The Invention of Dark Matter and Authentic Galactic Star Dynamics

Leandro Meléndez-Lugo[1], Esteban Chávez-Alarcón[2]

Instituto Nacional de Investigaciones Nucleares, Centro Nuclear de México, Departamento de Física, La Marquesa, Ocoyoacac, C.P. 52750 Edo. De México, México

Abstract: ***Through a mathematical analysis that includes the law of Gauss for the flow of the gravitational field, it is demonstrated that the force on several stars in a galaxy can be greater than what other researchers have estimated. Consequently, this means that neither galaxies nor clusters of galaxies disintegrate would have happened according to the great radial velocities of the stars and galaxies, that have been determined experimentally in the past. Using the obtained results of this analysis, the existence of the postulated Dark Matter, in order to justify and to balance these radial velocities that have been measured in many galaxies, is considered to be superfluous. Also, in this work we propose a method to determine, in an approximate way, the density and the distribution of the mass in galaxies and galaxy clusters, based on the radial velocity rotation curves that are obtained spectrally.***

Keywords: Dark Matter · Galaxies · Galaxy clusters · Density · Mass distribution

1. Introduction

During the 1920s, Edwin Hubble, among many other things, through spectral studies of the emission lines from the stars, had an important success in exploring the known nebulae of those years. Among them, the Andromeda nebula turned out to be another galaxy that is very similar to our Milky Way. Studying several galactic systems, after measuring the red shift in the spectra Hubble, among other researchers, proposed the now-famous expansion of the universe [1-4]. Undoubtedly, the supposed success obtained by Hubble and some other renowned astronomers, stimulated research to also measure the emission spectra of stars in galaxies [5]. Fritz Zwicky, a Swiss-American astronomer of Bulgarian origin in the 1930s and Vera Rubin an American astronomer in the 1960s and 1970s, among other attributes, obtained spectra of star emission lines in some galaxies and of galaxies in some clusters. According to their measurements and calculations, they obtained results that indicated that stars and galaxies move with totally unexpected dynamics [6-10]. An important number of stars and also many galaxies in the clusters move with velocities that are much higher than those predicted by the equations of the dynamics that they used as researchers. An immediate conclusion that they conjectured was that many stars and galaxies should not maintain their integrity, in fact they should not be there as gravitational systems [6-10]. The extraordinary speeds that they measured indicated to them that galaxies and clusters should fragment, and even shatter. However, such destruction did not exist, for stars and galaxies remained stable with a celestial dynamic that has made them endure for millions of years. Doubtless, there should have been a much greater retention force in those systems than they were calculating. That extra strength in galaxies and clusters should have provided in their calculations, the cohesion needed for keeping the galaxies integrated and also for keeping the galaxy clusters stable. In an effort to justify those great speeds that they obtained from their measurements, they decided to postulate the existence of a large additional mass which, in some cases, is several times the mass calculated for many galaxies, and is different from the mass that corresponds to the shining part of the galaxy. This additional mass would be practically invisible, to the extent that it could not be detected by known means, and for this reason it was called Dark Matter [6-10]. This is how the postulate of the ethereal Dark Matter appears, which supposedly provides the missing gravitational force that maintains intact galaxies and clusters of galaxies [11,12].

The formula used by Zwicky and Rubin appears in the body of an article published by Rubin in 2006 [13]. Textually it notes: “High school students learn that in a gravitationally bound system like our solar system, a planet moves in a closed orbit, such that $MG = V^2 r$ where M is the mass of the sun, G is the gravitational constant and V and r are the velocity of a planet and its distance from the sun. In $M31\,(Andrómeda)$, the same relation between mass, velocity, and distance holds”. From this expression we obtain that $V = \sqrt{MG/r}$. Therefore, the hope was that the velocity should vary as $V \propto \sqrt{1/r}$ [13], as with all planets in the Solar System [13]. Next it will be shown that this statement by Vera Rubin is wrong.

