15 août 2021

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Fourty years of works fully oriented towards interstellar travel and ufo phenomenon.

All the works referring to the Janus cosmological model are available online on the database of the French CNRS, at the address:

https://hal.archives-ouvertes.fr/hal-03285671/document

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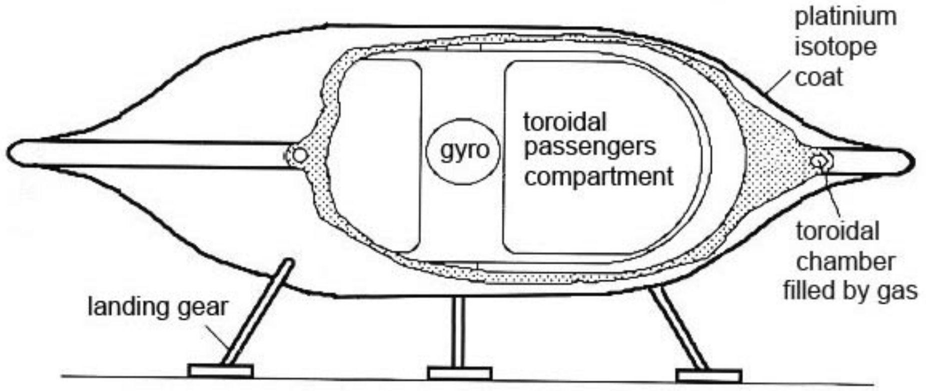
Abstract :

If we remain within the geometric framework of the General Relativity, interstellar travel is difficult to consider, because of its excessive duration. A modification must therefore be made. It turns out that the new model « Janus » which emerges then, where the central idea is to introduce negative masses, solves all the problems in which contemporary cosmology has been struggling for 50 years. All these works have been published in peer reviewed journals, of high level. Negative mass replaces both dark matter and dark energy. We trace the long genesis of this model, which starts with a heuristic approach where masses of the same sign attract each other and where masses of opposite signs repel each other. This idea immediately proved to be fruitful in many fields. Thus the negative mass, which dominates at the end of the decoupling, forming a network of spheroidal clusters and gives to the positive mass a lacunar structure. The Great Repeller, discovered in 2017, is one of these spheroidal clusters, repulsive and invisible. By infiltrating between galaxies and clusters of galaxies the negative mass ensures their confinement, gives the flat shapes on the peripheries of the rotation curves. We then build the geometry of this Janus model, where the Einstein equation becomes one of the two field equations of the system. Mathematiucal consistency is esured. An exact solution provides the cosmic acceleration, driven by the negative pressure of the negative mass. It is shown that the negative mass is a copy of our own antimatter, endowed with a negative mass. This is the primordial antimatter, geometrically invisible, which has been sought for so long. An alternative interpretation of the fluctuations in the CMB gives the values of the "scale factors" and the speeds of light.

In the negative world, distances are a hundred times shorter and the speed of negative energy photons ten times higher. This results in a gain of a factor of a thousand in the time of interstellar reavel, which thus becomes non-impossible. A possible technique of mass inversion is outlined, as well as the mode of speeding up the nefs.

We give the diagram of a nave using the technique of inversion of the mass. The important magnetic field, which must be uniform in all the concerned mass, is then produced by the setting in rotation of the electrically chargerd hull of the craft:



The concentration of energy, until disruption, is obtained by charging the long duration metastable levels of of excitation of nuclei of a metal shell, by nuclear magnetic resonance effect. A toroidal cabin, which could be disassociated from the hull, avoids the passengers to be centrifuged. During the cruise its regular rotation assures an artificial gravity.

The inversion of mass explains the instantaneous appearance and disappearance of the naves, which seem to appear from nowhere. We sketch an explanation of the right angle turns.

The MHD propulsion, also supported by a long series of articles published in peer reviewed journals (or/and) having been the subject of publications in international symposiums devoted to MHD and hypersonic flight, comes to complete this model. It is given as a complement and is based on the first works realized by the team, linked to UFO observations.

We find the techniques used by the Russians to ensure the operation of their hypersonic missiles Kinjal and Avangard which can only operate at such speeds (Mach 10 in dense air and Mach 30 in rarefiued air) by using MHD to prevent shock waves from forming.

1 - **Cosmology and astrophysics. State of the art.**

As I am speaking to specialists, this overview will be done very quickly.

- At the end of the seventies, when the flatness of the rotation curves of galaxies was confirmed, as well as the impossibility to account for this phenomenon with the visible mass, the scientific community concluded to the existence of an undetected mass to which one gives the name of Dark matter.

Thirty years later this dark matter is still not identified.

- In 1988, when the COBE satellite gave the first images of the CMB, remarkably homogeneous, the community of specialists believed in the hypothetical theory of inflation.

Twenty years later we have no model of this field and its associated particle: inflation

- In 2011 a Nobel Prize rewards those who have shown the acceleration of the cosmic expansion. The community of specialists concludes to the action of a dark energy.

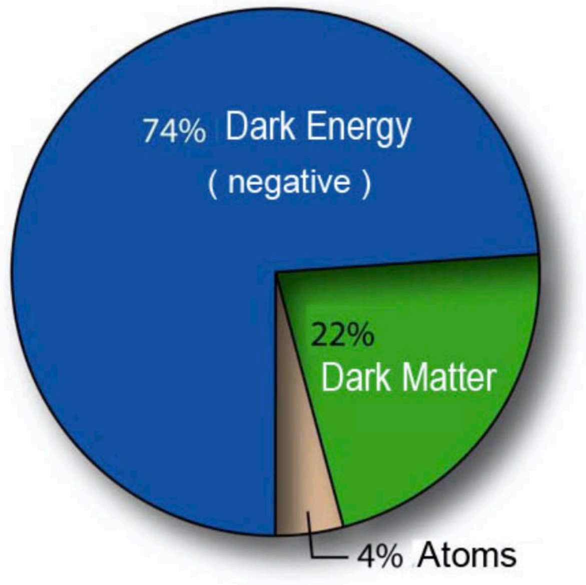
Ten years later we have no model of this dark energy,

except to associate it with the presence of the cosmological constant in the Einstein equation. The standard model of cosmology thus becomes the ΛCDM model (cosmological constant Λ plus Cold Dark Matter).

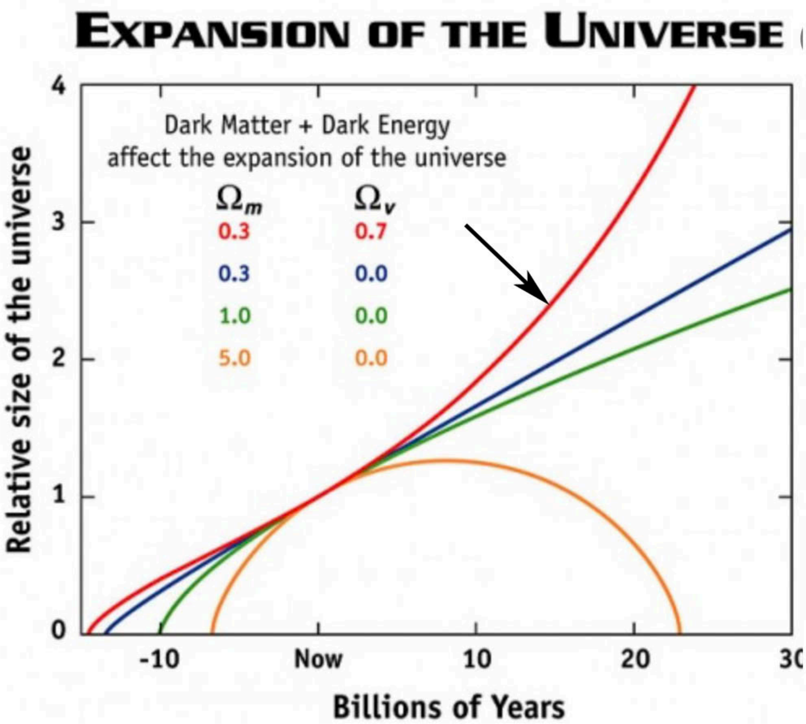
- To date, there is no explanation for the non-observation of primordial antimatter.

- For the last fifty years, attempts to detect supersymmetric partners in particle gas pedals have been failures.

At this stage, only 4% of the universe's content is for the moment accessible to observation.



