

Calculation of the Acceleration of the Expansion of the Universe

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In 1929, thanks to his astronomical observations, Hubble was the first to discover that the universe is expanding [3]. More recently, astrophysicists have found that the rate of the expansion of the universe was not uniform over time and that the expansion appeared to be accelerating over time [15, 16].

The universe expands, which slows down the angular rotation speed of the universe. Moreover, whenever energy is transformed in the universe, entropy (measurement of the amount of disorder) increases over time (such as a friction effect that slows down a wheel). We might be inclined to believe that the increase in the entropy of the universe causes the expansion of the universe, however, this is not the case. The increase of entropy in the universe is not the cause of the expansion of the universe, but the consequence of the fact that forces do not exist and that the universe is expanding.

By simply assuming that gravitational force does not exist (it is only a practical mathematical concept) and can be explained by a concept of radiation pressure [14], it is possible to explain why, universe is expanding. Our hypothesis explains why the expansion of the universe accelerates and allows calculating the value of this acceleration. It also makes it possible to know that the acceleration of the expansion of the universe decreases over time to eventually tend towards zero. When the limit of the apparent radius of curvature of the universe tends to infinity, no more interaction between the different photons contained in the universe will take place. The universe will then continue to expand at a constant rate which we arbitrarily call "k" (referring to our first paper [8]) and which is greater than the current velocity of light "c" in the vacuum.

The "force of gravitational attraction" as seen by Newton and the "space-time deformation" of Einstein explain the same phenomenon of acceleration from one object to another associated with gravitation. This phenomenon of gravitation is not really a fundamental phenomenon linked to the expansion of the universe. It is only a side effect that appears because we are inhabitants of the universe and we bathe in a huge bath of photons of different wavelengths.

As for entropy, the arrow of time is caused by the fact that forces do not exist and that the universe is in a process of expansion to infinity. There will never be a "big crunch" and the course of time will not be reversed. The disorder of the universe, that is its entropy, as well as time, can only increase because the forces do not exist.

KEY WORDS: Acceleration, expansion, universe, Hubble constant

1. INTRODUCTION

When astronomers and astrophysicists affirm that the universe is expanding (as suggested by Hubble [3]), it is suggested to the reader that the apparent radius of curvature of the visible sphere of the universe increases over time. When they say that the expansion of the universe is accelerating, then it is suggested to the reader that the variations of the apparent radius of curvature are greater as time goes on.

In this article, we want to show that because forces do not exist, the universe is expanding and allows the entropy to increase over time. Since forces do not exist, the entropy can only increase over time and implies a time arrow which can not move backward.

Mathematical equations give the possibility to describe our real world. Mathematics is a powerful tool which allows certain predictions, but not more over.

Newton and Einstein succeeded in describing the acceleration of objects towards each other on a macroscopic scale. Their equations work well in a well-defined framework. Mathematical equations describe the trajectories of objects, but these equations are not, by themselves, explanations of the underlying causes. "Forces" are useful mathematical concepts and the statement of their existences seems natural to everyone. But they simply do not exist. The appearance of their existence is simply due to the fact that we are bathing in a photon bath and that we are part of the universe that contains these photons.

2. DEVELOPEMENT

2.1. The Acceleration of the Expanding Universe

We must pay attention to the interpretations. If it has been possible for astronomers to observe, with the help of observations, that the universe is expanding [3] (first derivative of distance from time) and the expansion of the universe accelerates [15, 16] (second derivative of the distance from time), nothing has been measured or found with respect to the third derivative with respect to time. This means that the observations currently made by astronomers do not make it possible to know whether this acceleration is increasing or decreasing over time. To rule on this fact, this requires an unprecedented level of

precision on the measurements that are made or a revolutionary method that does not require precise measurements.

The measurements and observations made so far must be considered as an exploit in itself. It is unlikely (but not unachievable) that one day it will be possible to really be able to measure the third derivative with respect to time. This does not mean that it will not be possible to know whether the acceleration increases or decreases over time, without knowing how much.

In order to understand the level of difficulty of adequately measuring a third derivative of distance with respect to time, let us begin by observing that the Hubble constant H_0 , which allowed us to observe that the universe is expanding, is currently very poorly known. It represents a derivative of a distance with respect to time, by MParsec (which is a unit of measurement of astronomical distance where 1 Parsec = $96\,939\,420\,213\,600\,000/\pi$ meters [25], which corresponds to approximately $3.085677581 \times 10^{16}$ m). Ultimately, when distance units are chosen to cancel each other out, we get a constant that represents the inverse of the apparent age of the universe. Despite all the precise measurements that have been done so far, we can see that the value of the Hubble constant is between about 67 and 76 km/(s·MParsec). This variation represents almost a variation of one decade.

To observe acceleration over time, this requires a degree of precision that will allow us to discriminate if the measurement that is made is an error or a real acceleration. This requires a measurement gap that is at least 10 to 100 times smaller to see a variation over time. Similarly, to see if this change over time increases or decreases, you need another factor of 10 to 100, which means you need to know the Hubble constant 100 to 10,000 times more accurately than now. However, we do not want to deny that there may be other ways to find that the expansion of the universe is accelerating and that this acceleration is increasing or decreasing over time.