With all this at the table of the discussion about the missing mass, that strange substance that, despite the many great efforts that are made in various parts of the world, has not been detected by traditional and extraordinary means [8-10,13-16]; at least, it is possible to think on the non-existence of that said substance, since it does not emit heat, and there is no electromagnetic radiation hence, supposedly, its presence is only recorded through gravitational interaction [8-10,13-16] .

In this paper, it is mathematically shown that the resultant force that appears on many of the stars in galaxies and on galaxies in clusters does not meet the exact expression of Isaac Newton’s law of universal gravitation. This means, as a consequence, that the mathematical expression of Vera Rubin has no validity in the galactic systems. In other words, it will be shown that the force in these cases turns out to be greater than the traditional force of Newton that appears on the planets in the solar system. Therefore, here it is shown that the postulate of the existence of the so-called Dark

Matter not only stops being valid but it is superfluous to introduce it into the true celestial dynamics of stars and galaxies. Also, an experimental mechanics is established here to determine approximately the density of the galactic mass from the radial velocity curve.

2. Detection of Dark Matter

Between the 1960s and 1990s, there was a great research activity based on neutrinos. The existence of neutrinos was proposed by Wolfgang Pauli in 1930 [17]. Pauli's analysis of these particles was entirely theoretical and it transpired that in the calculations, the neutrino should be a particle that should not have an electric charge [17]. This was the reason why Enrico Fermi called it a neutrino. In Italian, neutrino means the little neutral [17]. In those years, the Solar Neutrinos Problem was intensely discussed. Due to its physical characteristics, the neutrino is an extremely difficult particle to detect. For this reason, one of the first proposals on the postulate of Dark Matter was related with the neutrinos. It was thought that the foreign matter that maintains the gravitational equilibrium in the cosmos would have to do with the neutrinos. Leon Lederman and Dick Teresi note with respect to the neutrino, in their book The Divine Particle, "Neutrinos are my favourite particle. They have almost no properties: they lack mass (or have very little), electric charge and radio; and for derision, strong interaction does not affect them" [18]. In fact, it is stated that there is nothing that has so few properties. There are many large experimental facilities for the detection of neutrinos and also for the study of the previously unknown nature of Dark Matter [16,19-21]. These laboratories occupy a large number of underground complexes on all continents. For example, in Spain, there is the Underground Laboratory of Canfranc (Huesca), which is located in an old railway tunnel in the Pyrenees Mountains [22]. Examples of precursors were Kolar Gold Fields (in India) [23] and the East Rand Proprietary Mine (South Africa). Most of these facilities are at depths underground of several metres, and in some cases kilometres, in an effort to isolate the facility from cosmic rays and any other disturbing effect. Some facilities are of another type like the Fermi telescope of the NASA that looks for sources of gamma rays that would be the product of the annihilation of two particles of Dark Matter. It is said that in the near future, the Euclid telescope of the European Space Agency will be in operation. This is a telescope that is under construction, which is expected to enter orbit in a short period, that is to say around the year 2020 [24]. In addition to neutrinos, among many other proposals, researchers seek to detect the so-called WIMPS particles (massive particles of weak interaction), the so-called MACHOS (massive astrophysical compact halo object), and all of them could supposedly configure Dark Matter [19-22,25-27]. In addition to all of this, the axion is presumably a neutral particle and very light in weight (but not without mass), and does not interact, or if it does interact then it does so very weakly, with conventional matter. You can see the axion as a "strange" photon. In fact, some theories predict that the axion, if it exists, could be transformed into a photon (and vice versa) within electromagnetic fields. This axion property is crucial for experiments that seek its detection. But, undoubtedly, one of the most suggestive properties of the axion is that it would have occurred naturally in large quantities at an early time in the Universe. These axions would continue to exist today and could constitute the Dark Matter of the Universe which, according to some scientists, must compose almost a quarter of the entire mass of the cosmos, but has not yet been detected. The axions are, together with the WIMPS, two of the most wanted candidates with which to form the enigmatic Dark Matter [27], [28]. Experiments are being carried out in this regard, although they are still far from "seeing" axions as predicted by the Peccei-Quinn mechanism [28]. Because quantum fields are supposed to produce particles, Peccei-Quinn's theory predicts the existence of this new particle, the axion. The standard model of particle physics has this candidate that is considered firm for dark matter, the axion QCD (Quantum Chromodynamics), that as yet, has not been observed. A recent study estimates its mass at between 50 μeV and 1.5 meV (the mass of neutrinos is less than 230 meV). This result will guide the experimental search for the axion, which is based on its interaction with photons, or its effect on the spin of the neutron [26-28].

