Assessment of Dark Matter Its Importance in Physics

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Abstract

***Nearly 80 percent of the universe is made up of matter that cannot be seen with the naked eye, This matter, which is not visible under any circumstances and does not emit any energy or light, is known as dark matter. It is said that dark matter must exist in the form of filamentary structures of galactic binders. For decades, physicists around the world have sought to understand the nature of particles that do not emit light and cannot be seen by humans, and are called dark matter, Due to a number of cosmic observations in the 1930s; the existence of dark matter was confirmed. It is interesting to note that all the constituent materials of stars, galaxies and planets, and the visible universe as a whole, make up only 5% of the total universe, and 23% of the universe is made up of dark matter, It has never been possible to identify dark matter particles (Trimble, 1987)*.**

The aim of this study was to investigate dark matter and its importance in the field of physics.

Research Method: This article is a review, which uses authoritative scientific books, as well as authoritative international articles.

The results of this study show: The nature of dark matter has not yet been discovered, and the human mind is still searching for a suitable and convincing answer. Certainly discovering the mystery of matter, which encompasses more than 80 percent of this vast universe, is important for cosmologists to be able to guess past, present, and future.

Keywords: Dark Matter, Galaxy, mass, Ionic charging, Non-ionic charge

INTRODUCTION

Recognizing and examining the order in the universe with human creation has always been one of the most prosperous questions of the people. Sometimes they mix it with myth and sometimes with a little reality. What we now call the science of modern cosmology is a science that has been debated in scientific circles for more than 3,000 years to the present day. When astronomers used gravitational methods to calculate the mass inside galaxies or galaxy clusters, they found that it was larger than the visible mass of the galaxy seen during light waves; That's why they introduced a new type of matter called dark matter into their theories (Mansouri, 2007).

The two main concerns in cosmology today are the issue of dark matter and dark energy. This means that a large part of the matter and energy that calculations indicate in the universe are not visible. More precisely, they do not have electromagnetic interactions. According to Planck, only 5.4 percent of the world's content is visible.

If you look closely, all the information that humans get from the environment through their five senses comes directly from electromagnetic interactions. It is a fact that the Atomic tribes have a strong interaction, and the foundation of the universe in the face of gravity has caused us to realize that in recognizing and observing the new universe at the beginning, we have just realized that centuries after we settled on the planet and tried to know the universe. We are on the way (Mowahed, 2014).

What is cosmology?

The word world is used to describe the whole space and all its contents, and cosmology is the study of the whole world. The universe in question in cosmology is the mass of galaxies, intergalactic matter, and light.

Cosmology does not examine stars and galaxies separately, but examines the characteristics of the entire universe, including the origin of the universe, its evolution, and its ultimate destiny.

Cosmology makes observations to achieve these goals. They use these astronomical data to study the conditions of the universe billions of years ago and finally provide models to describe the universe based on scientific principles (Phillips, 2009).

Dark Matter

It is a type of matter that has been hypothesized in astronomy and cosmology to explain phenomena that appear to be due to a certain amount of mass that is greater than the mass observed in the universe. Dark matter cannot be seen directly with a telescope;

obviously, dark matter does not significantly absorb or emit light or other electromagnetic waves. In other words, dark matter is simply matter that does not react to light. Instead, the existence and properties of dark matter can be deduced indirectly through the effects of gravity on visible matter, radiation, and the large-scale structure of the universe. According to the Planck Mission Team in 2013, based on the standard cosmological model, the total known mass-energy in the universe consists of 4.9% ordinary matter, 26.8% dark matter, and 68.3% dark energy. That is, dark matter makes up 26.8% of the total matter in the universe, and dark energy and dark matter together make up 95.1% of the world's total content (Bergstrom, 2000).