Let us now give an example showing that it is not really necessary to make precise measurements to know which way the acceleration of the universe is evolving. Suppose the floor of a house is infinitely straight and at level in every way. Suppose also the presence of a table deposited on this floor. Of course, for more alert minds, so that a table can not undergo the curvature of the earth, it implies that the table is small compared to the Earth. To know if the table is at level, it is possible to measure precisely, with a ruler, the height of its four legs. In theory, if the surface of the table is straight and the four legs are of the same length, it can be considered that the table is at level. But this requires great

precision in measuring the lengths of the table legs. Yet, simply drop a simple ball on the middle of the table to see if the table is at level or not. If it stays in place while being free to move, the table is undeniably level. If it moves, it will be easy to see that the table is not at level. What is wonderful is that the use of the ball does not require any specific instrument. Using the ball, however, we can not know what the height of the table is, but we know for sure that the table is at level or not and that the four legs of the table have the same length.

By this example, we wanted to show that the expansion of the universe was found thanks to the Hubble constant H_0 . But it is not necessary to use an accurate measure of the Hubble constant to see the acceleration of the expansion of the universe. In the future, a precise method, to see if the acceleration of the expansion of the universe is increasing or decreasing, can be discovered.

2.2. The Inexistence of Forces

Contrary to the four great forces of the universe (gravitational force, electrostatic force, strong nuclear force and weak nuclear force), these are just practical mathematical concepts. It must be admitted; the concept of force is very intuitive and seems natural. In fact, **the forces do not exist.**

The interstellar void is a void of matter, but it is full of photons of different wavelengths that constantly hit matter in all directions. For the moment, it is already possible for us to explain the gravitational force and the electrostatic force with the same principle using only the principle of radiation pressure (photon impacts on matter).

The principle of radiation pressure implies that we are "immersed" in a bath of photons of different wavelengths. For an expansion of the universe to be possible, the radiation pressure external to the universe must be less than that of the universe or zero. The potential existence of multi-universe is likely and possible. But it is only a speculation because it can never be proven since our field of vision is limited to our universe. For this reason, we are forced to assume that the universe extends into a void that is empty of matter and photons (otherwise, we could receive images of events outside the universe). This void is a quantum vacuum where there is absolutely nothing.

2.3. Value of the Physics Parameters Used

Let's outline all the basic physics parameters we intend to use in this article. These values are all available in CODATA 2014 [1].

• Universal gravitational constant	$G \approx 6.67408(31) \times 10^{-11} \text{ m}^3/(\text{kg}\cdot\text{s}^2)$
• Fine structure constant	$\alpha \approx 7.2973525664(17) \times 10^{-3}$
• Mass of the electron	$m_e \approx 9.10938356(11) \times 10^{-31} \text{ m}$
• Classical radius of the electron	$r_e \approx 2.8179403227(19) \times 10^{-15} \text{ m}$
• Planck time	$t_p \approx 5.39116(13) \times 10^{-44} \text{ s}$
• Speed of light in vacuum	$c \approx 299792458 \text{ m/s}$

2.4. The Universe is Expanding Because Forces Do not Exist

Let's start by establishing the fact that the universe is in rotation just like the particles that constitute it. We have already shown in the past [21] that an expanding universe, without rotation, would have a diffuse background temperature (CMB) close to 31.9 °K. However, a universe with a speed of rotation close to the speed of light (related to the fine structure constant), according to our calculations, would have a temperature around 2.73 °K. At present, the average temperature of the diffuse background is known quite accurately thanks to the Cobra probe which establishes it at 2.736(17) °K [17]. This undeniable fact allows us to conclude that the universe is indeed in rotation and can not be static.

When we observe an artistic skater doing rotations on herself, we see that by extending the arms, her rotational speed decreases. However, she has the leisure, as she wishes, to retract her arms on her chest to start turning faster. The angular speed of rotation of the universe therefore decreases as it expands. But unlike the skater who is endowed with a will, the universe can not contract and can not go backwards by decreasing its apparent radius. For this to be possible, it would be necessary that the "force of gravitational attraction" could force the universe to collapse on itself in a "big crunch". We only use the gravitational force here because it is the only one that can interact at long distance. Then the question to be elucidated is: "Does the gravitational force exist and can it allow a contraction of the universe?"

The gravitational force has already been quantified by Newton thanks to its equation of general gravitation. This equation is considered accurate for the specific cases where the velocities of the involved masses are relatively slow, the involved system is relatively small compared to the universe and the involved

masses are relatively small. As soon as we leave this framework, we see a discrepancy with reality. We must then turn to Einstein's general relativity equations. This one makes it possible to highlight relativistic phenomena which are not apparent within the limits of use of the general gravitation equation of Newton.

Einstein, in a more general concept, which includes the special case of Newton's theory, explains gravitation as a manifestation of space-time distortions. In such a system, the straight line is not the shortest distance between two points, but rather a curve. The trajectories of objects and light would be curved.

Whatever the theory used between that of Newton or Einstein, none allows us to really know the nature of gravitation. Newton's equation can not predict the evolution of the universe. Einstein's equations predicted that the universe was necessarily either in contraction or in expansion, and that the static option did not exist. Einstein did not believe the result of his expansion and falsified it by introducing a constant that he called the "Cosmological constant" to force the universe to be "static". In 1929, through his observations, that Hubble found that the universe was expanding [3].

