About dark matter and gravitation.

Alain Haraux

Sorbonne Université, Université Paris-Diderot SPC, CNRS, INRIA,
Laboratoire Jacques-Louis Lions, LJLL, F-75005, Paris, France.
e-mail: `haraux@ann.jussieu.fr`

Abstract

A close inspection of Zwicky's seminal papers on the dynamics of galaxy clusters reveals that the discrepancy discovered between the dynamical mass and the luminous mass of clusters has been widely overestimated in 1933 as a consequence of several factors, among which the excessive value of the Hubble constant H_0, then believed to be about seven times higher than today's average estimate. Taking account, in addition, of our present knowledge of classical dark matter inside galaxies, the contradiction can be reduced by a large factor. To explain the rather small remaining discrepancy of the order of 5, instead of appealing to a hypothetic exotic dark matter, the possibility of a inhomogeneous gravity is suggested. This is consistent with the "cosmic tapestry" found in the eighties by De Lapparent and her co-authors, showing that the cosmos is highly inhomogeneous at large scale. A possible foundation for inhomogeneous gravitation is the universally discredited ancient theory of Fatio de Duillier and Lesage on pushing gravity, possibly revised to avoid the main criticisms which led to its oblivion. This model incidentally opens the window towards a completely non-standard representation of cosmos, and more basically calls to develop fundamental investigation to find the origin of the large scale inhomogeneity in the distribution of luminous matter.

Key words: gravitation, dark matter, redshift, big bang.

1   Introduction

Albert Einstein is supposed to have said that one of the most important problems of physics is to discover the cause of gravitational force. The theory of relativity somehow eludes the question since the gravitational force simply disappears and is replaced by a curvature property of space-time depending on a local energy-momentum tensor of rather mysterious and abstract nature. The local curvature would determine the acceleration of any massive material object during its spatial displacement and would even modify the direction of light rays despite the fact that the mass of (somehow immaterial) photons is supposed to be zero.

Historically, the cause of gravitational force has become a basic question right after the discovery by Newton of the gravitational field produced by matter. And actually, precisely at that time appeared (Fatio de Duillier, then Lesage, cf .e.g.[1, 2]) the idea that gravity might be the result of interaction of matter with tiny unseen particles, qualified as "ultra-mundane", pushing, as a consequence of a mutual 3D shield effect, any pair of massive objects towards each other. At that time the atomic theory of matter was not found yet, but today one might think, if we follow this theory (almost universally rejected as we shall see later) that the "gravitational mass" of a material object is determined by the number of nucleons (protons+ neutrons), since it is not clear at all how the electronic cloud might interact with the particles. Fortunately, the "inertial mass" of an electron is inferior to that of a nucleon by 3 orders of magnitude, and apparently nobody thinks that the gravitational mass of a particle might overpass its inertial mass by a large factor. By the way, did anybody already see an isolated electron falling on the ground by the sole effect of its supposed "weight"? The experiment might be worth trying if ever realizable...

The author of the following lines is neither an astronomer nor even a professional physicist. He started to be interested in the cause of gravitational forces when more and more strange theories started to invade the field of Astrophysics in an attempt to explain what might be called Zwicky's paradox (the missing mass enigma) concerning a large excess of average rotating velocity of the galaxies in Coma's cluster with respect to the supposed total mass of the cluster. The more widely admitted explanation today is that some kind of "dark matter", made of exotic particles (WIMPS or AXIONS) is present inside galaxies and maybe also in the intergalactic space. But the existence of such particles has not been proved until now. Many experts have worked in about 3 centuries to disprove theoretically the existence of Lesage's ultra-mundane particles, but for dark matter, you can find almost everywhere quite determined claims about its supposedly very high percentage compared to "ordinary" matter, whereas no WIMP or AXION has been found in more than 40 years. Why such a difference?

In this text, we decide to forget (after recalling the most important ones) the arguments developed in the last 3 centuries by many extremely qualified experts to disqualify Lesage's theory. After underlying the important methodological biases existing in the studies which motivated the dark matter hypothesis, we shall see that some explanations are possible without appealing to exotic particles. First the stability of galaxies might be an illusion, since our observational capabilities of the motion of very distant stellar systems are extremely limited. Then concerning the Coma cluster, a thorough analysis of Zwicky's papers and hypotheses allows to reduce the discordance of masses by essentially a factor 100. For the remaining

anomaly, which needs to be investigated, we propose to rely on Lesage's model of gravitation, or on any other model allowing an inhomogeneous gravitation law. We finally derive some possible consequences of admitting such a theory to revise the present picture of our universe coming from the general relativity theory. This opens the door to a completely different picture, in which the "big bang" can be forgotten, and our universe becomes a cyclic ever changing multiverse without either beginning or termination.

