DECODING THE DARK ENERGY ENIGMA

KARAN R.TAKKHI
Pune 411015, India
E-mail: karantakkhi007@gmail.com

ABSTRACT

Dark energy, a mysterious and unknown form of energy is rightfully considered as the reason for causing the accelerated expansion of the Universe. Universe expanding at an accelerated rate instead of slowing down or even coming to a stop seems extremely uncanny. In this paper I present a theory/model as an alternative to dark energy in order to explain the mysterious accelerated expansion of the Universe. According to this theory/model, the large-scale structures are receding away from each other at an accelerated rate instead of space undergoing accelerated expansion. The reason why a cosmic structure recedes into the cosmic wilderness has also been unravelled in this paper.

Key words: cosmology: theory - dark energy - accelerated recession.

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 responsible 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.

Dark energy is hypothetical. The only indication for the existence of dark energy comes from the observations of distance measurements and their relation to the redshifts. Cosmic microwave background anisotropies and baryon acoustic oscillations only demonstrate that the observed distance to a given redshift is larger than the one expected according to Friedmann-Lemaître Universe and the locally measured Hubble constant (Durrer 2011). There are many theories that try to tackle the dark energy problem. What type of energy it exactly is remains an unsolved mystery.

In 1917, Sir Albert Einstein had introduced a special term into his gravitational equation to account for a "static" Universe; a Universe that neither contracts nor expands; the average distance between the cosmic structures remains same in a static Universe. The special term was the cosmological constant, denoted by Λ. This constant was introduced to overcome the gravitational attraction of matter that tends to contract and collapse the Universe. The fate of the Universe depends upon whether the cosmological constant is positive or negative. If positive, then gravitational repulsion or expansion is assured, and, if negative, then gravitational attraction or contraction would become inevitable.

In 1929, Sir Edwin Hubble gathered vital data from his observations of distant galaxies from Mount Wilson Observatory in California that proved that the Universe is expanding and is not static at all as was previously considered. The redshifts of the observed galaxies suggested that the distance between the galaxies was increasing, indicating that the galaxies were receding away from each other. This observation of expanding Universe against the idea of static Universe led to the abandoning of the cosmological constant idea.

Surprisingly, the independent observations of the distant Type Ia supernovae in 1998 and 1999 revealed that the Universe is not only expanding, but that expansion was accelerating. This observation made it imperative to bring back the discarded cosmological constant once again. In the simplest form the cosmological constant is equivalent to the energy density of empty space or vacuum (vacuum energy density). However, when the value of the cosmological constant is obtained according to the quantum field theory, a huge discrepancy is introduced. Quantum field theory provides the theoretical value of the cosmological constant to be extremely large (~ 2 x 10^{110} erg cm^{-3}) as compared to the observed value of the cosmological constant which is extremely small (~ 2 x 10^{-10} erg cm^{-3}) (Carroll 2001). The theoretically obtained value of the cosmological constant according to the quantum field theory is 10^{120} times greater than the observed small value of the cosmological constant. Such discrepant problem with the cosmological constant would lead to a vacuum catastrophe.

The main objective of this paper is to explain the accelerated expansion of the Universe by considering the molecular diffusion model, according to which the space is not expanding; more precisely, it is the accelerated recession of celestial objects causing the distance between them to increase with time. Accelerated recession of celestial objects upon a stationary space-time continuum should produce a feeble gravitational wave.

2 MOLECULAR DIFFUSION MODEL

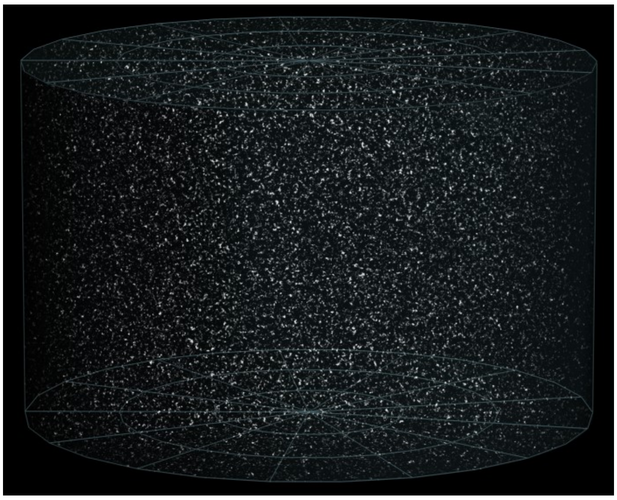

Figure 1. Large-scale structures within the "observable Universe". When compared to the infinite volume of the Universe, the large-scale structures can be considered as molecules within a vacuum chamber. Therefore, the cosmic structures just like molecules possess finite amount of energy by the virtue of which they diffuse or recede (expand freely) into the empty space at an accelerated rate just like molecules that diffuse or expand freely in an ultra-high vacuum chamber by the virtue of the energy that they possess.

