

## Brief Considerations on Dark Energy



### Engineering

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### ABSTRACT

*The Inflationary Universe Theory predicts that the universe has a high density, which can only be true if there is dark matter. The reason for this were the observations of a greater gravitational attraction than that predicted by the classical theory, i.e., dark matter is used to explain a greater gravitational attraction than expected. This invisible matter, called dark can be composed of unknown, exotic particles, which so far has not found a way to observe them. The physical outline theories about the existence of these particles, but experiments have not yet confirmed their presence. No one knows for sure what constitutes dark matter: may be subatomic particles, black holes, stars of very low luminosity, or even a combination of these or other objects. Another possibility is that our understanding of gravity needs a major review, but most scholars do not share this thought.*

### INTRODUCTION

Based on more than fifty years of observations on the expansion of the universe and the motions of galaxies, most astronomers believe that over 70% of the constitution of the universe is composed of particles or objects that can not be observed<sup>(1)</sup>. Dark matter is matter that does not emit light and so can not be observed directly, but whose existence is inferred by its gravitational influence on light, or predicted by certain theories matter. For example, astronomers believe that the outermost regions of galaxies, including the Milky Way, dark matter must have due to the observations of the movement of the stars. Albert Einstein was the first scientist to realize that empty space has amazing properties that are beginning to be understood. One of these properties, the cosmological constant was introduced by Einstein, for a static, homogeneous and isotropic universe. The cosmological constant acts as a repulsive force that prevents the collapse of the universe by gravitational attraction. Another property that Einstein discovered is that the cosmological constant is a kind of prediction that empty space can have its own energy<sup>(2)</sup>. The constant that is also known as "vacuum energy", which would be a kind of energy that is manifested through quantum phenomena, also called dark energy that involves about 70% of the universe. It is evenly distributed not only in space but also in time, that is, its effect is not diluted when the universe expands. A uniform distribution means that dark energy has no local gravitational effects, but an overall effect on the universe as a whole. This fact implies the appearance of a repulsive force, which tends to further accelerate the expansion of the universe. In other words, to explain the acceleration of the universe, we must take into account the contribution of the "dark energy", capable of generating a repulsive gravitational force<sup>(1)</sup>. One of the evidences of this phenomenon comes from studies of supernovae. So-called normal matter such as stars, dust and gas account for only 5% of the mass density inspected. Cosmologists are still trying to understand the structure of dark energy, which may represent about 70 percent of the universe. In general, attempts to discover its fundamental properties: its strength, its permanence, and any variation in direction. The evolution of the universe is governed by the amount of dark matter and dark energy<sup>(2)</sup>. Thus we perceive that the nature of dark energy is currently a matter of speculation. Some believe that dark energy can be "vacuum energy", represented by the cosmological constant, a constant uniform density of dark energy throughout the space, which would be independent of time or expansion of the universe. It is a part of the universe that astronomers know exists, but still have no knowledge of what exactly it is. It is matter because it can measure its existence through gravitational force it exerts. And it is dark because it does not emit any light. This second property is precisely what complicates their study. All observations of bodies in space are made from light or other electromagnetic radiation emitted or reflected by the stars. Since dark matter does not emit or reflect

radiation is called invisible<sup>(3)</sup>.

### DARK MATTER AND EVIDENCE

The evidence for dark matter (DM) in the universe are manifold. The possibility of it being a new particle (or particles) undiscovered has motivated a large number of experiments inspecting the DM directly or indirectly. On the other hand, the standard model of particle physics contains no candidates for DM. New theories beyond the DM are constantly proposed to include it, as well as make predictions about its experimental discovery. Among other evidence, one can consider the fact that the galaxies in our universe are rotating at a speed such that the gravity generated by its observable matter could not keep them together. Scientists speculate<sup>(4)</sup> there must be something that you can not directly detect that these galaxies is providing the right amount of extra mass, generating additional power to maintain the effect of gravity. This extra and unknown matter is referred to as "dark matter" that can only be detected from its gravitational effects. The most accepted theory about dark matter is that it is composed of weakly interacting massive particles, which interact with the rest of the universe through the weak force and gravity. This fact makes them extremely difficult to detect. Dark matter can not be observed by astronomers with telescopes. It does not emit or reflect light, so it does not shine like a star. On the other hand, dark matter is a key consideration for the Big Bang model of cosmology as a component which corresponds directly to measurements of cosmological parameters. Currently the cold dark matter is the simplest explanation for most cosmological observations. By definition<sup>(5)</sup> hot dark matter consists of particles moving ultra relativistically while warm dark matter involves particles moving relativistically. In turn, the cold dark matter is constituted by particles that do not move relativistically. An example of hot dark matter is the neutrino. Neutrinos were discovered entirely separated from the search for dark matter: were postulated for the first time in 1930, and first detected in 1956. Neutrinos have a very small mass: at least 100,000 times less massive than an electron. Much of the evidence for dark matter comes from the study of the movements of galaxies. The most promising candidates for cold dark matter<sup>(6)</sup> are neutral particles that interact very weakly with each other or with the baryonic matter, responding almost exclusively to gravity, and the main candidates in this class are axions and neutralinos. The neutralino is a hypothetical elementary particle predicted by supersymmetry. Theoretically there are four neutralinos, they are all fermions and electrically neutral. How neutralinos are fermions, each of them is identical with its antiparticle. They arise primarily as successive decays particles of heavier particles. The axion is a non baryon boson which was postulated in 1977 to explain to explain why the strong interactions retain the parity and the inversion charge, as it is, the symmetry<sup>(6)</sup>. The mass of the axion is a matter of theoretical discussion. It has not been observed experimentally. On the other

hand, it was also necessary to impose a quantity called dark energy because the expanding universe was not being braked, as predicted classical theories. On the contrary, it is accelerating, as if there were an opposite to gravity objects that repel rather than attract them, acting on scales larger Cosmos strength. The mysterious repulsive force is associated with a potential energy that scientists have named dark energy. Therefore, the dark energy is used to explain a negative gravitational attraction<sup>(7)</sup>. To better understand the idea of dark energy, we can make an analogy with the experience of playing a object vertically upwards. Due to the gravitational force of the Earth object velocity decreases with height. Suppose now that, suddenly, the object's speed up start rising. For this to happen we have to admit the presence of a repulsive force pushing it up higher than attraction to the center of the Earth. The effect of this repulsion force is equivalent to the presence of a dark energy, which produces a "repulsive force" and accelerates the expansion<sup>(8)</sup>.

## CONCLUSION

In the context of the general theory of relativity Einstein, it becomes possible to formulate cosmological models, such as the so-called Big Bang model, which provide a picture of confidence for the last fourteen billion years of evolution of our universe. The important thing is that this evolution can be tested by comparing predictions and astronomical observations. Dark matter is all around us in the universe. We know that dark matter exists because we can observe its effects in parts in the universe, for example, studying how fast galaxies orbit around each other, one can estimate the amount of additional dark matter that should be in the system. Despite the success, there are a number of open questions about the origin of dark matter, dark energy and the riddles of the universe which should guarantee a lot of research in cosmology in the coming years.

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