2 The missing mass enigma.

Who never heard about the missing mass problem? Maybe those persons who only heard about "dark matter" presented not as a hypothesis, but as a certitude or a scientific result. You can find almost everywhere on the web and in the literature estimates of the percentage of this dark matter, which might make sense locally (and in this case might very well be variable) or globally, and then it is implicitly supposed that the universe (a concept which was never rigorously defined) has a finite total mass. There is no, either empirical or theoretical, foundation to the idea that the mass of the "universe" is either finite or even definable. As long as the universe is not clearly defined in rigorous terms (and how could it be?), such percentages are a pure nonsense.

The missing mass problem follows from very interesting observations made by the americano-swiss astronomer Fritz Zwicky around 1930 and reported in the two basic papers [13, 14]. While examining the Coma galaxy cluster in 1933, Zwicky was the first to use the virial theorem to discover the existence of a gravitational anomaly, consisting in an excessive rotational velocity of the luminous matter compared to the calculated gravitational attraction within the cluster. He calculated the dynamical gravitational mass of the galaxies within the cluster from the observed rotational velocities and obtained a value at least 400 times greater than expected from the total luminosity of the cluster The same calculation today shows a smaller factor, based on greater values for the mass of luminous material. The factor can be made even smaller by taking account of the hot invisible gaz inside the cluster which was unknown at the time of Zwicky's observations, but even like that the "dynamical mass" appears much larger than the total mass of ordinary matter, either luminous or dark (gas, planets, dark dwarfs, black holes), found in the cluster until now. Since no other explanation was found, and because Zwicky himself mentioned the possible existence of unseen "dark matter" as a possible explanation of the discrepancy, some astronomers, after some problem with rotation of galaxies were pointed out in the seventies, started to investigate the possible existence of a different kind of matter (of non-baryonic nature) and to look for new particles called WIMPS or AXIONS. Although a lot of time, money and energy has been devoted to this research, no exotic particle such as WIMP or AXION has been found until now.

There are, of course, other possibilities to overcome the discrepancy, some of them were never very seriously investigated, some others seem to have a marginal impact, insufficient to understand what happens.
- The precisions of the measures may be a problem. At the distance where the Coma Cluster is situated, more than 300 millions of light years from us by the present consensus, the only way to measure the distances of galaxies is by angles assuming that the distance to the cluster

is correct. One must observe here that at the time of Zwicky's paper, that distance was estimated to 45 millions of light years only, since there had been a mistake in the evaluation of Hubble's constant H_0 due to the confusion between two classes of of cepheid stars. Concerning the velocities, three remarks at least are in order. First they are measured by evaluating the redshift of individual galaxies and comparing with the average redshift for the total cluster. This computation by difference is a source of potential errors in the calculations. Secondly, the cluster contains about 800 galaxies and in the paper, Zwicky provides the speeds for a sample of seven only. Some other speeds were probably evaluated as well, and we can trust that the examples given are signifiant, but today, with our computers, it should be possible to be much more precise. Finally Zwicky makes the hypothesis of a spherical shape for the cluster, and it is now well known that rotating structures tend naturally, in the long run, to self-organize into flat structures confined around a plane. Are we sure that sufficient time has been devoted to improve Zwicky's measurements, hypotheses and calculations when the outcome can be so important?

- The dynamics of clusters are still basically unknown, even the definition of clusters is evolving with time, since small galaxies are sometimes added to them, some others taken out! The calculations of Zwicky and all his followers are based on the hypothesis that the cluster is stationary and rotates like a solid object. This is far from obvious, actually there is no certitude about it. Interestingly enough, Zwicky investigated the hypothesis that some galaxies might be in an escaping process. But he concluded that it was improbable since the speed of isolated galaxies observed here and there outside the cluster has never been observed to be so large as the alleged rotational speed of the galaxies in the cluster, and even a quite large evasion velocity applied to all galaxies would be insufficient to modify substantially the huge factor 400 that he found. To modify substantially that factor, it seems that a rather complicated deformation scenario must be considered.

- The gravitational forces might differ substantially from Newton's formula when the distance becomes very large. This is the object of the "MOND" theory ([8]). It is true that Newton's formula has never been checked (and maybe will never be checked, due to our limited measuring possibilities) for extremely large distances.

- The linear Hubble law might be only local, or more precisely the law might be nonlinear. In this case, we are mistaken about the actual distance of the Coma cluster, resulting in a wrong appreciation of the total absolute luminosity of the stars, hence of the total mass of the visible matter.

