gravitation) are able to out power the mutual gravitational force with the energy that they possess required for diffusion or recession, and therefore they diffuse or recede; structures such as galaxy clusters, field galaxies and superclusters.

Therefore, the diffusion or the recession of large-scale celestial objects works effectively and efficiently on extra-galactic scales (between cosmic structures that are separated by large distances; between field galaxies, between galaxy clusters and between superclusters. And, not within planetary systems, within galaxies and within galaxy clusters as these are gravitationally bound systems) within gravitationally bound systems such as planetary systems, galaxies, galaxy clusters, the diffusion process is out powered by the gravitational force which is responsible for binding such systems; the gravitational force within such bound systems is more than the energy required for recession. Therefore, we have the distance between galaxy clusters, field galaxies and superclusters increasing, whereas the distance between stars in galaxies, galaxies within galaxy clusters and between planets and the central star in case of planetary systems remains significantly unchanged apparently.

In the molecular diffusion model, the space is not expanding, only the distance between the cosmic structures is increasing with time, therefore, receding cosmic structures should produce feeble gravitational waves in their wake as they drift upon a stationary space-time continuum.

## CONCLUSIONS

1) In this paper we have bridged the gap between the Big Bang theory and the Steady State theory. Most likely it was the Big Bang event that occurred 13.8 billion years ago within the infinite and eternal Steady State universe (Steady State - Big Bang).

2) The molecular diffusion model has been introduced as an alternative to dark energy. According to this model the space is not expanding, only the distance between the celestial objects is increasing due to their recession or diffusion into the Universe which most probably is infinite. The recession of cosmic structures upon a stationary space-time continuum should produce a feeble gravitational wave in their wake.

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