Nevertheless, Einstein's equation of general relativity provides for a possibility of a shrinking universe. But, as we said, mathematics is only a powerful tool that does not take into account physical realities. It is necessary to know more about the nature of the forces to know what is possible or not. The question that remains is: "What causes the phenomenon of gravitation?"

In a concept using the radiation pressure caused by the transmission of quantities of movements coming from photons, we have already shown that the concepts of "gravitational force and electrostatic force" do not really exist. Nevertheless, they are mathematical concepts that are useful and relatively easy to quantify.

To introduce the reader to our concept, let us first mention that the interstellar vacuum is a void of matter. The terminology "vacuum" used could misunderstand the reader by suggesting that it represents an absolute void. But this is not the case because vacuum is not nothingness. It is only a void of matter. However, it is filled with photons (electromagnetic waves) of different wavelengths. These photons are able to transmit quantities of movements by impacts.

The ether concept formerly used would be more accurate to us and the word ether would not refer to an absence of something, however, we can not redo the history and terminology of interstellar vacuum will remain.

Mathematical equations related to the different types of forces (gravitational, electromagnetic, strong nuclear and weak nuclear) do not allow to really understand the causes underlying the "forces".

At great distances, only "gravitational force" plays a role. It manifests itself when we are inside the universe and we undergo the impacts from photons of different wavelengths that surround us. Without this radiation pressure, the gravitational force as we know it would not exist. In fact, objects are not "attracted" to each other. They are rather "pushed" towards each other. Considering that the equation ends up being the same, the nuance may seem useless. However, it is important. Indeed, if an "attractive" gravitational force really existed, the universe could theoretically come back on itself by contracting in a "big crunch". However, this is not the case.

Even in Einstein's general relativity, gravitation is not considered like a force, but rather like a curvature of space-time. The original general relativity equation (without Einstein's cosmological constant) predicted a universe in expansion or contraction (even if Einstein did not believe it). But we must remember that the equation of relativity originates from a mathematical analysis of small space-time deviations and postulates that the speed of light is constant and represents the speed limit.

We have already shown that the speed of light in vacuum is not really the speed limit [18], but that it is at a $\varepsilon_v \approx 2.34 \times 10^{-114}$ m/s (which we have baptized "speed quantum") from the speed limit c , i.e. $c - \varepsilon_v$. Although this difference seems negligible, it is sufficient to limit the energy that can be transferred to a mass. Indeed, it is impossible to transmit to a mass more energy than there is in the universe itself. Moreover, it is impossible to transmit to each particle of an object more than the energy necessary for each particle to have Planck's mass. The Planck mass multiplied by the square of the speed of light represents the highest energy level that can be achieved for a given elemental particle.

We have already shown that light accelerates over time [8]. This acceleration depends on where we are in the universe. On the periphery of the luminous universe, that is, when the apparent radius of the universe is R_u , this acceleration is about $a_L \approx c \cdot H_0 \approx 7.00 \times 10^{-10}$ m/s². So, although Einstein's equations are quite in agreement with the short-lived experiments on Earth and even in our galaxy, the constancy of the speed of light (c which represents the speed limit in vacuum) would have to be reconsidered for long-term experiments. Indeed, Einstein's equations do not explain the Pioneer Effect, Doppler Effect, as we know it,

assumes that the speed of light is constant and leads to the conclusion that Pioneer probes slow down in time. However, considering that light accelerates over time, we find that Pioneer effect is an illusion due to the assumption that the speed of light is constant.

In fact, to get exactly Einstein's equations of relativity, it would have been more accurate to postulate:

For short-lived experiments compared to the age of the universe, it is possible to make the approximation that the speed of light in vacuum, out of gravitation, is constant for all reference systems. Moreover, although the speed of light in vacuum is not necessarily equal to the speed limit, it is close enough for us to consider the speed of light equal to the speed limit for any object displacement, any source of energy or information.

This has the implication that the speed of light we measure here, on earth, in vacuum, can not be the speed limit c . The influence of the Sun has an impact of about -6 m/s and the influence of the Earth has an impact of about 0.26 m/s. To measure the speed of light outside of gravitation, we are forced to measure the speed of light in vacuum, here on Earth, and then make the necessary corrections to take into account the gravitational effects that surround us (Sun, Earth and Moon, etc.). There comes a point where, in the measurements, even a big wave in the ocean, a tide or any animal that comes to roam on the ground can influence the measurements. Moreover, despite the acceleration of light over time we have predicted, it remains so small that, without having a better standard, the speed of light is without a doubt the best reference that we have now.

Even if we have calculated the annual variations of the different constants over time [19], it is preferable, from a metrological point of view (study of units of measurement), to say that the speed of light is constant and to reference as many units of measurement as possible with respect to the speed of light. For the moment, even if it's not true, it's still the best option because the speed of light varies so slowly on our time scale that we have a hard time measuring the difference over of time, during a human life.

By imposing the constancy to the speed of light, it has the effect of giving the impression that most parameters in physics are constant because when the speed of light will vary, the other physical parameters will vary accordingly. However, it will not be the case for the parameters that did not really vary, such as the fine structure constant α and N . These latter are necessarily constant over time because they represent ratios. If there were a variation in their numerator, their

denominator will vary in the same proportions and will cancel the variations. Even if in fact any physics parameter that has a unit of measurement varies over time, the reader will understand that by deciding to impose that the speed of light is constant, the only physical parameters that will seem to vary will be the true constant ones... and they are not numerous.