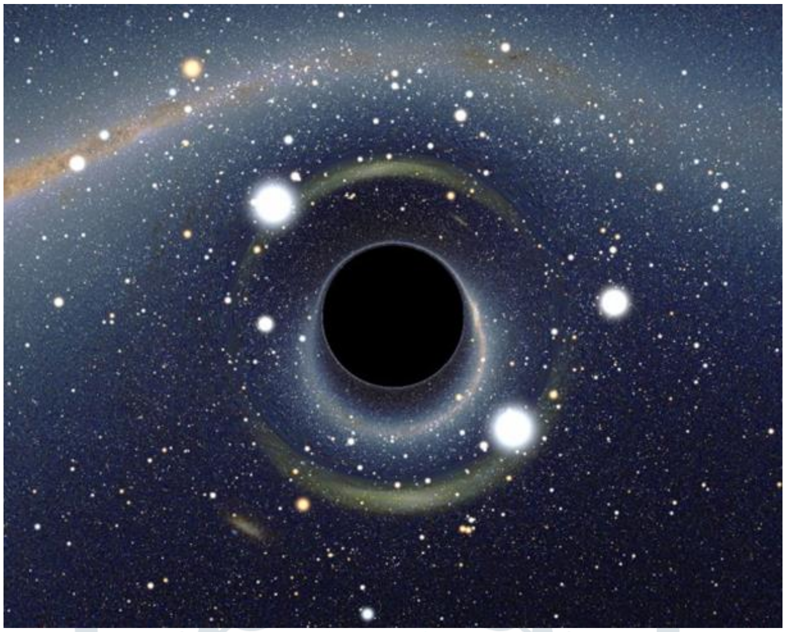

*Figure (1) View of dark matter (*Dodelson, 2003*)*

Dark matter with ionic charge and non-ionic charge

Three rows of evidence show that most of the dark matter is not composed of ordinary matter, including protons and neutrons. The Big Bang nuclear theory, which predicts with high accuracy the abundance of chemical elements observed, concludes that Ionic charge matter makes up only 4-5 percent of the world's critical density .On the other hand, evidence of large-scale structure and other observations suggests that the total density of matter should be greater than this. Large astronomical searches for gravitational microcosms, including the MACHO, EROS, and OGLE projects, have shown that only a small fraction of dark matter in the Milky Way galaxy may lie in dark compressed objects (such as black holes and neutron stars). In cosmic background radiation by Plymouth and Planck's satellite, it shows that about five-sixths of the world's total matter is in a form that does not interact significantly with ordinary matter and photons. A small portion of dark matter may be a dark matter Ionic charge astronomical objects, such as those of massive compressed halos made up of ordinary matter, but whose electromagnetic radiation is negligible. By studying the nucleation in the Big Bang, we can determine the high limit for the amount of barium in the universe, which means that most of the dark matter in the universe cannot be made up of baryon and therefore does not form an atom. Nor can it interact with ordinary matter through electromagnetic forces. Dark matter particles have no electric charge (Bertone, 2005).

The two hypotheses about non-baryonic dark matter particles are hypothetical particles such as axons or neutrino super symmetric particles. Due to limitations due to large-scale structure and galaxies with high redshift, they can only form a small part of dark matter. Unlike dark baryonic matter, non-baryonic dark matter did not play a role in the formation of chemical elements in the early universe. In addition, if the particles that make up the supernova are possible, they could destroy each other, and this destruction is likely to lead to visible effects such as gamma rays and neutrinos (Powell, 2009)

Non-ionic Charge dark matter is classified based on the mass of the hypothetical particles that make up the particle or the velocity of these particles. There are three prominent hypotheses about non-Ionic Charge dark matter called cold dark matter (CDM), dark matter (WDM), and hot dark matter (HDM). Some combinations of the above are also possible. The non-ionic charge dark matter model, which has been the most widely discussed, is based on the cold dark matter hypothesis, and according to popular belief, the corresponding particle is a heavy particle with poor interaction (WIMP). Hot dark matter may contain heavy neutrinos, but observations suggest that only a small fraction of dark matter may be hot. Cold dark matter leads to the formation of a "bottom-up" structure in the world. While hot dark matter leads to the formation of a "top-down" structure. Since the late 1990s, the dark matter has been rejected by observations of redshifts at the top of galaxies, such as Farazhfar Hubble Square (Trimble, 1987).