- More generally, some laws of physics assumed to be carved in marble and relying on universal constants (typically the speed of light and the gravitational constant) might be found consequences of still unknown phenomena which make them variable with the position in space.

We shall not discuss here the "MOND" theory which has the same rigidity as the "global and universal" Newton's law (relying on some absolute constants) and does not provide any clue for the CAUSE of gravity. Since it now seems to be admitted that the physical support of electromagnetic and electro-static forces would be an exchange of photons, why should we not try a similar explanation for gravity? Such a purely theoretical attempt was tried at the very epoch of Newton, as recalled in the introduction, however to solve the missing mass enigma by relying on such an approach, we may have to reconsider some physical laws usually thought as "carved in marble". One must not forget that it is exactly what was done by Einstein with Newton's mechanical theory which was completely satisfactory to study the behavior of

sufficiently close objects when the velocities are not too large.

Before going further, let us explain how the missing mass enigma, who left many astronomers indifferent at the period where it was pointed out by Zwicky, reappeared in another form around 1970 as a consequence of some measurements by Vera Rubin (cf. [10, 11]). Quoting wikipedia: "wishing to avoid controversial areas of astronomy, including quasars and galactic motion, Rubin began to study the rotation and outer reaches of galaxies. She investigated the rotation curves of spiral galaxies, beginning with Andromeda, by looking at their outermost material, and observed flat rotation curves: the outermost components of the galaxy were moving as quickly as those close to the center. This was an early indication that spiral galaxies might be surrounded by dark matter haloes. She further uncovered the discrepancy between the predicted angular motion of galaxies based on the visible light and the observed motion. Her research showed that spiral galaxies rotate quickly enough that they should fly apart, if the gravity of their constituent stars was all that was holding them together. Because they stay intact, a large amount of unseen mass must be holding them together, a conundrum that became known as the galaxy rotation problem." The expression "because they stay intact" sounds strange here. When did anybody actually prove that the shape of a galaxy is time invariant? The time of a full rotation of Andromeda is several hundred of millions years, and we started observing the spiral galaxies (before called "spiral nebulas") less than one century ago. Following the citation: "Rubin's calculations showed that galaxies must contain at least five to ten times as much dark matter as ordinary matter. Rubin's results were confirmed over subsequent decades and became the first persuasive results supporting the theory of dark matter, initially proposed by Fritz Zwicky in the 1930s..."

3 Some methodological biases common to both situations.

For the dynamics of both galaxies and clusters, there are two basic methodological biases which make the existence of non-baryonic matter more speculative than established.

3.1 The knowledge of stars.

The calculation of the mass of both galaxies and clusters rests on the hypothesis that it is possible to deduce it from the global apparent brightness and the distance. In particular, we must assume that the mass of a star is determined "in average" by its intrinsic magnitude. But even within the "main sequence", the relation between the mass m and the intrinsic magnitude L_0 is nonlinear, the simplest guess giving $L_0 = km^3$, and empirical studies providing a slightly different power function. Therefore applying mean-values in such a situation is in itself a source of uncontrollable mistakes, especially in the situation where individual stars are indiscernable, which implies that their distribution as a function of size is unknown. In addition, as often underlined by the specialist of stars Christian Magnan, even the knowledge of those stars which lie in our close environment shows that there is no such thing as a "normal star" or an "average star". Our knowledge of stars might be insufficient to make any generalization on distant ones, a fortiori on those who belong to other galaxies.

3.2 The measurements of distances and velocities.

As already mentioned, at the distance where the Coma cluster is located, the only way of measuring distances is via the Doppler effect. Having only one tool for such a measurement is in itself a source of errors, and history has proven it since in Zwicky's paper the distance of the cluster was set at 45 millions light years. The same tool is used to evaluate the supposedly tangential velocity of galaxies in the case of clusters, and of stars or regions in the case of galaxies. Here the fact that only the radial velocity is measurable by comparison with the global redshift is in both cases an important potential source of mistakes.

3.3 The dynamics of clusters and galaxies.

We should recognize that we have no real justification for the starting hypothesis that a cluster of galaxies is rotating as a solid object and that the observed velocities are rotating velocities only, since the time scale is huge and our only tool for measuring velocities is the redshift. After the pioneering works of Zwicky and Rubin, a lot of work seems to have been done in an effort to understand the shapes of galaxies and clusters by guessing the dynamics generating those shapes. However here two remarks are in order
- the time of a complete revolution of a galaxy is several hundreds of millions years, and when galaxies or clusters are observed, the motion is essentially imperceptible. This makes the mechanical theories essentially impossible to confirm by observation.
- basing all dynamical studies on pure mechanics is a dangerous simplification, since complicated thermodynamical processes are involved in the evolution of stars, collisions of galaxies, and so on. At a high time scale, the dynamics might be more chaotic than deterministic. And we do not have any tool to measure this.