If Einstein had to redo his equations of general relativity taking into account the expansion of the universe and the variation of the speed of light over time, the equations would be totally different and would see their level of complexity increase on a phenomenal and totally undesirable way. There is already a clear difference in complexity between Newton's equations and those of Einstein's general relativity. This is at the point where Newton's equations are shown to almost all students while only academic elite is able to understand and use Einstein's general relativity equations.

As forces in general do not exist, and especially the gravitational force does not exist [14], the impacts between photons can only lead to an expanding universe. When photons stop being impacted by other photons, photons in the universe seek to advance in a straight line. Whatever their point and direction of origin, they are eventually called to follow a path that will direct them to the void surrounding the universe. The parts of the void that are filled with photons (or matter) are now part of our universe. The photons that seem to "leave" our universe will necessarily have the effect of occupying a greater part of the void (which is infinite) and of increasing the apparent radius of the universe.

Note that Einstein has already shown that masses can not move at the speed of light [12] because this would involve an infinite amount of energy that is unavailable in the entire universe. When the universe began its expansion, after the big bang, the photons got a head start on the material. Now, when we observe the universe, we observe the celestial objects and lose sight of the fact that the universe is not only made of matter, but also (and mainly) of photons (electromagnetic waves) of different wavelengths. The apparent radius of the luminous universe is much larger than the apparent radius of the material universe.

What physicists call "dark energy" is nothing more than electromagnetic waves (photons) of wavelengths that we can not detect. For an electromagnetic wave to be detectable, it is mandatory to have an antenna of the order of a quarter wavelength, otherwise, it is impossible to perceive its presence. Of course, since our physical capabilities to design antennas of different wavelengths are very limited by the smallness of the Earth compared to the universe, there is a range of

wavelengths inaccessible to measurements. However, these electromagnetic waves have an impact on the world around us and we should not ignore them only by our inability to perceive them.

2.5. Is the expansion of the universe caused by the fact that the forces do not exist or because the entropy of the universe only increases over time?

The entropy of the universe began to increase as the universe began to expand. But is the expansion of the universe due to increased entropy or because forces do not exist? This question looks like "Is the chicken or the egg that came first? It is difficult to decide and requires some analysis.

From a technical point of view, the lowest level of entropy that has ever existed in the history of the universe existed just before the Big Bang. Indeed, the whole universe was in a compact sphere and nothing could move.

Each time there is a transformation of energy in the universe, the entropy increases over time and allows a slowing down of the rotational angular velocity (like a friction effect that slows down a wheel). Increasing the angular velocity of the universe allows its apparent radius to increase over time. We can then believe that the increase in the entropy of the universe causes the expansion of the universe, however, this is not really the case.

When we look at the speed dial of an automobile, we note that the displayed speed increases as the car picks up speed. The display reading is thus linked in a certain way to the speed of the automobile. But if we manually force the needle to a higher speed, will that increase the actual speed of the car? Of course it is not the case because the increase in speed is not the cause, but rather a consequence of moving the car. It is the same for the increasing entropy of the universe. It is the consequence of events happening in the universe.

Let's give an example that shows that entropy is a consequence and not a cause. Suppose a glass placed on the corner of a table and suppose that it is ready to fall to break into a thousand pieces. Entropy will not increase as long as an outside event does not force the glass to fall. If it falls, the entropy will increase irretrievably. It will take more energy to restore the glass to its original state than it took to drop the glass.

Since entropy is a consequence and not a cause, the expansion of the universe is not caused by the increase in entropy. The increase in entropy is only a measure of the increase in disorder in the universe.

2.6. The Universe is Expanding Due to the Nature of the Gravitational Force

In order to show that the universe can not be held back by any force, let's start by giving a plausible explanation of the "gravitational force" while showing that it is not necessary to use the concept of force to explain the gravitational interactions [14].

Newton has been able, thanks to its concept of universal gravitation, to quantify and predict events involving different masses in space. However, although a very good low speed approximation for systems involving small dimensions and relatively small masses, the universal gravitation equation is not an explanation in itself. It's only a mathematical equation.

Of course, Einstein's equations of general relativity turn out to be more accurate than Newton's universal gravitation equation. Because of the heavy mathematical arsenal that accompanies the equations of general relativity, it is rather difficult to see what causes gravitation. Einstein described the universe as a space-time in four dimensions. The masses contained in the space create distortions in this space-time and the objects are obliged to follow the distortions. The shortest distance between two points is no longer the straight line, but equipotentials that make curves.

That being said, there are sometimes many ways to see the same reality and to describe it. Some may be easier to represent at the level of the mind.

Let's make the assumption that the whole universe is somehow made entirely of photons. These photons may be in uniform rectilinear motion or be confined in matter in some manner. Indeed, even if the current particle accelerators do not allow us to prove it yet, the fact remains that the annihilation of matter always ends up giving photons of different wavelengths. Moreover, the famous Einstein equation $E = m \cdot c^2$ equation implies that it is possible to transform matter into pure energy (photons) and vice versa. This hypothesis therefore seems plausible.

Let us then assume that the interstellar void is an immense bath of photons of various wavelengths ranging from $\lambda = 2\pi \cdot l_p$ (where $l_p \approx 1.62 \times 10^{-35}$ m is the

length of Planck) to $\lambda = 2\pi \cdot R_u$ (where $R_u \approx 1.28 \times 10^{26}$ m is the apparent radius of curvature of the universe).