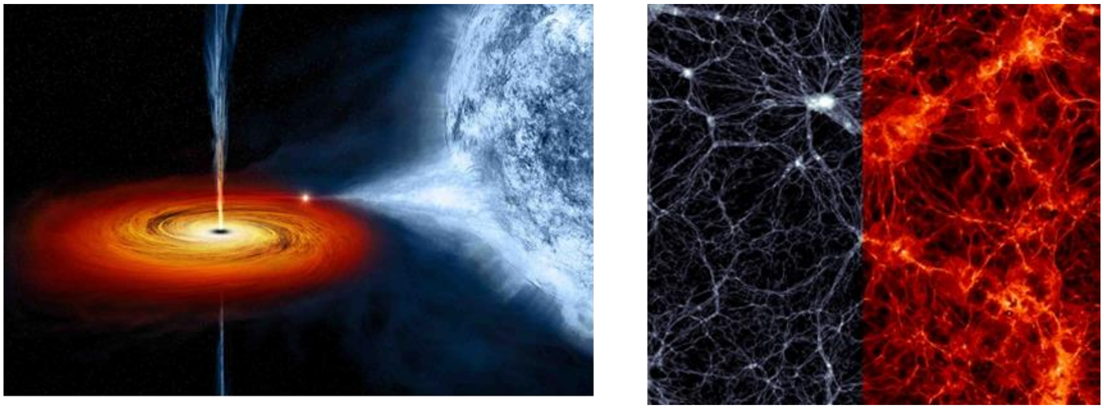

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*Figure (2) (a) Hot dark matter and cold dark matter, (b) Hot dark matter ((*Dodelson, 2003)

Experimental evidence for the existence of dark matter

The first person to interpret empirical observations and draw conclusions about dark matter was the Dutch astronomer Ian Evert, a pioneer in radio astronomy, who proposed her hypothesis in 1932. Evert was studying the movements of stars in the local galactic region when he realized that the mass on the galactic plane should be greater than what had been seen before. But it was later discovered that this measurement of objects was in 1933 by Frinter Zuiki, a Swiss astrophysicist who studied galaxies and clusters while working at the California Institute of Technology. A similar conclusion was reached by Zuiki who obtained the virial theorem for the application of the Coma galaxy cluster and the evidence based on the missing mass. Zuiki estimated the total mass of the cluster based on how the galaxy moves near its edges, and compared that estimate with another estimate based on the number of galaxies and the brightness of the cluster. He found that there was a mass about 400 times greater than seen. The gravity of the galaxies visible in this cluster is much smaller than that of such high-speed orbits, so there was a need for something more. This is known as the issue of missing crime. Based on these results, Zuiki concluded that there must be an invisible form of matter that provides enough mass and gravity to keep the cluster together.

Most of the evidence for dark matter comes from studying the motion of galaxies. Many of these motions appear to be relatively uniform, so according to Virial's theorem, the total kinetic energy must be half the energy of the galactic gravitational bond. Although the observed kinetic energy is much greater: to be more precise, assuming that the gravitational mass is only due to visible matter in the galaxies, the stars farther from the center of the galaxy are much faster than the virial theorem predicts. The diagrams of the galaxy's rotation curves, which show the speed of rotation based on distance, cannot be explained using visible matter alone. The idea that visible matter is only a small part of a cluster is the most straightforward way to explain this. The signs indicate that the galaxies are mainly composed of a nearly spherical halo of dark matter with a greater concentration at its center, and that the visible material is like a disk at its center. Dwarf galaxies with low surface luminosity are important sources of information for studying dark matter, because in these galaxies the ratio of visible matter to dark matter is unusually low, and bright stars are slightly centered on them. He was confronted (Rahvar, 2013).

Observations of the gravitational convergence of galactic clusters make it possible to estimate the mass directly based on its effect on the light of background galaxies. Masses of matter (dark or ordinary) cause light to bend through gravity. In clusters such as Abel 1689, convergence observations confirm that the amount of matter present is significantly greater than the amount of light emitted by the light of these galaxies. In the bullet cluster, convergence observations indicate that most of the mass that causes convergence is separate from the baryonic mass of the X-ray diffuser. In July 2012, convergence observations were used to discover a string of dark matter between two galactic galaxies predicted by cosmic simulations (Serious, 2012).