As time goes by, after 85 years of postulating the existence of Dark Matter, the search becomes somewhat frenetic, and at present there are several dozen projects that seek to detect and identify Dark Matter particles. In this direction, countries such as the United States, Canada, Italy, England and China finance large underground facilities that are aimed at detecting the exotic particles of the postulated Dark Matter. If the axion exists and if yes, as some suppose, it is the main component of Dark Matter, then the fossil axions that would be continually bombarding us could be detected using resonant microwave cavities (the axion mass) immersed in powerful magnetic fields [29]. In particular, this scheme is the one followed by the ADMX experiment (Axion Dark Matter Experiment) at the University of Washington, which could detect axions if Dark Matter would be composed of axions in their entirety [29].

To date, the result that researchers have, in the best of cases, is constituted by false alarms. In that, detection has not been possible.

3. Scientific Method

To make Science it is essential to use the Scientific Method. Science is undertaken by using a method which is precise, the Scientific Method. In other words, for Science to have certainty and validity requires extreme rigor and this rigor, to a large extent, is provided precisely by the Scientific Method. Among other things, this method requires a certain order of ideas and procedures. Here, it is imperative to point out two aspects of this method that are considered of utmost importance: a) The verification of a hypothesis should be able to be repeated a good number of times by different researchers and / or groups; b) It is advisable to propose hypotheses that produce a supposed advance in knowledge and not a setback.

In a large part, the development of Science as a creator of scientific knowledge is not uniform. One should not expect continuity in the appearance of knowledge as a product of scientific research. In fact, one can see jumps in time through history. It is not to be expected that there is uniformity between the laws of Kepler, then the contributions of Galileo, then Newton, then the famous researchers of electricity and magnetism such as Henry, Ampere, and Poison to give rise to Faraday and Maxwellian equations, etc. However, now in the era of supposed modernity, we can see a slowdown in the emergence of knowledge in the last 100 years of scientific research [29]. The two great modern pillars of scientific knowledge are the Theory of Relativity of Albert Einstein and the Quantum Mechanics of Erwin Schrödinger [30]. In this stage of the history of scientific research, two tendencies to undertake Science are introduced and put on the discussion table. With the emergence of both sciences, Relativity and Quantum Mechanics, a great change begins to occur on the weight given to the theory upon the experiment. In fact, the so-called Theoretical Physics is reinforced and Experimental Physics, in some magnitude is relegated. In particular, it is important to draw attention to the anti-intuitive nature of Relativity to such an extent that with any explanation about the theory one might feel ill at ease. Regarding general Relativity and theoretical physics, it can be said that for a long time there were only three experiments that validated the theory: the precession of the perihelion of Mercury, the deflection of light by the sun and the gravitational red shift [30]. On the other hand, with Quantum Mechanics a great abstraction is made [29]. That is, instead of explaining the theory in a framework belonging to physical space, it is abandoned and the explanation is transferred to the abstract world of Hilbert functions. The probability wave function of Quantum Mechanics has no direct physical meaning [29]. The physical meaning has to be sought in the so-called observables. In short, we can say that with the two main pillars of modern scientific research, to state it colloquially, we feel that the floor has moved from under us.