3.4 The sources of potential systematic mistakes.

In the previous paragraph we insisted on the fact that the actual dynamics of galaxies and clusters might be subject to some perturbations which are both invisible for us and unpredictable from purely mechanical considerations. Optimistic specialists might consider that these kind of fluctuations have a negligible effect at high spatial scale and might be considered as a sort of mechanical noise without real impact on the global dynamics. But there are also, in addition to the above mentioned difficulties, some potential sources of systematic mistakes.

a) The limits of observations. If we admit that the velocity of light is constant (and it is at least the case locally), the part of universe which has been observable in one century corresponds to as slice of less than 10^{-8} of the total space-time, if we consider that at each time t_0 we observe the state at time $(t_0 - T)$ of objects situated at a distance $d = cT$. This limit is essential and implies that at present we know less than about 10 billionths of what is called universe. In the next thousand years we can only hope to multiply that proportion of knowledge by a factor 10, independently of any technological progress except if we find a way of overpassing the speed of light.

b) The relationship between luminous mass and luminosity. It is now usually considered that the mass (expressed as a number of solar masses) of average galaxies is usually about 4 times the absolute luminosity (expressed as a number of solar luminosities), but this essentially

rests on the idea of an average star having about one third of the sun's mass with a repartition of masses corresponding to what has been observed or rather estimated in nearby galaxies . It is not very clear that this statistical argument can apply to the average galaxy of a given distant cluster in which individual stars are completely indiscernable for us.

3.5 Caution is necessary when speaking about high scale phenomena.

The author remembers a small sentence of Andre Brahic in 1989 introducing his talk in College de France (Paris) about the information brought to us on the solar system by space probes Voyager. He said "If you want to know how a planet **does not look like**, open an astronomy book from the sixties." As a first conclusion, all that will be said in the sequence of this text must be considered as pure speculation of the year 2020, but does not differ essentially from what has been written by real specialists of our time, sometimes presented as a certitude when everything essentially lies on shifting sands.

4 More detailed considerations about spiral galaxies and clusters.

4.1 About galaxies.

A first obvious remark is that we do not have (and probably will never have) any tool to study the global dynamical evolution of a given galaxy, including our milky way. Local considerations about speed distribution at a given time (or studied during one century, which is about the same compared to the time unit of 10^8 years corresponding to the minimal time to wait before anything significant may happen) do not give any global information on the dynamics. So to guess the dynamics, we need to compare different galaxies, and to bet that their dynamics are comparable, which is not at all a certitude, especially considering the previously recalled limits of our observation span. The observations of Vera Rubin, her colleagues and the followers, led to think that a halo of exotic dark matter surrounds all galaxies (or at least spiral galaxies) until the discovery of two galaxies for which this hypothesis is not necessary (cf.e.g. https://earthsky.org/space/galaxies-lacking-dark-matter-df2-udg). The conclusion of some specialists, against the most elementary common sense, is that exotic dark matter exists, because this absence contradicts MOND theory which they consider as the sole alternative solution. I would like to emphasize here that in all sciences except mathematics, each effect has (and will keep forever) an infinity of possible causes, for two reasons:

1) An experiment cannot prove the validity of a theory, but only that the theory is not contradictory with any of the facts that we know at the time of the experiment.
2) Since we shall never know everything in Science (even in Mathematics, the grammar of Science, this follows from Goedel's Incompleteness Theorem), new facts can appear at any time and result in the collapsing of any theory, including those admitted for centuries.

As a total neophyte in cosmology, I have a conjecture (which has exactly the value of a neophyte's conjecture) that spiral galaxies (at least) might undergo a complicated dynamics consisting in contraction around the central core and expansion of the more external regions. This might explain the flat velocity curve, although I do not know to what extent since I am not able to simulate any model by lack of specialized knowledge in the field. The reason of that

global behavior might be extra-mechanical, for instance thermodynamical or electro-magnetic or even both, resulting from a complex interaction between stars and dark dust clouds or small black holes. Even if such interaction was taking place in our close environment we would probably not have been conscious of its existence until now.

Although my idea will probably seem quite awkward, reality is sometimes far beyond our imagination, as shows this example found by the very same Vera Rubin (cf. [12]) of a galaxy in which half of the stars rotate clockwise and the other half anti-clockwise!