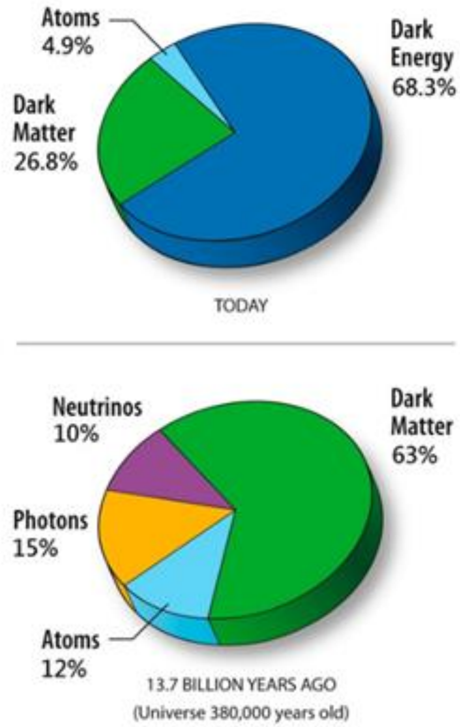

*Figure (3) Estimated distribution of matter and energy in the universe, today (above) and when cosmic background radiation was released (*Bertone, 2005)

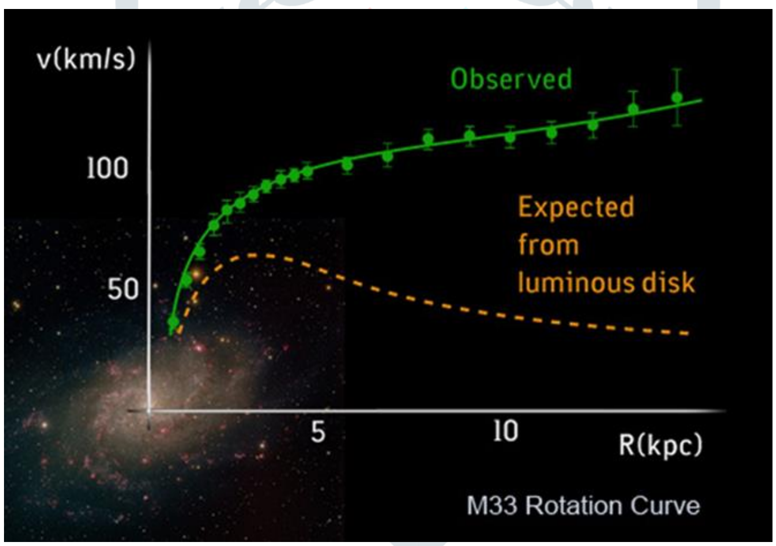

Figure (4) The rotation curve of galaxies (Farzan, 2015)

Freeze-in scenario for the production of dark matter

In this scenario, dark matter at temperatures above its mass can be produced by the interaction of standard particles, but the rate of production is so small that the density of dark matter never reaches the thermodynamic equilibrium value. The density of dark matter at T ~ mx is given by integrating the rate of production of dark matter per unit volume of volume with time from heating (immediately after inflation) until the temperature reaches T ~ mx. If, for high energies, the cross-sectional area of the dark matter production tends to be asymmetric, the density of the dark matter will depend on the open heating temperature (Farzan, 2015).

Freeze-out scenario for producing dark matter

In this scenario, dark matter particles in the primordial world reach thermodynamic equilibrium, but when the temperature drops below about 0.05 the mass of the particles, they leave the thermodynamic equilibrium, and then the total number of dark matter particles remains constant, resulting in a density of $(\frac{T}{m_x})^3$ drops.