Returning to the Scientific Method, in the experiments that are carried out in CERN, for example, looking for the so-called Higgs Boson that is said to have been found in the year 2012, it is not possible to perceive in perspective what is really being done as a scientific investigation [31,32]. The experiment can practically not be repeated in other laboratories. And the hypothesis that the Higgs boson gives mass to the rest of the particles of the Standard Model of the Physics of Particles remains in a kind of limbo where it cannot be verified [31,32]. The same has happened with scientific research on Gravitational Waves [35]. In principle, two black holes must be available to carry out the experiment and, in addition, variations of longitudinal displacements of the order of $10^{-21}m$ would be determined with the interferometer [33]. It causes amazement, especially disbelief, that an experimental researcher can measure such variation of the separation between the mirrors of the interferometer, a tiny fraction of the radius of a proton ($\sim 10^{-16}m$) that is integrated in the same mirror. In fact, it would turn out to be five orders of magnitude smaller than the radius of the proton. Finally, within the standard model of cosmology, the pillars of the theory are: The Big Bang or The Expansion of the universe, the theory of the inflation of the universe, Dark Matter, Dark Energy and the nucleosynthesis. These pillars of the Standard Model of Cosmology suffer from the same problem, which is inscribed as aspect b), as stated in the above. These pillars are introduced regarding seeking to explain something of the theory, but they in themselves are inexplicable. That is to say, originally one seeks to explain something and in the end one has to explain both the original problem and now also what has been proposed as an explanation. This happens mainly with the so-called Dark Matter. In that, one would wish to explain the excessive rotation speeds of stars and galaxies and now one must also explain the nature of that strange and dark substance that cannot be found.

4. Other Celestial Mechanics

Even though Herbert Goldstein's Classical Mechanics textbook starts its sections 3-7 with the phrase that literally reads: "Of all the laws of central force, the inverse square of r turns out to be the most important" [34], but it can be shown that both the laws of Kepler and the law of universal gravitation of Isaac Newton that manifest this variation with r are not really universal. That is to say, that the mathematical expressions of these laws of nature do not have the validity that could be necessary in circumstances that are arbitrary. In electricity and magnetism it is known, for example, that when there are environments with matter, neutral or electrically charged, the expressions of the fields change and they can change radically [35]. In the gravitational case something similar happens. In a medium where there are sources of the field, in this case gravitational field, the mathematical expressions of the field do not turn out to be the traditional expressions. This can be shown by means of Gauss's law [35], [36]:

In Classical Electrodynamics, one of Maxwell's field equations is precisely Gauss's law, which in differential form is [36]

$$\nabla \cdot \bar{E} = \rho_q / \varepsilon \quad (1)$$

This same equation in its integral form is written as

$$\oint_S \bar{E} \cdot d\bar{s} = q/\varepsilon \quad (2)$$

In order for this equation to apply to the gravitational field, it is enough to change GM instead of $q/4\pi\ \varepsilon$. With this change Equ. (2) remains as

$$\oint_S \bar{g} \cdot d\bar{s} = -4\pi\ G\ M_s \quad (3)$$

Supposedly, the gravitational field unlike the electric field is only attractive, and it has been found that only the positive mass exists, therefore, a negative sign is placed on the right member of Equ. (3). We have introduced $\bar{g}$ to represent the gravitational field and G as the gravitational constant. M_s is the total mass contained within the surface S, see Fig. 1.

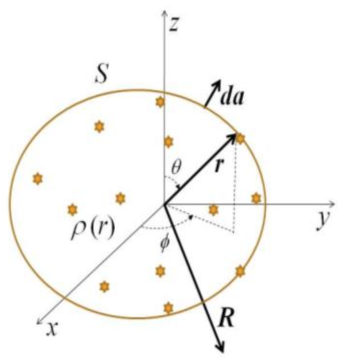

Figure 1: A Gaussian surface of a given shape immersed in a distribution of mass with density ρ (r). Many of the

applications of Gauss's Law take advantage of the symmetry that may be on the surface.

Here, the mass within an arbitrary Gaussian surface is defined as

$$M_s = \oint_s \rho dv \quad (4)$$

Where v is the volume within the Gaussian surface S and ρ represents the mass per unit volume within S. See Fig. 1.