The effect of the presence of this cosmological constant Λ in the equation is equivalent to the action of a repulsive content of constant density, independent of the expansion. Two forces are thus opposed, from which the general cosmic dynamics results. We have a force of attraction, slowing down this expansion, linked to the content in positive mass, observed or dark, which corresponds to a density varying in a-3, thus losing ground with time. To this is added the force of repulsion, translated by this constant Λ, which is equivalent to an invariable negative density. Thus, over time, it is the repulsion that dominates and the profile of the curve translating the evolution corresponds to the drawings below. A curve that tends to take the form of an exponential over time.



2 - **The problem of introducing negative masses.**

Negative masses are associated with negative pressures. One can therefore wonder if the introduction of a negative mass content in the field equation of General Relativity would not produce the observed acceleration effect of the expansion.

This introduction was envisaged in 1957 by the cosmologist Hermann Bondi [1]. But it does not work. It is very easy to see why. Einstein's field equation provides a solution in the form of a single metric, from which we calculate the geodesics along which the witness masses travel, whether positive or negative.

Let us write the Einstein equation in its mixed form, without its cosmological constant

(1) $$R_\mu^\nu - \frac{1}{2} R \, \delta_\mu^\nu = \chi T_\mu^\nu$$

It is known that the mixed form of the metric tensor reduces to the Kronecker tensor. In these conditions if in a region we have a non-zero matter field the matter energy tensor is written

(2)

$$T_{\mu}^{\ \nu} = \begin{pmatrix} \rho c^2 & 0 & 0 & 0 \\ 0 & -p & 0 & 0 \\ 0 & 0 & -p & 0 \\ 0 & 0 & 0 & -p \end{pmatrix}$$

A negative mass field will correspond to

(3)

$$\rho < 0 \quad p < 0$$

But, placing ourselves in the Newtonian approximation, this corresponds to zero p.

If we want to describe the geometry outside a mass M and inside it we will combine two metrics.

- The one describing the geometry inside a mass corresponding to a sphere of radius r_s filled with a material of constant density ρ :

(4)

$$ds^2 = \left[\frac{3}{2}\left(1 - \frac{8\pi G \rho r_s^2}{3c^2} \right)^{\frac{1}{2}} - \frac{1}{2}\left(1 - \frac{8\pi G \rho r^2}{3c^2} \right)^{\frac{1}{2}} \right]^2 c^2 dt^2 - \frac{dr^2}{1 - \frac{8\pi G \rho r^2}{3c^2}} - r^2 (d\theta^2 + \sin^2\theta d\varphi^2)$$

- The one describing the geometry outside this mass:

(5)

$$ds^2 = \left(1 - \frac{8\pi G \rho r_s^3}{3c^2 r} \right) c^2 dt^2 - \frac{dr^2}{1 - \frac{8\pi G \rho r_s^3}{3c^2 r}} - r^2 (d\theta^2 + \sin^2\theta d\varphi^2)$$

These two metrics are connected.

The geodesics are then (we have represented the geodesics of zero length) :

For a positive density:

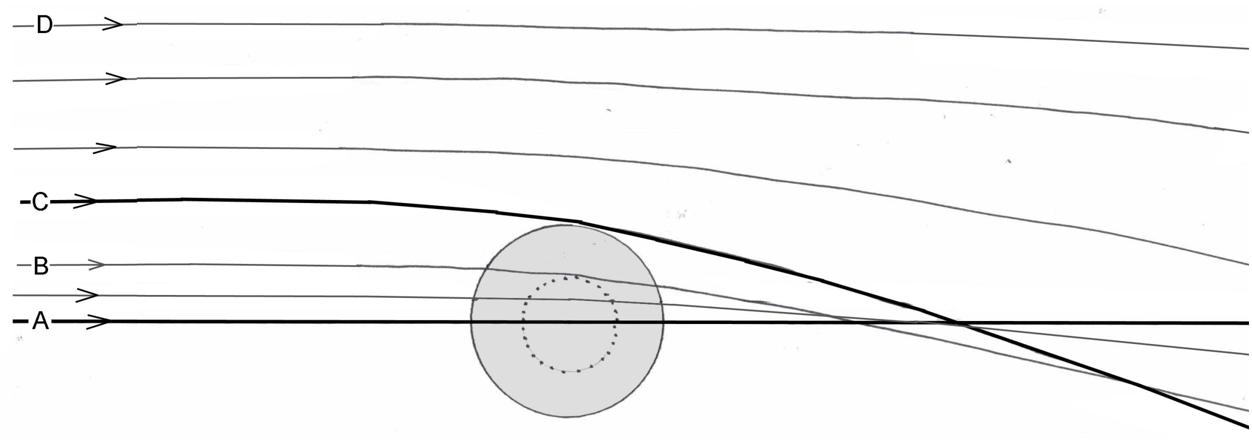


Fig. 1 : Deflection of positive energy neutrinos by a positive mass

For a negative density, we get this:

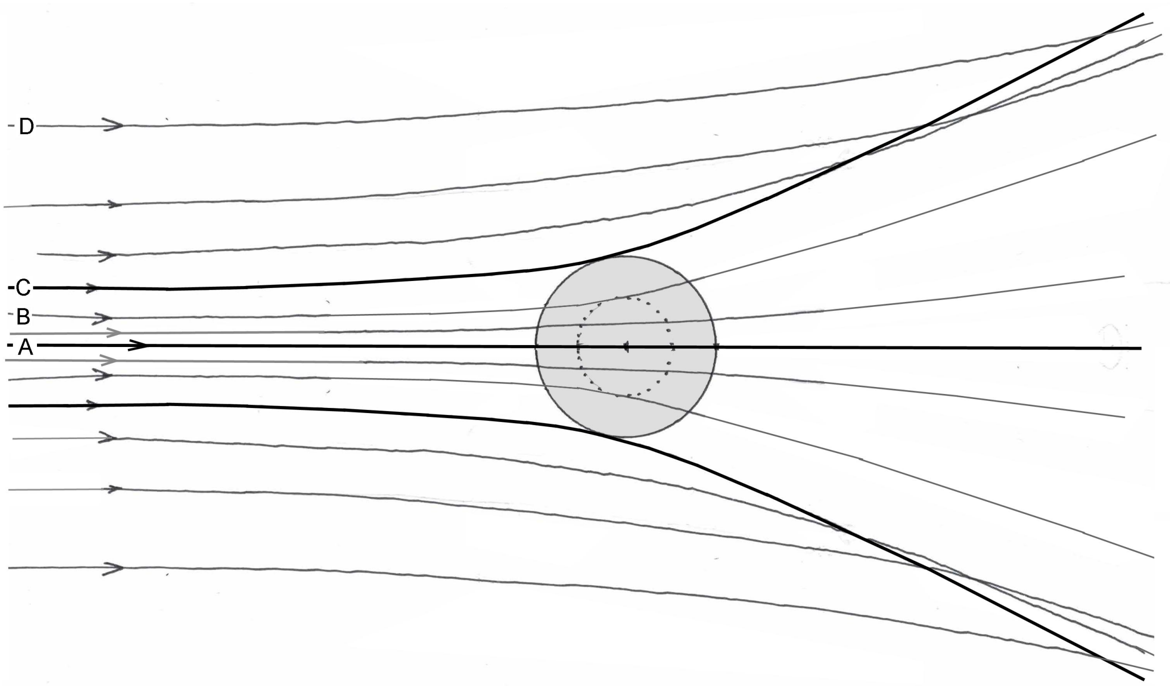


Fig.2 : Deflection of positive energy neutrinos by a negative mass.

We are not used to calculate the geodesics of zero length inside the masses. These are the trajectories that neutrinos would follow. Unless they are masses that would interact with this matter only through the force of gravity, which will be considered later.

In any case the geodesic-trajectories of the non-zero mass particles have the same shape. We deduce the following result:

- A positive mass generates a system of geodesics evoking an attraction.

- A negative mass generates a system of geodesics evoking a repulsion.

This can be summarized by writing :

- Positive masses attract as well as negative masses

- Negative masses repel each other as well as positive masses.

Bondi does it differently, but it is clearer with geodesics.