4.2 About the Coma cluster.

It is quite interesting to read with some attention the two papers of F. Zwicky [13, 14] and even to compare their approaches. In [13] the paradox appears as a rather short remark (Section 5 of [13]) because most of the paper is devoted to promoting the redshift as a measurement tool for distant universe, and the calculations are somewhat intricated. In [14], the calculations are more detailed and the contradiction comes from comparing the total luminous mass (evaluated from a statement on the average luminosity of the galaxies, without specifying if it is in the cluster or in general) and the dynamical mass calculated from the average relative radial velocities and the average distances in the cluster. A crucial hypothesis is that the cluster is essentially spherical with uniform distribution of galaxies (a thing that we might never be able to check!) at least in the more central part, this allows to fix the average distance and the relation between average squared radial velocity (the only accessible component) and average squared actual velocity. To compute the "dynamical mass" of the cluster, the final formula, assuming that the shape of the cluster is stationary or not too far from it, is of the form

$$M \sim a \frac{\overline{v^2} R}{G}$$

where R is the radius of the cluster and a is around 1, with two possible values depending on the hypotheses. From this formula, Zwicky concludes that the rate Mass over Absolute luminosity of the average galaxy in the cluster overpasses the usual value (currently admitted to be around 4, with what we know on the average mass repartition of stars in neighboring galaxies) by a factor 125. This is already less than the factor 400 claimed in [13] . In addition, we would like to underline 2 facts :
1) It is now estimated that classical dark objects (clouds, brown dwarfs, black holes...) multiply the real weight of galaxies by a factor around 4, this reduces the factor 125 to around 30, more than 10 times less than the initial claim. And there might exist other "black" objects made of "normal" matter which were not found yet.
2) We must also analyse the effect of the wrong value of H_0 at the time of Zwicky. Actually, the Coma cluster happens to be about 7 times farther from us than what was thought in the thirties. As a consequence, the total absolute luminosity has been underestimated by a factor 49, and R by a factor 7. This reduces the discrepancy from the factor 30 to less than 5.
That factor 5 is not really negligible, especially since Zwicky's estimate of the total mass is an estimate from below. But it might be explained much more easily than the initial factor 400 by the combination of potential methodological biases recalled in Section 3... and perhaps another idea which will now be investigated.

5 The Fatio de Duillier - Lesage theory.

In this section, we recall the main ideas of the theory of "pushing gravity" which was an attempt to explain by a simple mechanism the characteristics of the gravitational field. This theory, appealing to some kind of infinitesimal mechanism involving ultra-microscopic particles is in a sense the exact opposite of Einstein's theory which relies on macroscopic local deformations due to presence of matter of a preexisting global curvature of that ultra-macroscopic substratum usually called universe.

5.1 Basic principle of the model.

At the time of Newton, nothing was known about atoms and molecules. These two authors (with a very different personality and almost opposite cognitive profile) thus imagined independently that the cohesion of matter and gravity might share the same origin. According to Wikipedia: "Le Sage's theory of gravitation is a kinetic theory of gravity originally proposed by Nicolas Fatio de Duillier in 1690 and later by Georges-Louis Le Sage in 1748. The theory proposed a mechanical explanation for Newton's gravitational force in terms of streams of tiny unseen particles (which Le Sage called ultra-mundane corpuscles) impacting all material objects from all directions. According to this model, any two material bodies partially shield each other from the impinging corpuscles, resulting in a net imbalance in the pressure exerted by the impact of corpuscles on the bodies, tending to drive the bodies together. The theory posits that the force of gravity is the result of tiny particles (corpuscles) moving at high speed in all directions, throughout the universe. The intensity of the flux of particles is assumed to be the same in all directions, so an isolated object A is struck equally from all sides, resulting in only an inward-directed pressure but no net directional force. With a second object B present, however, a fraction of the particles that would otherwise have struck A from the direction of B is intercepted, so B works as a shield, i.e. from the direction of B, A will be struck by fewer particles than from the opposite direction. Likewise B will be struck by fewer particles from the direction of A than from the opposite direction. One can say that A and B are "shadowing" each other, and the two bodies are pushed toward each other by the resulting imbalance of forces. Thus the apparent attraction between bodies is, according to this theory, actually a diminished push from the direction of other bodies, so the theory is sometimes called push gravity or shadow gravity, although it is more widely referred to as Lesage gravity."