Considering that to capture a particular wavelength, you have to have a quarter-wavelength antenna, it is easy to see the physical limitations that we have on Earth. Even if we were able to make antennas from the infinitely small to the size of the Earth's circumference, such antennas would still represent a very limited band of wavelengths compared to what can exist in the universe. Of course, not being able to capture wavelengths greater than the circumference of the Earth, our tendency is to deny the existence of these waves. We have long believed that electromagnetic waves did not exist until theoretically predicted by James Clerk Maxwell in 1865 [22] and experimentally demonstrated on March 15, 1888 by Heinrich Hertz [23].

All forces do not really exist. They are useful concepts for calculation purposes only. We have already shown that to explain the gravitational forces [14] and the electrostatic forces [13], it was possible to start from a single concept; the transfer of momentum from photons around us. The repeated and random impacts of ambient photons seem to explain the four basic forces: gravitational force, electromagnetic force, and strong and weak nuclear forces. Although we have not yet demonstrated strong and weak nuclear forces, our research is progressing and seems to be moving in this direction. In any case, to explain the expansion of the universe, only "gravitational forces" (if we agree to use the concept of force) have a range of action sufficient to have any effect.

The goal here is not to make the mathematical demonstrations that led us to express Newton's law [14] (which is of course a valid approximation only for static systems of small dimensions compared to the universe) from our concept of transmitting momentum by ambient photons (which can be seen as a radiation pressure). We only want to inform the reader, in short, of the underlying idea.

As mentioned later, suppose the universe is a huge bath of photons. Let's put a first mass m_1 in the universe. A pressure of photons will be felt all around this mass, ensuring the cohesion of it.

Let's put a second mass m_2 in the presence of the first. When the distance between the two masses is small compared to the dimensions of the universe, it becomes obvious that there are fewer photons between the two masses than coming from outside. Greater radiation pressure will be felt from the outside and will push the two masses closer together. As we get closer, the number of photons between the masses decreases and the masses accelerate.

Masses are not really "attracted" to each other, but they are "pushed" towards each other. From a mathematical level point of view, this concept leads exactly to Newton's equation, but this reality leads us to consider the expansion of the universe in a completely different way.

According to the value promoted by the CODATA 2014¹, universal gravitational constant $G \approx 6.67408(31) \times 10^{-11} \text{ m}^3/(\text{kg}\cdot\text{s}^2)$ [1]. The "attraction" force F obtained between a mass m_1 and a mass m_2 spaced by a distance r is given by equation (1). By convention, the gravitational force is negative to express an "attraction".

$$F = \frac{-G \cdot m_1 \cdot m_2}{r^2} \quad (1)$$

Note that Newton's universal gravitational constant is "valid" for our location in the universe as well as in the immediate vicinity. However, according to our research, we do not think it is valid everywhere in the universe. It can be seen as a constant for small displacements, much like we could say that the water pressure is relatively constant all around an object of 1 mm in diameter to 100 meters deep in the sea. For small variations in distances, the pressure can be approximated as being constant, but we know that this is not the case. The same goes for the universal gravitational constant.

Assuming that our present position is arbitrarily at β times the apparent radius R_u of the universe, we can conceive that a slight displacement around this position will not cause large variations in radiation pressure.

Let us now assume that we are at the R_u position of the apparent radius of the sphere of expansion of the universe. On one side, there is a void where the radiation pressure is zero. On the other side (that of the universe), the radiation pressure is non-zero because of the presence of photons that are moving away from the center of mass of the universe since about 361 108 years after the moment of the big bang [20]. Any other photon generated following this event is necessarily located less far away. This fact implies that the radiation pressure at the periphery of the sphere of expansion of the universe is lower than the radiation pressure that can be found at any position within the sphere of expansion.

¹ According to our research [9], we are able to measure $G \approx 6.673229809(74) \times 10^{-11} \text{ m}^3/(\text{kg}\cdot\text{s}^2)$. This value is obtained using an equation emanating from our research as well as from the values of c , m_e , r_e and α constants from CODATA 2014 [1].

The internal radiation pressure of the universe pushes all the photons as well as the matter towards a void. The universe is destined to grow to infinity until the distance between the photons is such that there can no longer be any interaction between them. From this moment, the acceleration of the expansion will cease and the luminous universe will extend at a constant speed which we will arbitrarily call k .

It must be understood that even light is influenced by other photons. To better understand, we can compare the photon to a person who is trying to run "straight" through a crowd of people running in all directions. This person ends up hitting on others and sees his race deviated and slowed down. But as soon as she stops being embarrassed by the crowd, she runs faster and at a constant speed (her maximum speed). For now, at our location in the universe, the radiation pressure is such that the speed of light is c . However, gradually as the universe expands, the density of photons present in the interstellar vacuum (absence of matter) decreases and allows a slight acceleration of light.