This can be illustrated by the drawing:

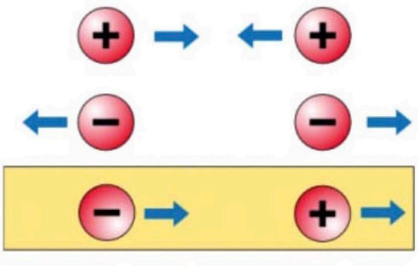


Fig. 3 : Negative masses in General Relativity. Laws of interaction

Below we see what happens when two masses of opposite signs are brought together. The positive mass runs away, pursued by the negative mass. The couple undergoes a uniform acceleration motion, but the energy remains constant, because the kinetic energy of the negative mass is itself negative.

This diagram also represents a violation of the action-reaction principle and the equivalence principle. We can indeed distinguish two types of masses.

- The gravitational mass mg , which indicates the way this mass contributes to the gravitational field. It is positive for positive masses and negative for negative masses, in this form of introduction of negative masses.

- The inertial mass mi, which indicates the way this mass reacts in a force field, here in the gravitational field. It is positive for positive masses as well as for negative masses, in this form of introduction of negative masses.

The equivalence principle for positive masses corresponds to

$$m_g^{(+)} = m_i^{(+)}$$

It is violated in this form of representation of negative masses, sinc

$$m_g^{(-)} = -\, m_i^{(-)}$$

To imagine a world where particles acquire velocities limited by the speed of light, while no energy input is involved, is quite shocking for the physicist. William Bonnor [2] has examined again this idea of negative masses in General Relativity. In good English humor he apologized for having developed this article by specifying that his preoccupation had been "to understand why God had chosen positive masses". But other authors have tried to build a cosmological model by integrating this disconcerting property, that is to say by deciding to remain within the framework of General Relativity, that is to say of a geometry resulting from the Einstein equation.

Benoit-Lévy and Gabriel Chardin [3] take up the Dirac-Milne model, which amounts to assuming that the universe contains as much positive mass as negative mass. The global density is therefore zero, as is the global gravitational field. So the expansion is linear with time. Their idea is that this second component of negative mass would correspond to cosmological antimatter, to which they attribute by hypothesis a zero mass.

The Englishman Jamie Farnes [4] adds the hypothesis of the existence of a mechanism of continuous creation of negative mass which would ensure the constancy of its mass density. Thus this negative mass content would be equivalent to the introduction of the cosmological constant into the equation. As for the runaway phenomenon, he imagines that it could be the source of very high energy particles

3 – **Heuristic approach**.

Heuristics or euristics (from ancient Greek εὑρίσκω, heuriskô, «I find») This type of analysis allows us to arrive at acceptable solutions in a limited amount of time. This type of analysis allows to reach acceptable solutions in a limited time.

The Janus model corresponds to the idea of introducing negative masses into the cosmological model while preserving for this second species the principle of equivalence and for both species the principle of action-reaction, which would eliminate the unmanageable runaway phenomenon. The desired interaction scheme becomes

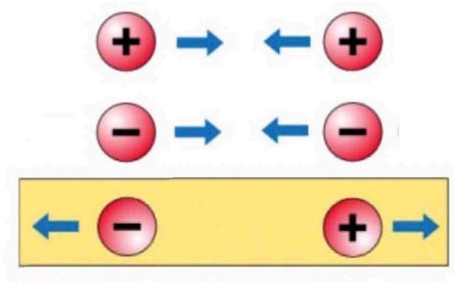


Fig.4 Targeted interaction scheme.

This was our strategy in the early nineties, using 2D numerical simulations. The first idea was to see how a mixture of positive and negative mass points with equal density and identical temperatures would behave. The result, obtained on a Cray-one, corresponds to the following figure:

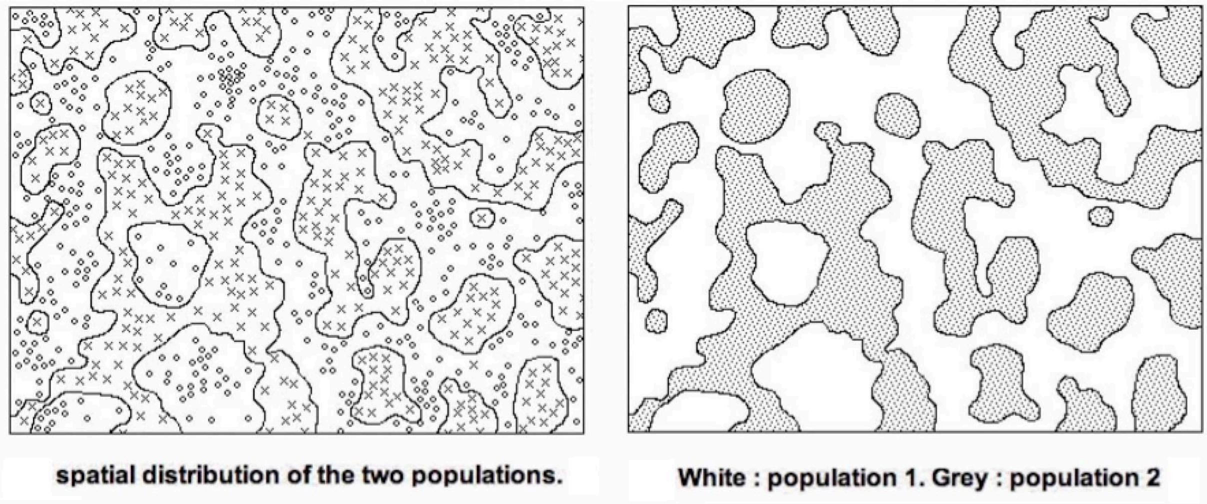


Fig4 : Result of a simulation with $\rho^{+} = \left|\rho^{-}\right|$

The two populations tended to separate, in a percolation mechanism. But this did not look like anything that could be related to any observation. The idea then came to us to repeat the operation by attributing to the negative masses a higher density, in absolute value. The negative masses were then arranged in a regular network of clusters, the positive mass occupying the space left free between them.

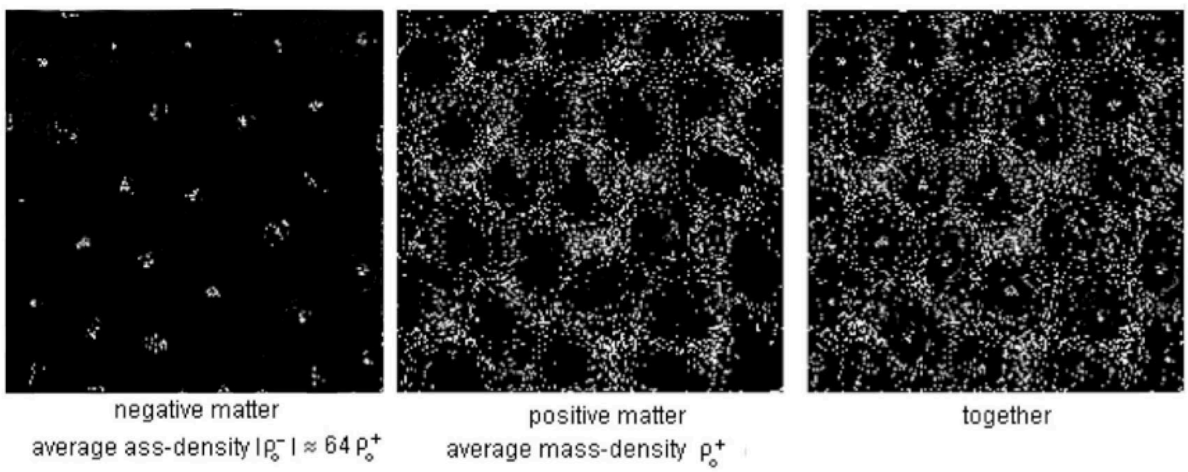


Fig.5 : Result of simulation 1995 with $|\rho^{-}| \gg \rho^{+}$.
(a) Negative matter with average mass-density $|\rho^{-}| \approx 64\rho^{+}$. (b) Positive matter with average mass-density ρ^{+}. (c) Positive and negative matter together.

This is a result that illustrated our 1995 publication [5] . Immediately this suggested a possible pattern of constitution of the large scale structure of the universe, the positive mass, in 3D, being constituted according to a pattern comparable to joined soap bubbles.