For simplicity, suppose that the particle density of dark matter and its antiparticles are equal, and both are given by nx. This assumption is satisfied in most models. In fact, the emergence of inequality requires a relatively complex mechanism (such as the mechanisms developed to explain the asymmetry between the density of ordinary matter and antimatter). Another possibility is that the particle of dark matter and the particle of the particle coincide. (For example, dark matter particles are made up of real scalar particles with Mayuran formions.) In this case, the following formulation and discussion is also true. Suppose the cross-sectional area of technology X and X' are given by standard particles with σ_{ann}. The evolution of the density of dark matter over time in relation to Boltzmann's relation is given as follows:

$$\frac{dn_x}{dt} = -Hn_x + < \sigma_{ann} V > (n_x^2 - n_{X.eq}^2)$$

Where $n_{x\cdot eq}$ is the density of dark matter if a thermodynamic equilibrium is established:

$$n_{x.eq} = gx(\frac{M_X T}{2\pi})^{3/2} e^{-m_x T}$$

And gx shows the degrees of freedom of the dark matter particle (Harvit, 2005).

In most models, the extinction of the dark matter pair takes place at the oscillating angle of the zero orbital angle (s-Wave), and therefore in the first approximation, the σ_{ann} does not depend on velocity. Solving this equation shows that when the temperature reaches Tf = $\frac{M_x}{\log(\frac{g_x m_x m_{pl} \sigma_{ann})}{(2\pi)^{3/2}}}$ The total number of dark matter particles remains constant and the density in the form of (T/ mx)3 decreases with the expansion of the universe. The contribution of dark matter to the density of the universe is now given by the following relation:

$$\Omega_x = \frac{2m_x n_x(t_0)}{\rho_c} = 3\,x\,10^{-10} \left(\frac{GeV^{-2}}{\sigma_{ann}}\right) \frac{1}{\sqrt{g_b}} \frac{1}{2h^2} \log(\frac{g_x m_x m_{pl} \sigma_{ann}}{(2\pi)^{3/2}})$$

In this scenario, unlike the Freeze-in scenario, the density of dark matter does not depend on the reheating temperature. Achieving thermodynamic equilibrium destroys the memory of dark matter from time immemorial. In addition, the dependence on mass is only logarithmic, but its dependence on σ_{ann} is inversely linear. As a result, the measured density does not determine the mass of the dark matter, but the cross-sectional area of the dark matter pair is well determined:

$$\sigma_{ann} \simeq 1 \text{ pb} = 10\text{-}36 \text{ cm}^2$$

We have no information about the spin of the particles that make up dark matter, although most models assume that the spin of dark matter is zero or 1.2, this assumption has no observational basis. The assumption of Gravitno, which is one of the famous candidates for dark matter, has a spin of 3.2 (Farzan, 2015).

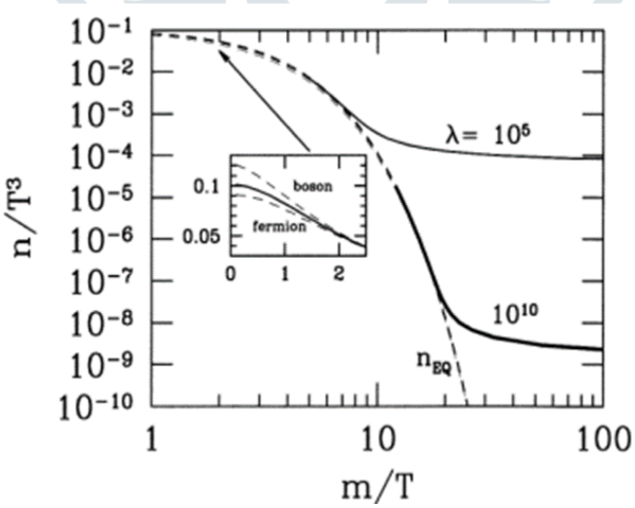

Figure (5) Numerical solution of the Boltzmann equation for dark matter in two different values of λ (Movahed, 2014)