Some may think that it is the same thing to say that the masses are "attracted" to each other or that they are "pushed" towards each other, as long as Newton's equation is written the same way. But that's not really the case. Indeed, as long as masses are contained within the universe, Newton's equation can be considered as a good approximation when the velocities involved are small and the distances are small compared to the dimensions of the universe. But it is at the level of the universe itself that it becomes possible to see the importance of the subtlety of our concept. Indeed, the universe includes matter and electromagnetic waves (photons). As long as we can detect photons or matter, we are still in the universe. Outside the universe, it is total a void. The interstellar "vacuum" is an absence of matter but not an absence of everything. On the contrary, it is a real bath of photons of different wavelengths. The void is a quantum vacuum where there is an absence of matter and photons. There is no more radiation pressure coming from the photons since they are absent.

The universe extends by filling the void of its photons and its matter. There is no radiation pressure in the void because there is total absence of photons. According to our concept, the universe can not return to itself in a "big crunch". At the limit, when each photon has reached an infinite distance from the origin of the big bang of the universe, no more constraint will affect these photons. They will continue in a uniform rectilinear motion without being affected by anything. Their speed will be constant and will represent an impassable speed limit. This limit, we arbitrarily call it " k ".

The fact that the universe can only be expanding imposes an arrow of time that only goes forward. The universe can only go towards a bigger disorder by continuing its expansion. Like a can of oil spreading on a floor, the oil stain can only expand over time without ever returning to the can. And if we clean the oil stain so that the oil can be brought back into the can by borrowing the energy provided by the oil to clean it, the can will not be completely filled. The same goes for the universe. If we seek to restore the original order of the universe, we must borrow energy from the universe and this makes it impossible to finish what we started. It is therefore impossible to return to the initial state in a "big crunch".

The second principle of thermodynamics predicts that a system evolves over time by irreversibly transforming itself so that entropy (disorder) can only increase over time. It is possible to associate qualities with different forms of energy. The best form of energy being electrical energy and the lowest form of energy being heat. During any transformation, energy is always transformed into other forms of energy of "lower quality". Even if the amount of energy is conserved, to return to the initial form of energy, we must consume even more energy than we originally had.

Finally, we find that the universe is expanding because of the fact that gravitational force, as we conceive it, does not really exist [14].

2.7. Calculation of the Acceleration of the Expansion of the Universe over Time

As the universe expands, the speed of light increases [8]. Indeed, Einstein has already shown that an imposing mass was able to change the refractive index of the vacuum and to slow down the electromagnetic waves. Based on the equations of general relativity, Schwarzschild [10,11] came to quantify the speed of light v_L as a function of a distance r from the center of mass m using the following equation:

$$v_L(r) = \frac{c}{\sqrt{1 + \frac{2G \cdot m}{c^2 \cdot r}} \sqrt{1 - \frac{2G \cdot m}{c^2 \cdot r}}} \quad (2)$$

This equation uses the universal gravitational constant G and the speed of light in vacuum c .

In 1929, Hubble showed that the universe is expanding [3]. Following his research, he brought out a parameter of the universe that he called "Hubble constant H_0 ". We should rather speak of a pseudo-constant since its inverse represents the apparent age of the universe. The value of H_0 is therefore called to evolve and decrease in value over time. However, for a short period of time relative to the age of the universe, this parameter may appear constant.

The value of the Hubble constant is difficult to measure and despite many efforts, astrophysicists still find values between 67 to 76 km/(s·MParsec). However, the most realistic value, in our opinion², was found by the Xiaofeng Wang team [4] with a value of $H_0 \approx 72.1(9)$ km/(s·MParsec).

The value of the Hubble constant H_0 corresponds to the inverse of the apparent age of the universe T (which is around 13.56 billion years [24]):

$$H_0 = \frac{1}{T} \quad (3)$$

The Hubble constant makes it possible to calculate the apparent radius of curvature of the luminous universe R_u (can carry several different names [5, 6 and 7]):

$$R_u = \frac{c}{H_0} \quad (4)$$

This radius of curvature corresponds to the radius of curvature of an expanding sphere, if it were at the speed of light c from a point of origin, for a period of time equal to $1/H_0$. Be careful, this does not mean that the expansion of the universe was at a constant speed. Indeed, by using the current speed of light and the "apparent" age of the universe (which is the inverse of the Hubble constant H_0), it is as if we were doing a kind of average speed of expansion over time to get the total path traveled.

At the big bang event, light began to invade the void to form what we call the luminous universe. Taken as a whole, the luminous universe is expanding at the speed of light. Although light composing the universe (which we have called the luminous universe) can extend at the speed of light, the expansion movement of the material universe can not be realized at the same speed.

² Thanks to our research, we have theoretically calculated the precise value of Hubble constant [9] to get $H_0 \approx 72.09548580(32)$ km/(s·MParsec) using the values of c , r_e and α from CODATA 2014 [1].

Thanks to his equations of the special relativity of 1905, Einstein was able to show us that it is impossible for any object to reach the speed of light [12].

Considering the fact that material objects can not move at the speed of light, we hypothesize that the material universe expands at a fraction of the speed of light, i.e. βc . The arbitrary factor β represents the ratio between the expansion speed of the material universe versus the speed of light c .