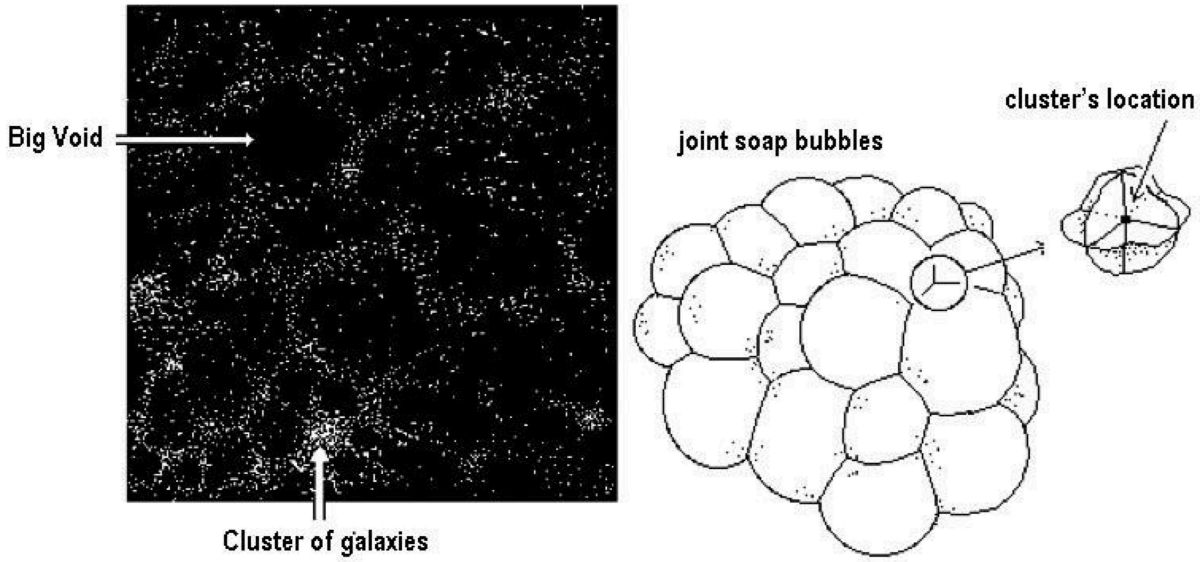


Fig.6: 3D Very Large Structure

The idea also emerged from the invisibility of negative masses. Indeed, these have an energy $mc^2 < 0$. If we imagine that it could be the copy of ours with a negative mass, it would then emit photons of negative energy, that our eyes and our instruments of observation could not capture.

In 2017 the discovery of the "Great Repeller" [6] brings a confirmation to this intuition.

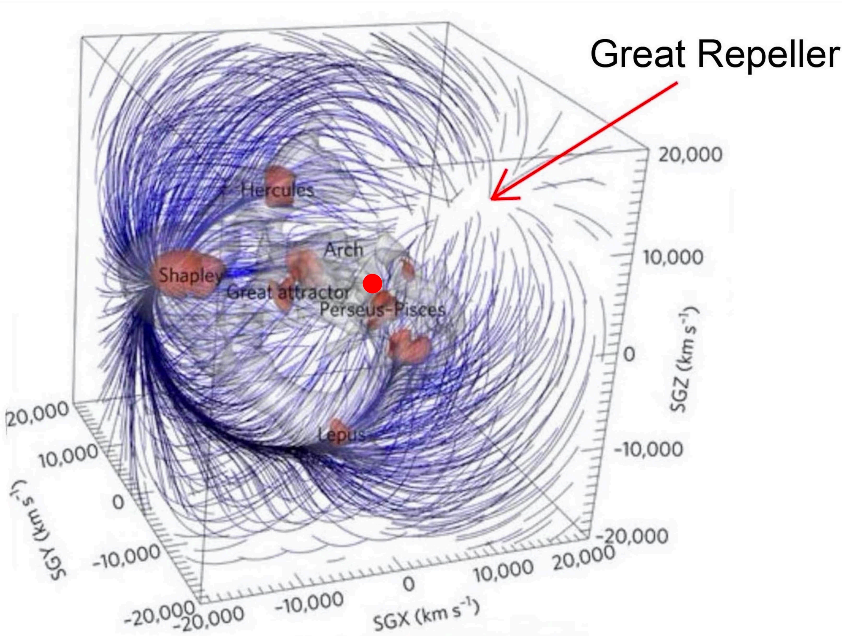


Fig.7 : The Great Repeller [6]

We then started to develop a draft theoretical model by considering "joint gravitational instabilities". Indeed the Jeans instability develops according to a characteristic time:

(6)

$$t_J = \frac{1}{\sqrt{4\pi G|\rho|}}$$

As the absolute value of its density is higher, the negative mass, self-attracting, forms the first of the spheroidal conglomerates, by gravitational instability.

At the beginning of the nineties, the ideas are jostling. The pattern of constitution of this large-scale structure of the universe suggests an alternative pattern of galaxy formation, also by gravitational instability. In the ΛCDM model this question is approached by numerical simulations, bringing into play ad hoc quantities of dark matter. The pattern that emerges and leads to a different scenario. When this very large scale structure is formed, just after the decoupling, the negative mass clusters exert a counter pressure on the positive mass, confined according to plates. Hence a temperature excursion, followed by a radiative cooling.

At that time (1992) we only have at our disposal the PCs of the time, unable to manage systems of mass points in sufficient number. The few results mentioned here were obtained by a young student from the DESY laboratory in Hamburg (synchrotron), Frédéric Descamp, who carried out these simulations without the knowledge of his research director, for only a few months. This work was immediately interrupted as soon as the latter realized that the means of calculation were being misused. The following drawings illustrate the idea, which still needs to be developed.

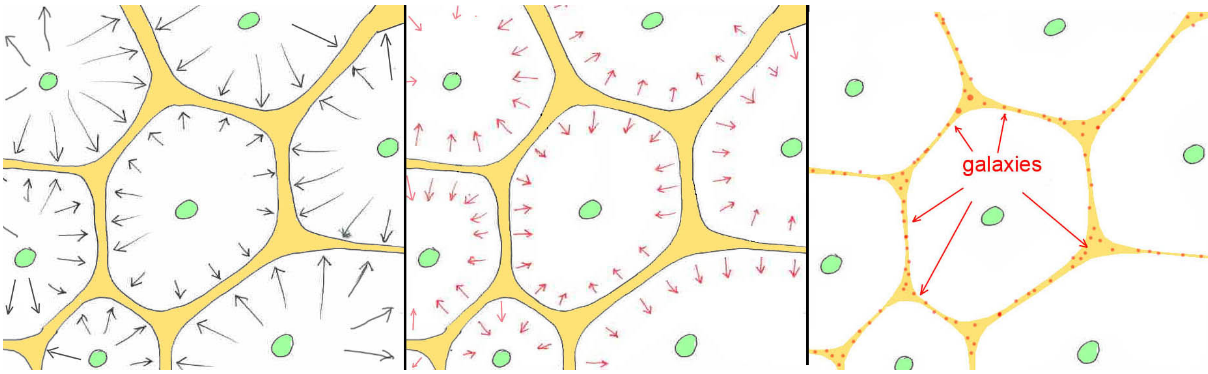


Fig.8 : Schéma de formation des galaxies.

The first image in Figure 8 shows the young, positive mass material, formed into plates, undergoing back compression exerted by the adjacent negative mass clusters (green). This results in heating and rapid radiative cooling, center figure. The thin plate structure is indeed optimal for radiative dissipation. The positive mass is then destabilized and the gravitational instability resumes, giving birth to galaxies, right image. In this view, the majority of galaxies, if not all, are formed at the same time. This is what gives them a relatively narrow spectrum of masses, elliptical galaxies differ from spiral galaxies only by an order of magnitude.

A number of so-called irregular galaxies can be observed in the universe, systematically studied by Halton Arp who drew up a catalog of them [7] . Today, there are authors who think that these are galaxies in formation. We do not share this opinion, and perhaps we will discuss this question at the end of this article.

In the middle of the seventies I published a number of notes in the Comptes Rendus de l'Académie des Sciences de Paris, devoted to galactic dynamics, through models built by supposing that the distribution function of stars had an elliptical shape.

3 – **Digression on galactic dynamics**.

This part will better speak to astrophysicists, specialists in galactic dynamics.