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 concentrated within the observable Universe. Therefore, they must diffuse from the region of their higher concentration to the region of lower concentration, that is, from the observable Universe to the region beyond the observable Universe. Such diffusion will only cease when the Universe would have achieved a homogenous or uniform 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, instead of maintaining a fixed position within the Universe, the cosmic structures would most probably prefer to diffuse out or expand freely into the infinite realm by the virtue of the diffusion energy that they possess, after all, diffusion or recession of a molecule occurs due to the energy it possesses, and, the diffusion of molecules in an ultra-high vacuum chamber will be faster as compared to the diffusion of molecules inside a pressurized chamber; pressure affects the mean free path of the diffusing 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.

Gravity being the only force between the distant large-scale structures is not strong enough to retard the accelerated recession (diffusion energy possessed by the receding large-scale structures is greater than the mutual gravitational force between them). 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 by out powering the gravitational force with increasing distance between the distant large-scale structures. Such diffusion or recession 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 or the mass 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. 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 large-scale structure diffuses or recedes as a single molecule.

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 remain clumped together instead of diffusing out. The molecular attractive force is analogous to gravity between large-scale structures. 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 structures works effectively and efficiently for the 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 diffusion or recession. Therefore, we have the distance between galaxy clusters, field galaxies and superclusters increasing at an accelerated rate, 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 at an accelerated rate with time, therefore, a cosmic structure receding at an accelerated rate should produce a feeble gravitational wave as it drifts upon a stationary space-time continuum.

3 ENERGY THAT CAUSES THE DIFFUSION OR RECESSION OF A COSMIC STRUCTURE: WHY SHOULD A COSMIC STRUCTURE RECEDE ?

The energy possessed by an object moving with velocity v is given as,

$$E = \frac{1}{2}mv^2 \qquad (1)$$

Equation (1) should also be valid if expressed in terms of velocity as,

$$v = \sqrt{\frac{2E}{m}} \qquad (2)$$

Equation (2) suggests that an object possessing sufficient amount of energy will also possess velocity and therefore the object will recede. This is exactly what is observed in the case of a molecule, that is, if the molecule gains more energy than before, then according to equation (2) the velocity of the molecule will increase. Now, since a large-scale cosmic structure possesses sufficient amount of energy, therefore, such cosmic structure will recede with a velocity according to equation (2).

In an environment where gravitational force is stronger, like on Earth's surface, the energy possessed by an object will not cause the object to recede, as gravitational force takes over, however, a molecule is an exception in this case. Since, the mass of a molecule is minuscule, therefore, a molecule is not influenced significantly by Earth's gravitational force; the energy possessed by a molecule turns out to be greater than the gravitational force acting upon it, and therefore the molecule recedes purely by the virtue of its own energy. Similarly, in deep space environment the gravitational influence is significantly weaker; particularly between the cosmic structures that are separated by large distances. Therefore, the energy possessed by a large-scale cosmic structure will make it recede, just like a molecule, as the energy required for recession is greater than the gravitational influence between the receding cosmic structures.

By knowing the mass and the instantaneous recessional velocity of a receding cosmic structure, it becomes possible for us to know its instantaneous energy using equation (1). The value of energy thus obtained is the amount of instantaneous energy that is causing the cosmic structure to recede with this instantaneous recessional velocity. As cosmic structures gain acceleration gradually and gradually over time, more accurate values of diffusion or recessional energies possessed by them will be revealed. It is this energy possessed by cosmic structures that causes them to recede. And, once the recession begins, the distance between the cosmic structures keeps on increasing, causing the gravitational force between them to weaken, thereby giving rise to accelerated recession over time.

CONCLUSIONS

The molecular diffusion model has been introduced in this paper 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 diffusion or recession at an accelerated rate into the Universe which most probably is infinite. The accelerated recession of cosmic structure upon a stationary space-time continuum should produce a feeble gravitational wave.

ACKNOWLEDGEMENTS

I am thankful for reviewing my manuscript.

REFERENCES

Carroll S. M., 2001, LRR, 4, 1
Durrer R., 2011, RSPTA, 369, 5102
Einstein A., 1917, Sitz. Preuss. Akad. Wiss. Phys.-Math, 142, 87
Frieman J. A., Turner M. S., Huterer D., 2008, ARA&A, 46, 385
Hubble E. P., 1929, Proc. Natl. Acad. Sci., 15, 168
Perlmutter S., Aldering G., Goldhaber G., Knop R. A., Nugent P., et al., 1999, ApJ, 517, 565
Riess A. G., Filippenko A. V., Challis P., Clocchiatti A., Diercks A., et al., 1998, AJ, 116, 1009
vixra.org/abs/1712.0096