5.2 The criticism from the scientific community.

At the time of Newton, and later until the beginning of the last century, many scientists have been informed of Lesage theory and criticized it. Rather interestingly, as reported on Wikipedia, some major scientists as different as Newton, Euler, Kelvin had essentially the same reaction: at first happy that an explanatory mechanism was found and sometimes even saying that it was the only possible, then concluding that the theory had too many weak points to be considered reasonable. Then they did not try to find alternative theories, somehow confirming that no other system could be imagined. Maybe Poincaré was an exception in the sense that he never showed any belief in the model, and confirmed some arguments of his predecessors implying that the theory is not viable (communication in 1908). Moreover, this theory was essentially abandoned after the discovery of atomic structure of the matter, maybe because the cohesion of matter and the behavior of solids were considered as definitely understood while

Lesage theory cannot really explain at the same time the weak gravitational forces and the important cohesion forces leading to the stability of matter. Among the numerous criticisms made to this "kinetic gravitation model", there are three particularly important arguments, understandable even for non-physicists:

– The economy of nature: the idea seems complicated and counter-natural, and appeals to extremely strong invisible forces to explain the relatively weak gravitational force.

– Heating. If we apply to the corpuscles the laws of mechanics concretely observed for macroscopic objects and axiomatized as principles of theoretical mechanics, depending on the type of interaction with matter it is possible to evaluate the quantity of heat produced by the shocks, and the calculation shows that to produce by shielding effect a pushing gravity of the size observed in reality, one would produce such an intense heating that solid matter would be instantaneously vaporized.

– Constance of the weight. If gravitation results from a difference of pressure as supposed by the theory, the slightest variation of the global flux or the speed of impacting particles would result in a visible variation of weights with time. Such kind of fluctuations were never observed.

There has been historically many other criticisms, such as invoking the existence of a drag induced by the shocks for moving objects, and a (related) remark of Maxwell concerning the stability of planetary orbits. Concerning the heating problem, the calculations of Henri Poincaré discouraged almost all scientists to go on looking for possible variants of Lesage model, except much later with the Higgs Boson for which the interaction is essentially virtual, a theory which could only be developed after some knowledge on elementary particles was accumulated.

The invariability of mass might be the most serious of all reservations against the Lesage model, since it is a fundamental problem related to the basic theory of incertitudes or small relative variations acting on a difference, that criticism is independent of any hypothesis on the nature of interactions between the corpuscles and matter.

5.3 Interesting aspects of the model.

If we assume that matter is made of very tiny grains separated by vacuum or any substance which does not interact with the corpuscles, it is not difficult to understand that the intensity of the pushing gravitational force so created varies as the inverse of the square of the distance and is approximately proportional to the product of "masses", defined as the number of "material grains" constitutive of the objects A and B. Interestingly enough, to recover Newton's gravitational law, the creators of that model had to imagine the existence of atoms with about 2 centuries of anticipation, although, by our modern view of matter (thinking about metals with their electronic sea) the grains should probably refer to the atomic nuclei rather than atoms. Lesage also estimated the velocity of " ultra-mundane corpuscles" to be about 10^5 times the speed of light, but after all who ever said that Einstein's theory applies to "ultra-mundane corpuscles" which are somehow immaterial?

Although this is a source of difficult problems from the point of view of geometry, the pushing gravity model opens the door to a possible variability of the "gravitational constant" G at very large spatial (or time) scale. This is one of the main reasons for our present interest in this theory.

6   The possibility of an inhomogeneous gravity

Let us forget for a moment the fact that Lesage's theory of pushing gravity has been rejected (with quite relevant arguments) by most physicists and try to understand whether this type of model might help to solve the missing mass paradox. Since we do not wish to invent a new word for something which might not exist, let us call "gravitons" the " ultra-mundane corpuscles" although this term has been used with a different meaning, for other things whose existence have not been established either so far. Then gravitons can be thought as forming a gas of immaterial particles (like photons) possessing however a linear momentum which can be transferred partially to material particles after a shock. Then the gravitational force can be thought as a pressure, the difference with usual gases that we meet in physics being that the graviton gas can cross the matter and the force is proportional to the volume of matter struck by gravitons rather than any kind of surface. And actually this is only approximative (cf. e.g. [2]) since, among other complicated phenomena, successive layers of matter reduce the number of incoming particles by a small proportion. In this model, the gravitational constant G can be seen as representing a local pressure per volume of space. And the final formula for the gravitational force will be only sharp when a large number of nuclei are involved and the distances are not large enough to imply a big variation of the gravitational pressure, which is usual in our macroscopic but not extra galactic familiar world.