A gas in a state of thermodynamic equilibrium sees its molecules acquire thermal agitation velocities corresponding to a Maxwell-Boltzmann statistic. If n is the number of density, the number of molecules per unit volume, m their mass, T the absolute temperature, k the Boltzmann constant and V the modulus of the velocity of the considered element, the distribution function of this thermal agitation velocity is:

(7)

$$f = n\left(\frac{m}{2\pi k T}\right)^{\frac{3}{2}} e^{-\frac{m V^2}{2kT}}$$

Here this function is a solution of the Boltzmann equation :

(8)

$$\frac{\partial f}{\partial t} + \mathbf{v} \cdot \frac{\partial f}{\partial \mathbf{r}} + \frac{\mathbf{F}}{m} \cdot \frac{\partial f}{\partial \mathbf{v}} = \left(\frac{\partial f}{\partial t}\right)_{collisions}$$

The thin letters are scalars, the bold letters are vectors. In this case the force **F** is the force of gravity arising from the gravitational potential Ψ. In the case of stellar dynamics the collisions are almost zero and the second member is zero (Vlasov equation).

(9) $$\frac{\partial f}{\partial t} + \mathbf{v} \cdot \frac{\partial f}{\partial \mathbf{r}} - \frac{1}{m}\frac{\partial \Psi}{\partial \mathbf{v}} = 0$$

We can write (7) according to:

(10) $$L_n f = Cst + L_n n - \frac{3}{2} L_n T - \frac{m}{2kT}\left(u^2 + v^2 + w^2 \right)$$

It is a spherical polynomial of degree 2 in u , v w , components of the speed.

In the same way we can, by dividing by f , write (9) according to :

(11) $$\frac{\partial L_n f}{\partial t} + \mathbf{v} . \frac{\partial L_n f}{\partial \mathbf{r}} - \frac{1}{m} \frac{\partial L_n f}{\partial \mathbf{v}} = 0 \quad -$$

By introducing (10) in (11) we obtain a polynomial of degree 3 in u , v , w. By canceling a system of ten partial differential equations, to be coupled with the Poisson equation :

(12) $$\Delta \Psi = 4 \pi G \, m \, n$$

This is what Chandrasekhar did in 1942 [8] . A book in which he calculates the mean free travel time of stars in a galaxy, coming to the conclusion that this is large compared to the age of the universe. He develops the Maxwellian stationary solution with spherical symmetry by showing that the temperature T (linked to the velocity of agitation of the stars in this spheroidal galaxy) was constant

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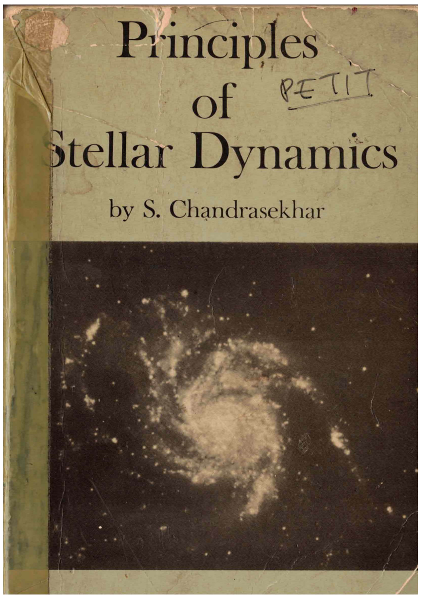

By solving numerically the Poisson equation he obtains the profile of the density of matter in this object.

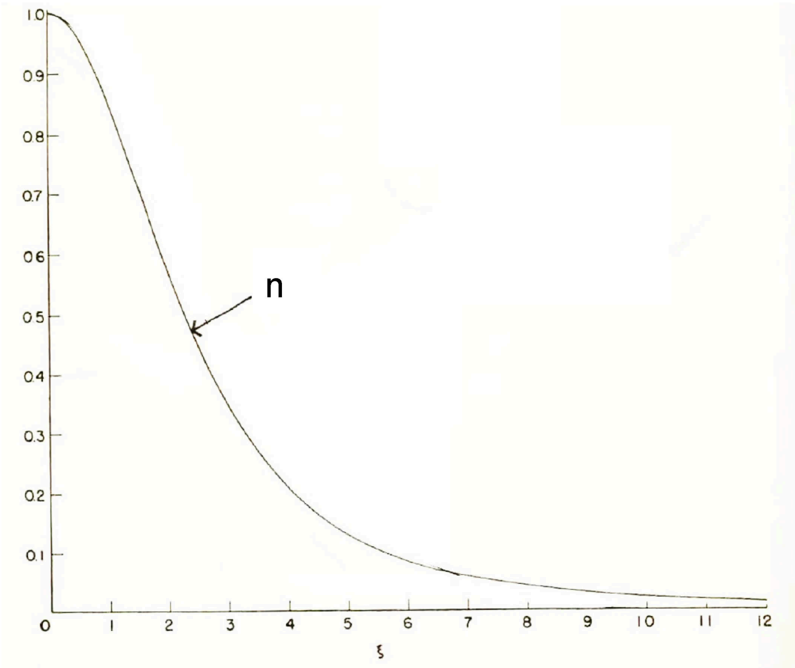

FIG. 25.—The isothermal distribution for globular clusters.

Fig.9 : Matter density in a spheroidal cluster (Chandrasekhar 1942)

But Chandrasekhar, who tries through this to model the density in the globular clusters, notes at once that by integrating this density the object has an infinite mass:

(13)

$$N = \int_{r_o}^{\infty} \frac{1}{r} r^2 \, d\Omega \, dr = 4\pi \int_{r_o}^{\infty} \frac{1}{r} r^2 \, dr = \infty$$

This property makes this approach less interesting, for example when trying to model a spheroidal galaxy. Here is with more details the result of this calculation:

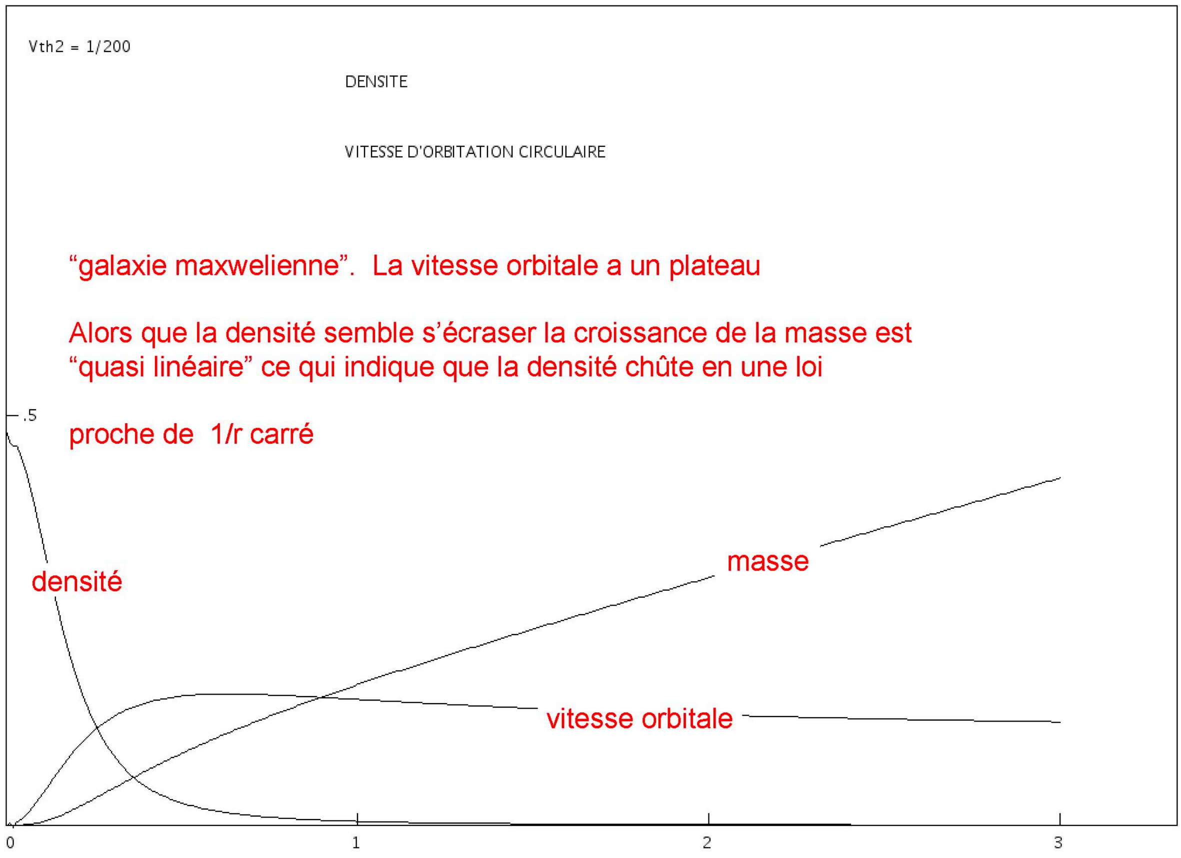

Fig.10 : Object with spherical symmetry, Maxwellian distribution

In galaxies (here I address to astrophysicists) the velocity distribution is not spherically symmetric. This isotropy of the velocity field (called residual velocities by astrophysicists) is linked to the return to thermodynamic equilibrium, resulting from collisions. From this point of view, galaxies, as systems of self-gravitating mass points, orbiting in their own gravitational field, are totally non-equilibrium systems. It is therefore not surprising that the velocity statistics of the stars near the Sun leads, not to a spheroid of velocities, but to an ellipsoid of velocities, with three axes. One axis perpendicular to the spiral arm, and two transverse axes, with approximately equal velocity dispersions, but corresponding to half the value of the major axis.