If we want to know where we are in relation to the growing periphery of the luminous universe, we can calculate the apparent radius of curvature r_u in relation to the center of mass of the universe by doing:

$$r_u = \beta \cdot R_u \quad (5)$$

Note that Hubble constant H_0 also corresponds to the rotation frequency ω of the material universe (visible) on itself (considering an apparent radius of curvature of the material universe equal to r_u). Similarly, H_0 corresponds to the rotation frequency ω of the luminous universe on itself (considering an apparent radius of curvature of the luminous universe equal to R_u).

$$H_0 = \omega = \frac{\beta \cdot c}{r_u} = \frac{c}{R_u} \quad (6)$$

Still using Hubble constant H_0 as well as the universal gravitational constant G and the speed of light in vacuum c , Carvalho [2] shows that it is possible to evaluate the apparent mass of the universe using the following equation:

$$m_u = \frac{c^3}{G \cdot H_0} \quad (7)$$

Knowing that the universe is expanding, it is realistic to think that all matter of the universe is moving away from any center of mass. There may be local movements of rapprochement between certain objects such as galaxies. However, globally, galaxies move away from each other over time.

This movement of expansion over time makes one realize that moving away from a center of mass, the index of refraction of vacuum of the expanding universe must necessarily decrease over time. This decrease in the global refractive index of the universe would allow light to accelerate over time.

The current speed of light would then be a snapshot in time of a slow progression. We can then assume that this progression will take the same form as equation (2),

but with a speed limit other than c . Let's take arbitrarily the constant k to represent this new limit. By taking an expansion of infinite dimension, the speed of light will therefore tend towards the value k for an apparent age of the universe which tends towards infinity.

Let's rewrite equation (2) using the value of k instead of c :

$$v_L(r) = \frac{k}{\sqrt{1 + \frac{2G \cdot m}{k^2 \cdot r}} \sqrt{1 - \frac{2G \cdot m}{k^2 \cdot r}}} \quad (8)$$

In this equation, for a value $r = r_u$ (that is to say, that corresponds to our location in the universe relative to the center of mass of the universe) and for a mass equal to the apparent mass of the universe m_u , we necessarily get the current speed of light in vacuum which is c .

$$v_L(r_u) = \frac{k}{\sqrt{1 + \frac{2G \cdot m_u}{k^2 \cdot r_u}} \sqrt{1 - \frac{2G \cdot m_u}{k^2 \cdot r_u}}} = c \quad (9)$$

The speed c represents the derivative of the distance with respect to time. As we mentioned earlier, the material objects of the universe can not move at the speed of light and will always have a delay in relation to light, hence the factor β we introduced earlier. The objects of the universe therefore move at the speed v_m .

To obtain a more general equation, while being in a universe of mass m_u , let's replace the distance r_u by any distance r .

$$v_m(r) = \frac{\beta \cdot k}{\sqrt{1 + \frac{2G \cdot m_u}{k^2 \cdot r}} \sqrt{1 - \frac{2G \cdot m_u}{k^2 \cdot r}}} \quad (10)$$

Deriving the velocity v_m from equation (10) with respect to distance r and evaluating it at the distance r_u , we obtain exactly the Hubble constant H_0 . Indeed, the Hubble constant is the derivative of the speed of expansion of the material universe (since Hubble used the objects seen at the telescope, here on Earth, to measure the value of its "constant") compared to the distance r .

$$H_0 = \left. \frac{dv_m(r)}{dr} \right|_{r=r_u} = \frac{\beta \cdot y \cdot k}{r_u} \cdot \left(\frac{1}{(1+y) \cdot \sqrt{1-y^2}} \right) \quad (11)$$

where $y = \frac{2 \cdot G \cdot m_u}{k^2 \cdot r}$

So far, the known parameters of the universe we have used are only the speed of light c , the universal gravitational constant G and the Hubble constant H_0 . We are looking for five unknown parameters, namely the apparent radius of curvature of the universe R_u , the apparent radius of curvature of the universe r_u at our location, the apparent mass of the universe m_u , the ultimate speed of light k when the apparent radius of curvature the universe will tend to infinity and β which represents the ratio between the speed of expansion of the material universe and the speed of expansion of the luminous universe (which is presently equal the speed of light in a vacuum c). Having five unknowns, we need five equations to solve. Let us use equations (4), (5), (7), (9) and Erreur ! Source du renvoi introuvable. to obtain the following results:

$$R_u \approx 1.28 \times 10^{26} \text{ m} \quad (12)$$

$$r_u \approx 9.80 \times 10^{25} \text{ m} \quad (13)$$

$$m_u \approx 1.73 \times 10^{53} \text{ kg} \quad (14)$$

$$k = c\sqrt{2+\sqrt{5}} \approx 6.17 \times 10^8 \text{ m/s} \quad (15)$$

$$\beta = 3 - \sqrt{5} \approx 0.76 \quad (16)$$

Let's look at the acceleration of the matter a_m over time evaluated at the point $r = r_u$. The acceleration of matter a_m at our location is the derivative of the speed of matter $v_m(r)$ with respect to time evaluated at $r = r_u$.