Wimp scenario

Suppose the mass of dark matter particles and every new particle that appears in the Finman diagram related to the extinction of the dark matter pair is mx, Take the coefficient of mating of dark matter with known particles as gx. With a dimensional estimation of the cross-sectional area of the extinction of the dark matter pair to the pair of standard particles, we can write as follows:

$$\sigma \sim \frac{gx^4}{4\pi m_x^2}$$

In many theories, the value of gx is predicted from the order of the weak electro theory. The most popular of these theories is the standard model super symmetric committee theory, in which the neutrino particle plays the role of dark matter. In the Freeze-out scenario, a numerical value of σann must be within the pico barine range to obtain the observed abundance of dark matter. If the numerical value of gx is about the fractional coefficient in the ecclesiastical theory, mx should be in the range of 100GeV to 1TeV. This observation is very exciting from a laboratory point of view because the mass and coupling coefficient of dark matter to standard particles are within this range. We expect these particles to be produced in the LHC blood test. Also in this interval, there is a place for direct and indirect search of dark matter (Michaels, 2007).

Dark matter candidates

MACHO

One of the earliest options for dark matter was heavy, dim objects in the galactic halo, or so-called MACHO. These objects provided the necessary mass for dark matter and at the same time did not emit so much light. MACHO covered a wide range of celestial bodies. Black Holes, Neutron Stars, (which were kind of like black holes but didn't have enough mass to collapse) Brown dwarfs (a type of dwarf called rejected stars) Typically, they have a mass 30 to 75 times the mass, but these stars did not have enough mass to start the nuclear fusion process.

The gas and dust around the black holes usually cause synergistic pills around them, The disk is absorbed into the black hole, and those particles that enter quickly enough produce a fountain outside the black hole that will be observable and therefore cannot be dark matter. Now, if these black holes are located in isolated parts of the galaxy, they do not have overlapping disks, but certainly isolated black holes will not have a large share of dark matter in the galaxy's halo, because they disturb the gravitational balance in the galaxy.

The most common way to identify these objects is to use gravitational micro-convergence, which has been described. The MACHO project claims that the amount of MACHO found during 5 years by examining the effect of gravitational micro-convergence on 12 million stars in the case of large LMG modular clouds over 5 years, Generally, white and red dwarfs with a solar mass can make up 20% of the dark matter, What is confirmed in the collection is that MACHO in the range of 108 to 100 times the mass of the sun will not be able to describe a significant share of dark matter (Mowahed, 2014).

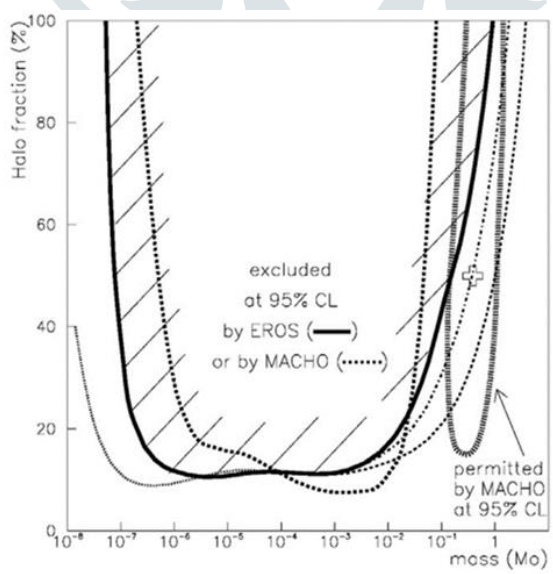

Figure (6) Based on the results of MACHO, EROS, these objects cannot have a large share of dark matter in a wide range of their mass limits (Movahed, 2014)

Generalized MOND or gravitational theories

Mass difference in stellar systems manifests itself only when gravitational acceleration falls below a certain value, Milgram therefore proposed in 1938 a correction of Newtonian dynamics (MOND) as a solution to non-baryonic dark matter. Despite the great efforts that have been made, these theories are not very capable of justifying some of the evidence, and there are no proper tests to determine their accuracy (Sadat, 1968).