These are the only data we have, concerning this ellipsoid of velocities, that astrophysicists call vertex. The major axis does not point to the center of the galaxy. This is called the "deviation of the vertex".

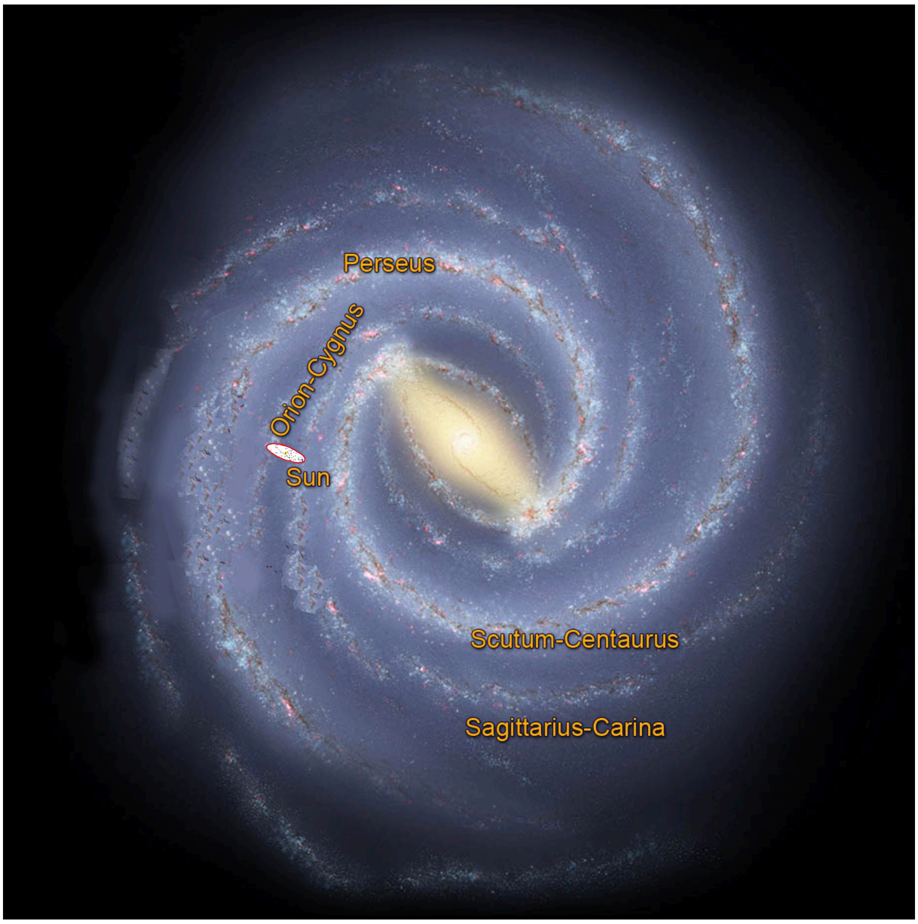

Fig.11 : Position of the velocity ellipsoid near the Sun.

Specialists know that the spiral arms have shock wave structures, insofar as the velocities of the gas exceed the thermal agitation velocity in this one, of the order of some km/s. When a shock wave travels through a gas (collisional system), at the crossing of this wave, whose thickness is equivalent to a few mean free paths, the velocity distribution is elliptical, with a major axis perpendicular to the plane of the wave. Then the medium thermalizes and the distribution becomes isotropic again downstream, around a higher velocity of agitation. We can think that the orientation of the ellipsoid of velocities in the vicinity of the Sun obeys this same logic.

We can also think that by reason of symmetry this ellipsoid evolves towards a spheroid in the vicinity of the galactic center. According to this logic, at the beginning of the seventies I supposed that one could try to build a model of a spheroidal galaxy, in stationary regime, starting from the hypothesis that the major axis of the ellipsoid points towards the galactic center:

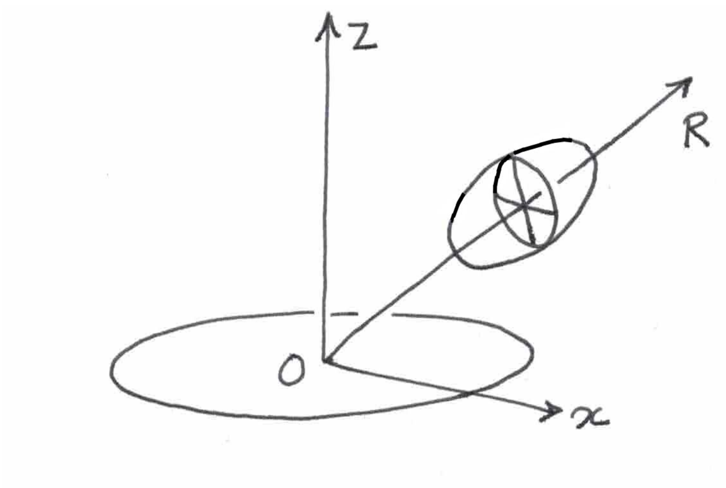

Fig. 12 : Hypothesis of an ellipsoid of velocities pointing to the center.

For more details:[43]. Technically this amounts to giving a particular form to the velocity distribution, which is always a polynomial of degree 3. We then obtain the evolution of the velocity ellipsoid as a function of the radius. Its major axis remains constant. At the center the distribution is Maxwellian. The transverse axes tend to zero at infinity. The Poisson equation, in spherical symmetry, becomes:

(14) $$\Psi'' + \frac{2}{r}\Psi' = \frac{4\pi G \rho_o}{1 + \frac{r^2}{r_o^2}} e^{-\frac{m\Psi}{kT_o}}$$

Numerically, we get this:

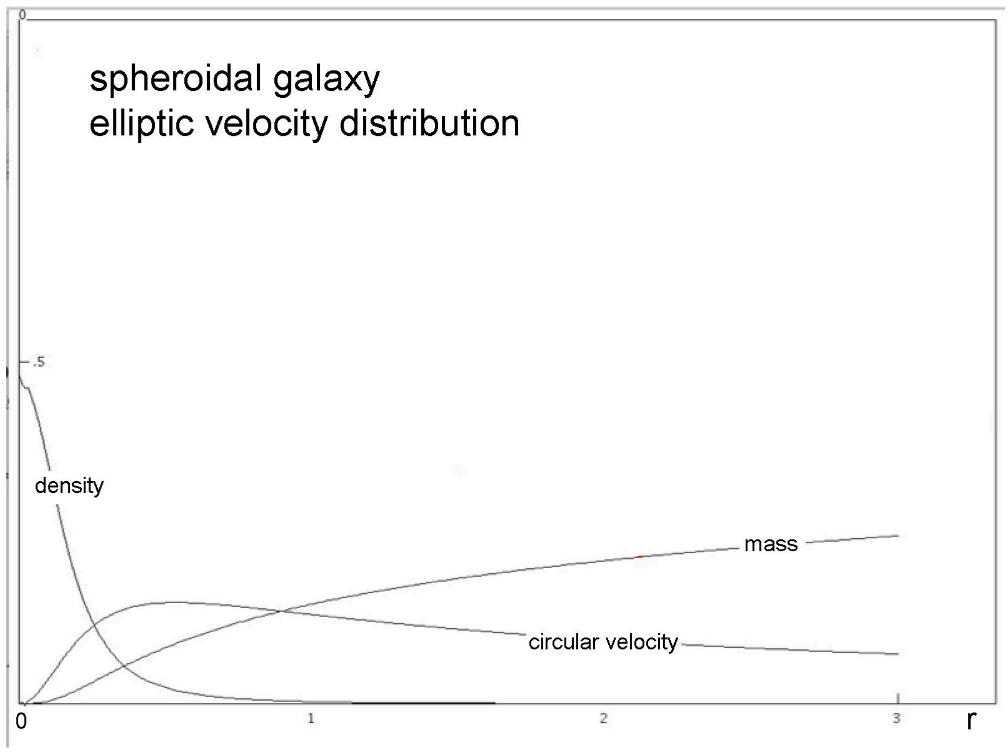

Fig. 13 : Spheroidal galaxy, elliptical velocity distribution.