As a first example, a mass distribution with spherical symmetry is proposed. In order to simplify the mathematical calculations a spherical galaxy with radial symmetry will be assumed. Suppose that we have a galaxy where the density distribution is such that

$$\rho(r) = cte \quad (5)$$

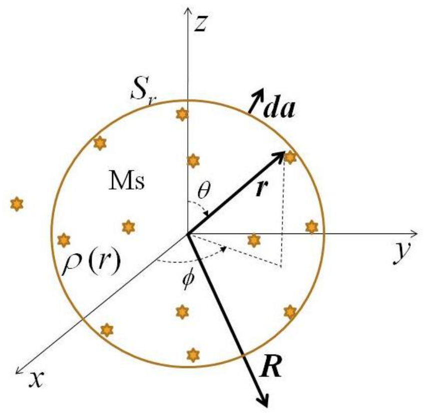

Figure 2: A Gaussian surface of spherical shape immersed in a distribution of mass with density ρ (r). In the general case, the mass contained within the Gaussian surface will depend on the density and the distance to the end of the galactic centre.

With Equ. (5) substituted in Equ. (4), we have

$$M_s = 4\pi \rho_{cte} r^3/3 \quad (6)$$

By the symmetry in the integral of Equ. (3) the field is constant in magnitude on the surface S_r and with Equ. (6), after integrating it is written

$$g\, 4\pi r^2 = -4\pi G\left(4\pi\rho_{cte} r^3/3\right)$$

From this expression

$$g \propto r \quad (7)$$

In this spherical galaxy with the proposed star density, Equ. (5), the gravitational field does not change as the expression of Newton's universal gravitation that says the gravitational field varies as $1/r^2$. In fact, here the field grows towards the periphery. With this, it is shown that the expression for the force of gravity of Newton is not universal, it is only valid in the Solar System, but not in all galaxies. By obtaining this variation of the gravitational field in a galaxy such as this one, relatively large velocities can be had for an important part of the stars of the periphery, and much greater than those obtained by Vera Rubin [13]. If we write

$$g = k\, r \quad (8)$$

where k is a constant, with m the mass of a star in that galaxy, subject to the force of the gravitational field of Equ. (8), by equalising this force with the "centrifugal" force on each of the stars, i.e.

$$k\, m\, r = mV^2/r \quad (9)$$

the expression for the radial velocities is calculated: It is obtained that the velocity varies with the distance to the galactic centre as

$$V \propto r \quad (10)$$

Practically, Vera Rubin obtained constancy in the determination of the speeds, therefore, with a simple calculation it can be shown that to that constancy in the radial velocities corresponds a distribution of the density $\rho(r) \propto 1/r^2$. With this form of mass density in Equ. (4) we obtain that $M_s \propto r$. With this expression for the mass contained within the Gaussian surface, it is obtained that the gravitational force is such that Eqn. (9) is now written as

$$k\, m/\, r = mV^2/r \quad (11)$$

from where it is obtained that V does not depend on the distance to the galactic centre. Here we can see that, in the case of that which Vera Rubin found, when there is evidence of constant radial velocity, it is most likely that the galaxy can be found to have approximately the proposed mass distribution, that is, $\rho(r) \propto 1/r^2$.

This calculation can be made for different radial velocity curves and the shape of the distribution of the mass ρ that could correspond to each case can be approximated [37]. For example, a galaxy with $V \propto \sqrt{r}$ corresponds a radial mass density such that

$$\rho(r) \propto 1/r \quad (12)$$

In fact, with this reasoning in this order, a very good approximation can be obtained for the distribution of the mass in a galaxy by experimentally determining the curve of the radial velocities of the stars [37].

5. Numerical Calculation

Two cases were considered for the numerical calculations, one where the particle configuration is distributed according to the density function $\rho(r) = a$, and another where $\rho(r) = a/r$, being a constant. The results are shown in Figs. 3 and 4, where the calculated values of the gravitational field $\bar{g}$, velocity V and density, normalised to the maximum, ρ/ρ_{max} for each case have been plotted.