Cosmic residual particles

The main option for dark matter is a particle left over from the nuclear synthesis period. In other words, in order for these particles to be suitable for the formation of dark matter, they must have survived a kind of nuclear synthesis at the beginning of the universe, during the 13.7 billion years that have passed since then, Be present all over the world and have no effect other than gravitational influence. Fortunately (because the motivation to study physics has increased beyond the standard particle model), the standard particle model has not proposed a particle that behaves this way.

Dark matter must have a specific time dependence. The speed of the sun on the galactic plate is $2x10^5$m/s. The Earth orbits the Sun at an angle of 60 degrees at a speed of $3x10^4$m/s. Therefore, the velocity of the earth in the bed of dark matter varies in seasons. In May, dark matter will increase and decrease in June. This is the basis of DAMA performance (Sabuti, 2004).

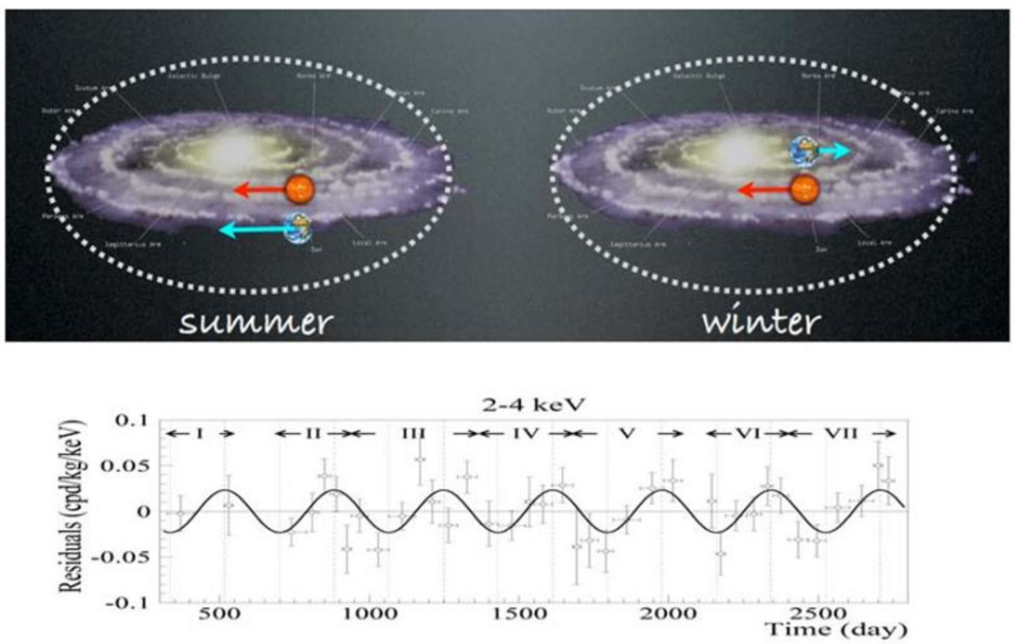

Figure (7) Observation of intermittent saline changes in the number of dark matter collisions observed by DAMA (Peebles, 2003)

Conclusion

Numerous evidences from the presence of dark matter have left little doubt as to its existence. Despite numerous theories, the scientific community considers the surviving cosmic particles to be the main choice for the nature of dark matter. Deadlocks in finding theories beyond the standard model in the field of elementary particles and a brief tracking of new physics particles in the matter of dark matter have also interested physicists in fundamental particles in this field. Therefore, in recent years, a kind of scientific mobilization has been carried out to explore the dark matter. What has been said of the great and numerous experiments in direct and indirect excavations is proof of this claim.

The results of experiments such as DAMA and CDMS, gamma rays recently observed from the center of the galaxy, and the difference in the Positron fraction -electron fraction observed by AMS will all be good news for the possibility of finding the secrets of dark matter identity in the near future. The rapid and exciting developments in cosmology in recent decades are just the beginning of a movement that will lead us to a deeper understanding of the structure of the universe and its components in the not-too-distant future.

One of the most obvious features of dark matter, which is also its name, is that it does not emit light. Dark matter, unlike interstellar gas or gas inside galaxy clusters, does not emit light to be seen with its help.

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