By comparing with the Chandrasekhar solution we see that the mass always tends to infinity. In the seventies this work is extended in collaboration with the astrophysicist Guy Monnet, at that time director of the observatory of Marseille, to an axisymmetric elliptic solution, always with the major axis of the ellipsoid of velocities pointing towards the center. We present the results on the occasion of an international symposium on galactic dynamics, held at the Institut des Hautes Etudes de Bures sur Yvette, near Paris [9], a work made possible by applying the technique of matrix calculation. The numerical results are similar and the mass is always infinite. This is the reason why theorists have moved away from this approach.

But, still in this heuristic approach, we imagine that a galaxy can be confined by an environment of negative mass, repulsive. The solution then depends on two Vlasov equations, coupled by the Poisson equation. We start with the description of a spheroidal galaxy and imagine it confined by a negative mass to which we attribute a Maxwellian velocity distribution, associated to a constant temperature. The numerical solution emerges quickly. First, let us figure the parameters associated with a spherically symmetric gap in an isothermal distribution of negative mass:

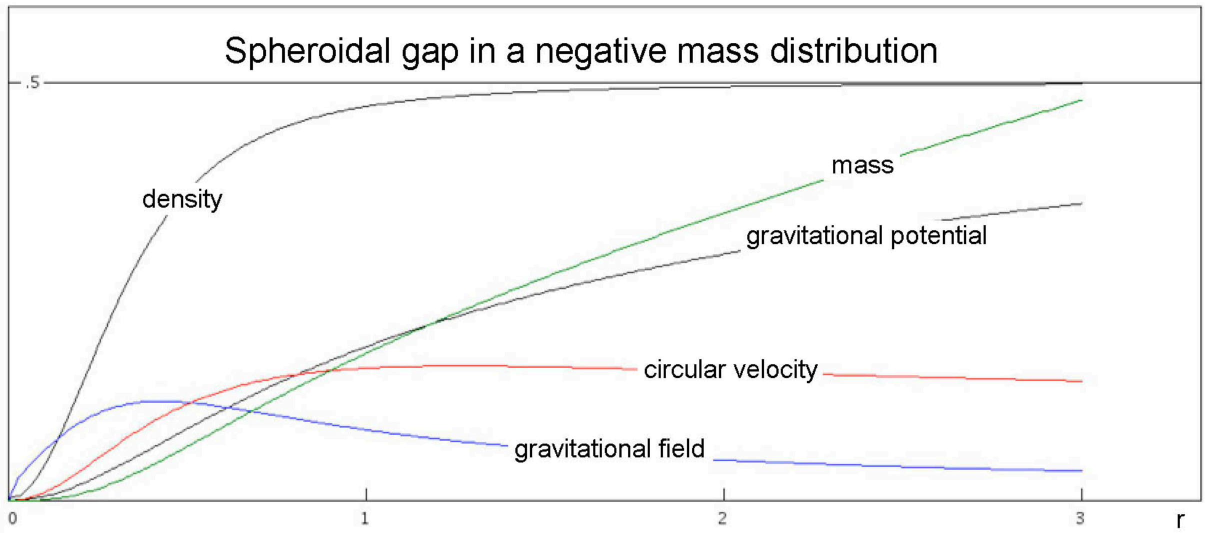

Fig. 14 : Spheroidal gap in isothermal negative mass distribution.

It is this gap that will impose the circular velocity plateau in the periphery. It replaces by its effects the ad hoc distribution of dark matter of positive mass.

This has an impact on the parameters of the positive mass:

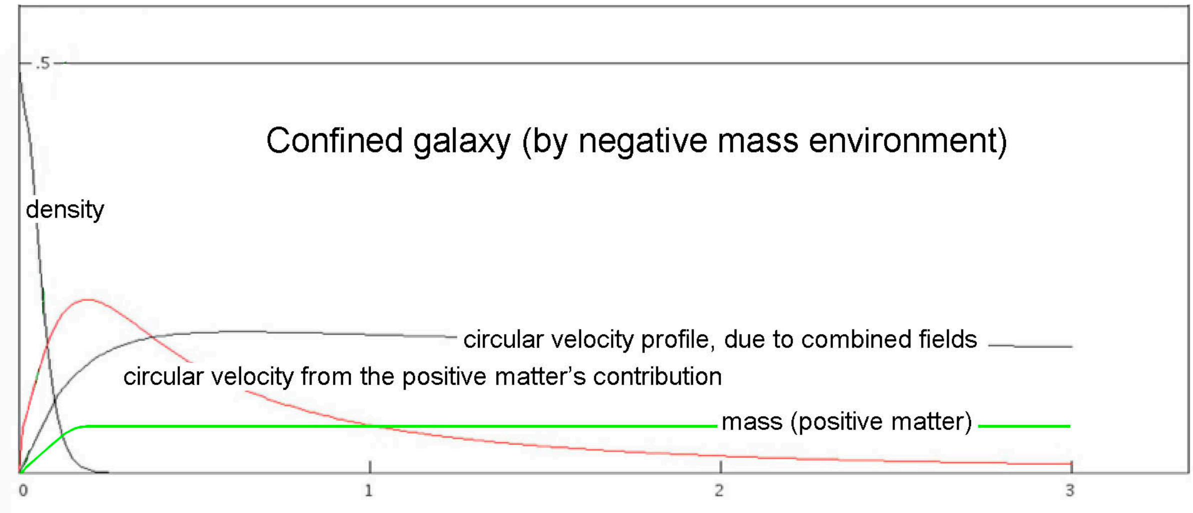

Fig. 15 : Confined spheroidal galaxy.

The confinement is immediate. The integrated mass tends rapidly towards a constant. The galaxy does not have an infinite mass anymore. When we calculate the circular orbit velocity based on its contribution to the gravitational field we obtain a quasi-Keplerian profile. On the other hand, by summing up the two contributions of the two types of masses, we obtain a linear growth near the center, then a plateau at the periphery.

Still following this heuristic approach, it appears that this hypothetical presence of self-attracting negative mass pushing back the positive mass, whose absolute value of the density dominates that of the positive mass, gives an important number of interesting aspects.

Moreover, with respect to its contribution to the gravitational field, a gap in the negative mass being equivalent to that of its image, changed in sign, it was obvious that this heuristic model also solved the problem of anomalous gravitational lensing effects in the vicinity of galaxies and clusters.

Returning to the question of the shape of the rotation curves, it is exceptional that they offer such regularity.