In detail, a discrete distribution of total mass M was produced numerically. Assuming a spherical configuration of radius r_0 enclosing n particles of mass $m_i = M/n$, $i = 1, \ldots, n$ we have, that the density of particles is $\rho(r) = n/v$ where $v = 4\,\pi\, r^3/3$ and, therefore, $n = 4\,\pi\, r^3 \rho(r)/3$ is the number of particles within each spherical surface of radius r. We calculate the gravitational field $\bar{g}$ and the velocity V of a test particle, in n_{test} points to $\left(r_j, \theta_j, \phi_j\right), j = 1, \ldots, n_{test}$ which lie along a radius of the particle distribution. The field is calculated from the superposition of the individual fields that are produced by each particle m_i in the test points, while the velocity is obtained by equalising the gravitational force with the centrifugal force, ie $V = \sqrt{rg}$.

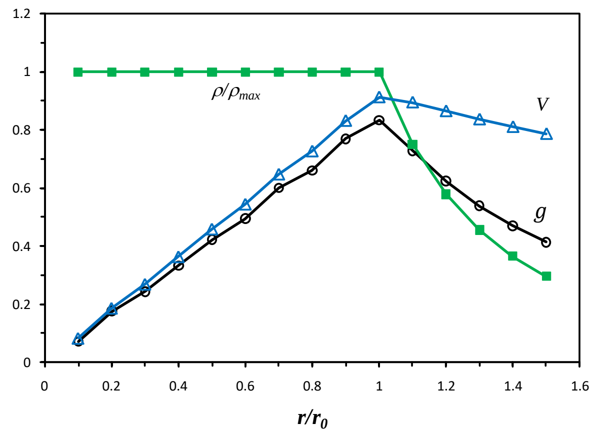

Figure 3: The results obtained for the case $\rho(r) = \text{constant}$ are shown. The graphs show that both $\bar{g}$ and V vary linearly, that is, within the discrete mass distribution.

Fig. 3 shows the case of constant density. It is observed that both $\bar{g}$ and V exhibit a linear behaviour in the whole range that is occupied by the particle distribution, from $r = 0$ to r_0, to decay, from this point, probably as $1/r$.

The results for the second case are shown in Fig. 4. We can see that, in the region occupied by the particle distribution, the density decays as $1/r$, while $\bar{g}$ remains approximately constant and V grows as $\sqrt{r}$. In both cases, the results agree with what was predicted in the previous section.

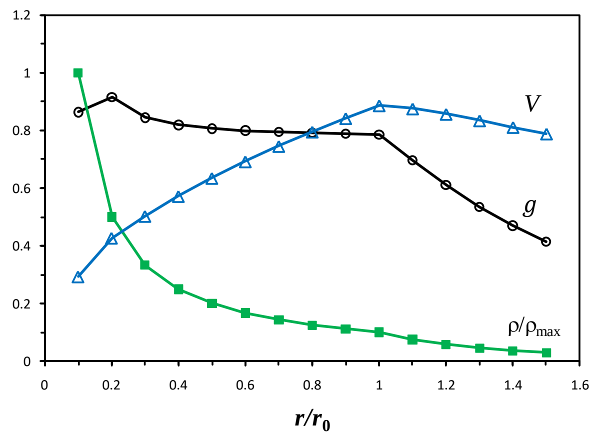

Figure 4: Here we see that, in the case of a density that varies as $1/r$, the field $\bar{g}$ is almost constant inside the mass distribution, whereas V behaves like $\sqrt{r}$.