6.1   A different local gravitational constant might fill the gap in Zwicky's estimate.

Let us therefore start from the working hypothesis that gravitation is produced by gravitons. The Coma system is located more than 300 millions of light years apart from our galaxy. It does not look completely absurd to imagine that the pressure of gravitons is only locally constant, permitting around Coma a value of G four or five times greater than in our local group of galaxies. A variation of G with respect to time (and what we see from Coma is 300 millions years old!) will not surprise all physicists, especially if one thinks about "Big Bang" which implies a violent evolution at the "beginning". Some authors already imagined a variation of G with respect to time in their models, for instance J.P. Petit in some of his cosmological reflexions. A spatial variation might be considered more improbable by most physicists convinced that things tend to homogenize naturally, but this is valid for systems near equilibrium, and according to what we see in Astronomy, we are rather living in an ever evolving universe, with subsystems that rotate or oscillate without any kind of rest. Very large subsystems have very small rotation speeds with respect to their size which might, seen from a distance, make us believe that they are static and invariable, but we know that this is an illusion.

6.2   A connection with the large scale structure of universe.

Is it really a coincidence that 300 millions of light years is about the size of the "bubbles of matter" discovered in the pioneering paper of Valérie de Lapparent and co-authors in [5] ? Later this repartition of luminous matter has been confirmed by many large scale observations and called "Cosmic Tapestry", which is a very suggestive term. It does not look entirely absurd to imagine that, whatever be, either temporal or spatial, the character of the variation, the gravitational pressure might vary at the same scale as this fundamental inhomogeneity of

universe. More than that, such a variation could explain why matter concentrates in such a strange way to display complicated configurations qualified as "bubbles" or "matter filaments" in the literature. We might even conjecture that large galactic clusters are always situated where the local gravitational pressure is highest (The Coma cluster is precisely very large). In a recent modelisation (2014), J.P. Petit presented the interesting idea that the presence in the same geometrical space of an anti-universe of ours (theory of twin universes) would have produced the bubble structure by anti-gravitational repulsion. We shall present in the next section another (purely speculative) possibility based on Lesage's model of gravitation.

7   Beyond the dark matter controversy

It is, we believe, clear for everybody that as long as no proof is given and no identification is realized, the exotic particles such as AXIONS, WIMPS and gravitons remain an object of speculation rather than Science. In this section, we make a (quite arbitrary) hypothesis on the identity of gravitons and, independently of that hypothesis, try to guess which kind of universe would be compatible with a highly variable gravitational pressure. We concentrate on one possibility only, which might explain also the redshift and the CMB. This section can be entirely skipped by the readers which do not appreciate science-fiction, since it is exactly what we shall be doing now, without any proof whatsoever.

7.1   The velocity of light.

Many physicists, including Einstein, got a long time ago the intuition of a very special connection between gravity and the electromagnetic waves such as light. In [4], M.R. Edwards, well aware of the filament-like large scale structure of matter, even constructed a theory in which the graviton would be a photon, and constant exchanges would take place between electromagnetic energy of light or other radiations and gravitational potential energy. We now suggest, somehow amplifying the important idea of Einstein according to which the presence of material objects modifies the light's trajectory, to imagine that even the velocity of light could depend on the local gravitational "constant" G. Although it is not at all clear whether the velocity of light is the velocity of the photons or rather that of the associate propagation wave, we may imagine that some interaction between gravitons and photons of a damping nature is the factor which decides locally the velocity of electromagnetic waves. In this case, the local value of c would be a decreasing function of the local gravitational "constant" G.

7.2   A possible identity for the graviton.

The above interpretation requires an interaction between gravitons and photons. It is generally supposed that the photon is its own anti-particle, which is possible since it carries no electric charge. What about the graviton? To repel the nucleons of our matter in a manner independent of electro-magnetic forces (if it were positively charged this would make a problem with electrons, and otherwise a problem with protons ...), that particle should be of the type "anti-matter without charge". The first obvious candidate for this is the anti-neutrino, presently supposed to have an extremely small mass, which should consequently be associated to a very large, of course supra-luminal, velocity to produce a reasonable linear momentum. This is consistent with what was assumed by LeSage and his followers. Repelling the nucleons

and having no interaction with electrons, that particle has no reason to produce any heat during the "shock" with matter which takes place without actual contact in the sense of classical mechanics. Of course, this choice is completely arbitrary and the true nature of gravitons, if they exist, might lie completely outside the field of our present imagination, bounded by the comparison with already discovered elementary particles.

7.3   A cosmic billiard as an alternative to big bang.

After the tapestry, a billiard? But this hypothesis is situated at an even larger scale, essentially the size of observable universe which is two orders of magnitude above the bubbles' size. We imagine now that our "universe", instead of being curved, is just a normal 3D region with a boundary against which the gravitons are bouncing from time to time, maybe exchanging something (energy for instance) at the rebound, They would logically follow complicated paths modified by the "shocks" with either obstacles like our matter, or the boundary, and the type of trajectories could ressemble non ergodic trajectories of billiards, in which most of the time is spent near the boundary. Schematically speaking, the density of gravitons (and maybe also their velocity) would be maximal close to the boundary. Since G becomes large near the boundary, the photons travel at a lower speed and, having less energy, they may also increase their wavelength far from the "core "of our world. Here we reconnect with the idea of "tired light" proposed by F. Zwicky before the big bang theory. And finally the microwave cosmic background might be either some kind of "echo" of the back and forth motion of highly energetic gravitons, or the result of random collisions between gravitons and their counterparts trying to reach ... the other side!