The speed of matter $v_m(r)$ is obtained by multiplying the speed of light $v_L(r)$ by β in equation (8).

$$v_m(r) = \frac{\beta \cdot k}{\sqrt{1 + \frac{2G \cdot m}{k^2 \cdot r}} \sqrt{1 - \frac{2G \cdot m}{k^2 \cdot r}}} \quad (17)$$

But equation (8) does not contain the time variable, but rather the distance r . Therefore, to obtain the acceleration a_m , it is necessary to use the derivative of the speed with respect to the distance r and to multiply it by the derivative of the distance r with respect to time evaluated here at $r = r_u$.

$$a_m \Big|_{r=r_u} = \frac{dv_m}{dt} \Big|_{r=r_u} = \left(\frac{dr}{dt} \cdot \frac{dv_m}{dr} \right) \Big|_{r=r_u} \quad (18)$$

The derivative of the distance r with respect to time evaluated at $r = r_u$ is equal to the speed of light in the current vacuum c . Let's do the replacement in (18):

$$a_m \Big|_{r=r_u} = \left(c \cdot \frac{dv_m}{dr} \right) \Big|_{r=r_u} \quad (19)$$

We can evaluate the derivative of the velocity of the material universe v_m with respect to the distance r using equation (17) and equation (20), we obtain an equation that allows us to evaluate a_m at our location (for $r = r_u$):

$$a_m \Big|_{r=r_u} = \frac{\beta \cdot w \cdot c \cdot k^3}{\sqrt{(x-w) \cdot (x+w)^3}} = c \cdot H_0 \approx 7.00 \times 10^{-10} \text{ m/s}^2 \quad (20)$$

where $x = r_u \cdot k^2$
and $w = 2G \cdot m_u$

As we mentioned earlier, **Hubble measured the acceleration of the expansion of the material universe to our location and for material objects only.** Therefore, instead of measuring the acceleration of light a_L , he measured the acceleration a_m of the material universe evaluated at $r = r_u$.

2.8. Does the Acceleration of Universe Expansion Increase or Decrease over Time?

Several astrophysicists agree that the universe is expanding and that this expansion accelerates over time [15, 16]. But what about the second derivative with respect to time? Does acceleration increase or decrease over time? To answer this question, it suffices to find the sign of the a_m derivative evaluated at $r = R_u$ with respect to time.

Let us start from equation (18) and derive each side of the equation from time t . Since the equation for $v_m(r)$ can only be derived with respect to the distance r , we still use the same trick as before, that is, we multiply once more by dr/dt and we derive one more time dv_m with respect to the distance r to get dv_m/d^2r .

$$\left. \frac{da_m}{dt} \right|_{r=R_u} = \left(\frac{dv_m}{d^2t} \right) \bigg|_{r=R_u} = \left(\frac{dr}{dt} \cdot \frac{dr}{dt} \cdot \frac{dv_m}{d^2r} \right) \bigg|_{r=R_u} \quad (21)$$

At our location in the universe, the value of $dr/dt = c$. Rewrite equation (21) with this fact in mind:

$$\left. \frac{da_m}{dt} \right|_{r=R_u} = \left(c^2 \cdot \frac{dv_m}{d^2r} \right) \bigg|_{r=R_u} \quad (22)$$

Using equations Erreur ! Source du renvoi introuvable., (17) and (22), this derivative can be evaluated as this:

$$\left. \frac{da_m}{dt} \right|_{r=r_u} = \frac{-\beta \cdot w \cdot c^2 \cdot k^5 \cdot (2x - w)}{\sqrt{(x + w)^5 \cdot (x - w)^3}} = \frac{-c \cdot H_0^2}{\beta} \cdot \sqrt{5} \approx -4.79 \times 10^{-27} \text{ m/s}^3 \quad (23)$$

$$\text{where } x = r_u \cdot k^2$$

$$\text{and } w = 2G \cdot m_u$$

We find that the da_m/dt derivative evaluated at $r = r_u$ is negative. We conclude that despite the fact that the universe is expanding faster and faster, the acceleration of the expansion of the universe decreases over time. As our model of the universe predicts, the rate of expansion will tend towards k when the radius of curvature of the universe will tend to infinity. At that moment, no more photons will be able to create any radiation pressure on anything and the matter

will break up to end up in photons. Indeed, as the forces do not exist, each piece of matter will become part of the expanding universe until all the photons of the universe are at an infinite distance from other photons. The apparent radius of curvature of the universe will be infinite and no more matter will exist.

3. CONCLUSION

The universe is expanding because the gravitational force does not exist and can not "hold" its content.

The expansion is done by accelerating over time, but at the same time, this acceleration also decreases over time.

We have been able to associate the Hubble constant H_0 with the derivative with respect to time (speed), for a distance of 1 MParsec.

Then, we evaluated the acceleration of the expansion of the material universe as it can be seen by different techniques associated with the evaluation of Hubble constant H_0 . Note that the value of the acceleration of the expansion of the material universe is related to the value of the acceleration of the expansion of the luminous universe multiplied by β (which we have associated with the ratio between the speed of expansion of the material universe and the speed of light c).

Thanks to the evaluation of the second derivative of the speed of expansion of the material universe with respect to time, we have been able to observe that, although the rate of expansion increases over time, the acceleration of the expansion of the universe diminishes over time. The universe can not go back and there will never be a big crunch. As a result of the fact that the forces do not exist and that the universe will be eternally expanding, the measure of entropy will only increase over time. As the increase of entropy over time, the arrow of time that is only moving forward is also a consequence of the fact that the forces do not exist. Thanks to the relativistic effects, it is possible to slow down the flow of time or to stop it, but it will never be possible to reverse it.

The speed of expansion of the luminous universe will tend towards a value which we have called k . When the radius of curvature of the luminous universe will tend towards infinity, the radiation pressure will tend towards zero and the matter will gradually be reduced in photons free to circulate in straight line without being influenced by anything. At that moment, the measure of entropy will tend towards infinity.

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