6. Conclusions

In this work, it is shown that the gravitational dynamics in a solar system is different to the galactic dynamics and the dynamics in the clusters. The gravitational laws (Kepler and Newton) that are supposed to be universal at the end of this analysis have to be non-universal. The mass that is dispersed in a galactic system is in fact discretised, occupying practically all of the volume of the gravitational system, unlike the solar system where the sun contains almost all of the mass. When a star moves in an environment where sources of the gravitational field exist, the variation of the resulting force on the star generally turns out to be different from the traditional form. In fact, it has another radial dependence, that is different from the universal gravitation of Isaac Newton. With respect to the solar system, it can be said that there is a different dynamic than the dynamic of a galaxy and the dynamic for galaxy clusters. When obtaining new expressions for the force in terms of the distance to the galactic centre, it is concluded that it is superfluous to introduce the postulate of the so-called Dark Matter that, as it is settled, would make up approximately 25% of the total mass of the universe. The excessive radial velocities that were found experimentally, now have a plausible mathematical explanation, since the resultant force can be so great that it maintains the integrity of these gravitational systems.

Despite the insistence, to date it has not been possible to detect something that can be called a Dark Matter particle, and the economic investment to try to detect the particles that would make up this invention of the Dark Matter turns out to be large. Several countries around the world are engaged in this unsuccessful search. The curves of the rotation speed of stars and galaxies have a clear mathematical explanation and it is not necessary to search for these alien, strange and apparently nonexistent particles.

With the analytical demonstrations that are carried out in this work, it can be affirmed that galaxies and galaxy clusters maintain their integrity, that is, they do not tear apart, because the gravitational force has a different expression from that which was assumed by Vera Rubin and others, and they are in fact of greater magnitude in many cases.

The numerical calculations undoubtedly reinforce the analytical results that have been obtained for the gravitational force in the galactic systems. Also, as stated, it is possible to obtain an approximate expression for the density and distribution of the mass in these galactic systems from the measurements of stellar rotation speeds.

Finally, it is emphasised that, with an adequate collateral analysis of this gravitational dynamics, from the experimental curves of rotation of speeds in galaxies and clusters, it is possible to study the distribution of the galactic mass, that is, approximate expression can be obtained for the density of mass in these celestial bodies.

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References

[1] Dodelson, S. "Modern Cosmology", Academic Press (2003)
[2] Spergel, D.N., Bolte, M., Freedman, W.: PNAS **94**, 6579-6584 (1997)
[3] Bolte, M., Hogan, C.J.: Nature **376**, 399-402 (1995)
[4] Mitchell, W.C.: Physics Essays **10**, 370-379 (1997)
[5] Harrison, E.: Astrophys. J., Part 1 (ISSN 0004-637X) **403**, 28-31 (1993)
[6] Zwicky, F.: Helv. Phys. Acta **6**, 110–127 (1933)
[7] Zwicky, F.: Astrophys. J. **86**, 217–246 (1937)