7.4   On the other side...of the universe.

Of course, a boundary implies another side. But what is there outside? What about an anti-universe somehow symmetric to ours, which is bombed by anti-gravitons (neutrinos) sent by us and bombing us with gravitons (anti-neutrinos)? So our neutrinos are compacting the matter of our anti-universe, while our matter is compacted by the anti-neutrinos sent by our anti-universe. Of course the scheme also works with any pair of gravitons and anti-gravitons. We did not lose half of the universe, it is "just in front of us"! We recover, with a different piucture, the idea of twin universes of J.P. Petit [9].

7.5   Twin universes or multiversal net?

Then, why only a bi-universe with two components? This is quite difficult to picture out, since the interior of one component is the outside of the other and conversely. This would give a 3D version of the Ying and Yang picture from the old chinese wisdom. Seducing picture, but except if both components are unbounded (this implies a hard life for some gravitons!) there will be some extra space outside both components. What is going on there?

It is much easier, geometrically speaking, to conceive an infinite network of "universe cells" and "anti-universe cells"s or anti-cells such that each cell is only in contact with anti-cells and conversely. This time, the whole 3D space is filled. A scheme with isometric cubes or parallelipipedons shows that this kind of network is possible, but of course we may imagine infinitely many other types of nets, where the transition zones would contain no matter, and

would be devoted to travelling of gravitons and energy exchanges.

Beyond the "cosmic tapestry" which is now a proven observational fact, we now find ourselves living in a bounded component of an unlimited "multiverse". The concept of multiverse has been supported by a certain number of experts, among which L. Mersini-Houghton [7]. That "multiversal tapestry", if it is real, saves us from the problem of "boundary" without appealing to curved manifolds and without necessity of the anthropo-centered idea of Big Bang. Our finite existences do not require that our world has also a birth and a death. Of course, the reader might object that this picture is a bit easy to claim, since we shall never know whether or not it is true. But this weak point is common to all cosmological theories of the past, the present, and without doubt, of our limited future as a living specie.

7.6 Specific weak points of the model.

This model has of course several weaknesses, even before any quantitative simulations which might pull it down if we make our hypotheses more quantitative in accordance to the observed phenomena. For instance:

1) It is not at all easy to conciliate the idea of cosmic billiard, with gravitons visiting more often certain regions, with the very concrete fact that the weight of an object on earth does not move when we travel, or more precisely is only affected, in a predictable way, by the relative altitude with respect to the geoid. Indeed, if we follow by thought the alleged trajectories of gravitons, this experimental fact supports preferentially the idea of a homogeneous sea of gravitons with identical speeds in all directions. Of course locally everything looks constant and we cannot deduce what happens at the cosmic scale from what we observe on earth, but this fact is troublesome and it is not easy to understand which kind of geometry can allow simultaneously the cosmic billiard and constant weight on earth.

2) The relationship between decrease of the light velocity and increase of the wavelength is not at all obvious. Without knowing more about the interaction of photons and gravitons, it seems extremely difficult to quantify anything here. The very nature of photon, which is still the object of very involved research, does not allow us to certify anything about it.

8 Conclusion.

The discoveries of F. Zwicky and V. Rubin on the extragalactic world have produced fascinating questions which motivated important studies on the structure of deep universe. Then in the eighties, it was found that most of the visible (luminous) matter of our world is concentrated in particular zones of the space looking like a gigantic foam with bubbles having a diameter of about one cent of the diameter of visible universe. This is a major discovery, maybe more important than the controversy about dark matter and exotic particles of any type, showing that if we are interested in matter (supposed until now to produce the gravitational field!) and not only in the geometry of ambient space, the universe is far from being homogeneous at high scale as supposed by the theory of relativity. This suggests that the theory of relativity might be less efficient to understand the behavior of matter than the behavior of electromagnetic waves which motivated its construction. Now, if we abandon the big bang, the origin of baryonic matter has to be revised fundamentally. Unfortunately, the photons are not enough

to produce a world like ours. The reader will certainly be kind enough to understand that I will not recreate all of baryonic matter in my next neophyte's paper on cosmology.

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