[8] Rubin, V.C., Ford, W.K.: Astrophys. J., **159**, 379-403 (1970)
[9] Rubin, V.C., Ford, W.K., Norbert, Th.: Astrophys. J., Part 2 - Letters to the Editor, **225**, L107-L111 (1978)
[10] Rubin, V.C.: Scientific American, **248**, 96-108 (1983)
[11] Einasto, J., Kaasik, A., Saar, E.: Nature, **250**, 309-310 (1974)
[12] Einasto, J., Saar, E., Kaasik, A., Chernin, A.D.: Nature, **252**, 111-113 (1974)
[13] Rubin, V.C.: Phys. Today, **59** 8-9 (2006)
[14] Arun, K., Gudennavar, S.B. Sivaram, C.: Gen. Phys. (physics.gen-ph), Advances in Space Research, **60**, 166 -186 (2017)
[15] Sivaran, Ch.: (Letter to the Editor), Astrophys. and Space Science, **219**, 135-141 (1994)
[16] Nieves, J.M., "¿Primera detección directa de materia oscura?": Broadcasting ABC Ciencia, 20/10/(2014).
[17] Cassini, A.: Scientiae Studia (Print versión ISSN 1678-3166) **10,** Sao Paulo 1-17 (2012)
[18] Lederman, L., Teresi, D.: "La partícula divina" , Si el universo es la respuesta, ¿Cuál es la pregunta? CRITICA, México D. F. 21 (2013).
[19] Servant, G., Tait, T. M. P.: Nucl. Phys. B, **650,** 391-419 (2003).
[20] Pretzl, K.: Spatium, No. 7 May 2001, INTERNATIONAL SPACE SCIENCE INSTITUTE, Bern, (2001)
[21] Giudice, G.F., McCullough, M., Urbano, A.: J. of Cosmol. and Astropart. Phys., CERN, Theoretical Physics Department, Geneva, Switzerland, **2016**, (2016)
[22] Sarsa, M.L.: Rev. Real Academia de Ciencias, Zaragoza. **63**, 41-100 (2008)
[23] Ang, R.: AsianScientist, October 12, (2017)
[24] Moreo, R.T.: Espacio-Tele[o (Universidad Politécnica de Cartagena) no. 3, 133-136 (2012)
[25] Clowe, D., Bradac, M., Gonzalez, A.H., Markevitch, M., Randall, S.W. Jones, Ch., Zaritsky, D.: Astrophys. J., **648,** L109-L113 (2006)
[26] Navarro J.F., Frenk C.S., White S.D.M.,: Astrophys. J., **462,** 563-575 (1996)
[27] Hernandez, M., Ma, T., Wang, Sh.: J. Math. Study, **48**, 199-221 (2015)
[28] Irastorza, I.G.: "¿Qué es el Axión y qué relación tiene con la Materia Oscura?, CPAN: Centro Nacional de Física de Partículas Astropartículas y Nuclear. Ingenio 2010, 16/12/(2013)
[29] Laserna, D.B."Las paradojas de la física" (Los mayores rompecabezas científicos), RBA Contenidos Editoriales y Audiovisuales, S. A. U. Impreso en España (2017)
[30] Kaufmann, III, W.J.: "Relatividad y Cosmología", Segunda Edición, Harla, S. A. de C. V. Buenos Aires Argentina, 33 (1977)
[31] Carroll, S.: "The particle at the end of the universe" (How the hunt for the Higgs boson leads us to the edge of a new world), Dutton, printed in USA, (2012)
[32] Meléndez-Lugo, L.: Inter. J. of Applied Res., **1**, 670-676 (2015)
[33] Moskowitz, C.: Scient. American, February 11, (2016)
[34] Goldstein, H.: "Classical Mechanics", second Edition, Addison-Wesley Publishing Company, 94 (1980)
[35] Scott, W.T. : "The Physics of Electricity and Magnetism", New York-John Wiley& Sons, Inc. Third Printing, 17 (1962)
[36] Jackson, J.D.: "Classical Electrodynamics", John Willey & Sons, New York, Second Edition, (1975)
[37] Persic, M., Salucci, P., Stel, F.: Mon. Not. Roy. Astron. Soc., 281, (1996)

Author Profile

Leandro Meléndez Lugo, Degree in Physics and Mathematics ESFM, IPN. Master's and Doctorate credits in Physics, Faculty of Sciences, UNAM. Award "Dr. Nabor Carrillo Flores ", for technological development: Design, construction and operation of the Tokamak Novillo (ININ). PhD. Department of Physics UAM-I. Doctoral thesis: New solutions of the Einstein equations for the Mixmaster and Taub universe models and the antigravity phenomenon. Approximately 40 papers on: Plasma Physics, Electrodynamics, Cosmology, Gravitation, Relativity, Sociology and Filosofy. (SNI) National Researcher Level 1.

Esteban Chávez-Alarcón, M.Sc. Physics degree from Universidad Autónoma Metropolitana, Mexico 1999.He was a member of the Plasma Physics Group of the Instituto Nacional de Investigaciones Nucleares (ININ) and he collaborated in the operation of the Mexican tokamak called "Novillo", until 1999. He developed a code to simulate the magnetic fields in toroidal devices. He has participated in some projects at Instituto de Ciencias Nucleares, UNAM, and more recently he was involved in the design of an ergodic divertor for MEDUSA tokamak in collaboration with the Costa Rica Technology Institute. His current research interests include the numerical simulations of magnetic fields in toroidal devices and their behavior due to external magnetic perturbations caused by asymmetries of the magnetic fields.