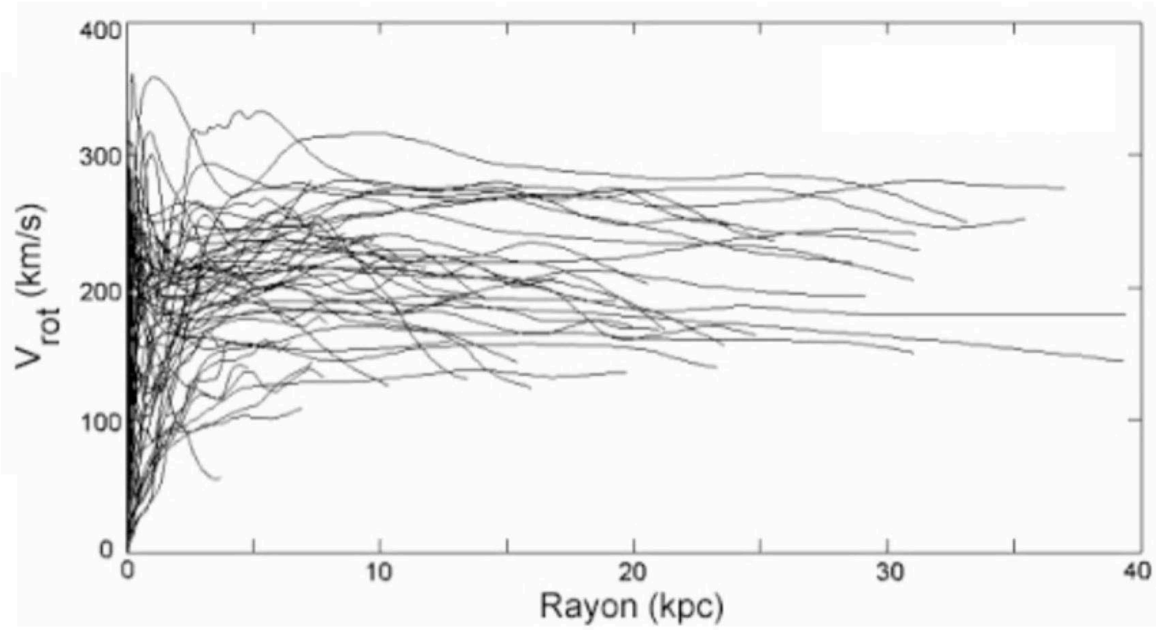

Fig.16 : Density curves of different galaxies.

These curves generally show a velocity excursion near the center. Among the exceptions:

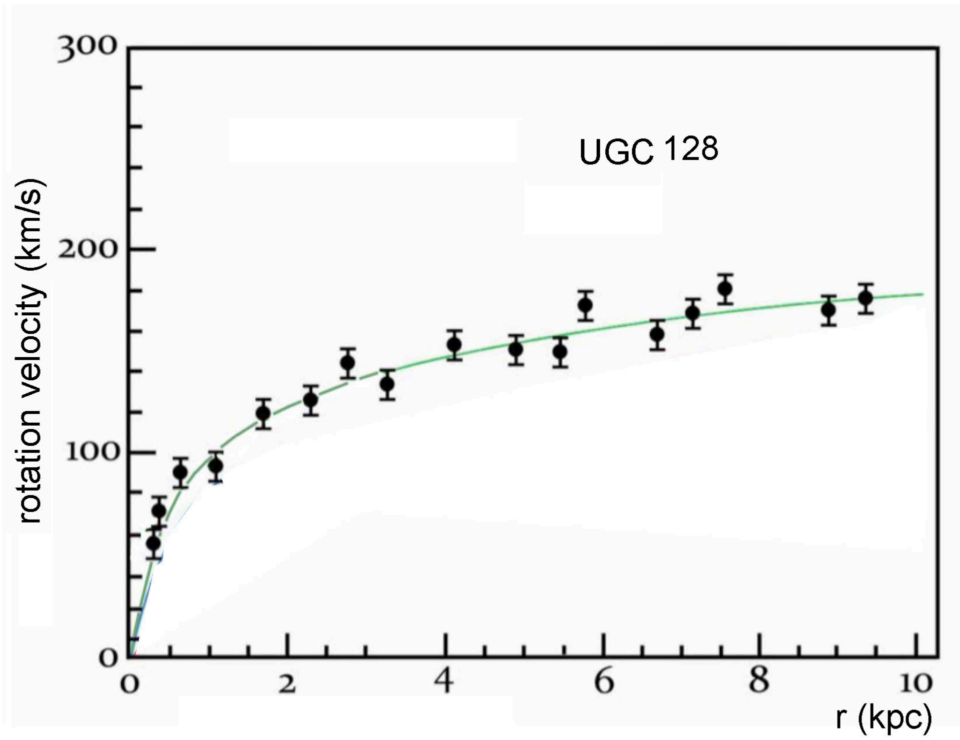

Fig.17 : Rotation curve of 'UGC 128

Theorists, who try to account for these curves by resorting to dark matter halos of positive mass, are obliged to include a peak in this density, near the center, to account for this strong increase in angular velocity. They do not understand how the dark matter could acquire such a density distribution.

The explanation is to be found in the phenomenon of galactic cannibalism, about which all theorists agree that it is a very frequent phenomenon in the early childhood of galaxies. Let us imagine two galaxies that have just formed, with dissimilar masses. We must first ask ourselves about the origin of the rotational movements of galaxies. Currently the Andromeda galaxy gives an order of magnitude of the dilution of this "gas of galaxies". It can be compared to a pea held at arm's length. But if we go back in time, we get a configuration where the galaxies were as tightly packed together as grapes in a bunch. The interactions were then much more intense. We can then consider this "gas formed by the primitive galaxies" as a collisional medium. Comparing it to a gas of molecules, one will be led to think that this medium will tend towards thermodynamic equilibrium and that in these conditions the tendency is such that the kinetic energy, of agitation of the galaxies, will be transferred in the form of rotational motion. In the final state of a thermodynamic equilibrium the energy is distributed equally among the different degrees of freedom of the system. Thus the kinetic energy corresponding to the thermal agitation tends to become equal to that corresponding to the rotational motion.

If this march towards a completed thermodynamic equilibrium could be carried out, the light galaxies would then have angular velocity vectors of rotation more important than the massive galaxies. At the moment when the massive galaxy absorbs the light galaxy, the matter of the latter falls freely towards the center of the former, without interacting since these environments are non-collisional. This increase in mass does not change the density curve of the whole, without a "peak". On the other hand, by being in the vicinity of the galactic center, the components of the light galaxy make an important contribution of angular velocity, in the way that the skater increases her speed of rotation by bringing her arms along her body. As a conclusion, we can conclude that UGC 128 has not absorbed any other lighter galaxy.

It would be relatively easy to reconstruct the rotation curve of a galaxy using not two Vlasov equations, but three equations, referring to two galaxies and a negative mass gap, all coupled by the Poisson equation. It would then be possible to reconstitute the state of the two galaxies, before cannibalism.

At the beginning of the nineties, ideas emerge one after the other. Thus, it is predicted that the negative mass clusters of the very large scale structure must attenuate the luminosity of the galaxies in the background, with strong red shift, by negative gravitational lensing. Indeed, the galaxies at $z > 7$ have low magnitudes which led astrophysicists to conclude that they were dwarf galaxies. But this new model suggests that they could be normal size galaxies, having their magnitude attenuated by negative lensing.

During the few months when we can benefit from the computational means, thanks to the student Frédéric Descamp, before his hierarchy puts an end to this detour of the DAISY center computation time, we build the initial conditions corresponding to a 2D galaxy orbiting in a negative mass gap, ensuring its confinement. Hereafter the shape of these initial conditions. Both systems are non-collisional. As initial conditions we endow our galaxy with a solid body rotation. Hereafter our 2D galaxy in initial conditions.

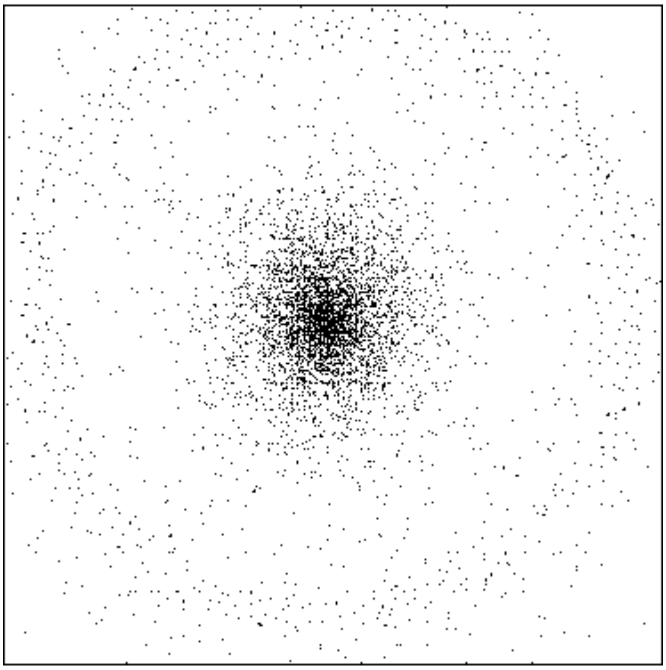

Fig.18 : Initial conditions of the 2D simulation

The result was immediately amazing (1992 !)

A superb barred galaxy is formed after a few turns during which strong transient variations occur.

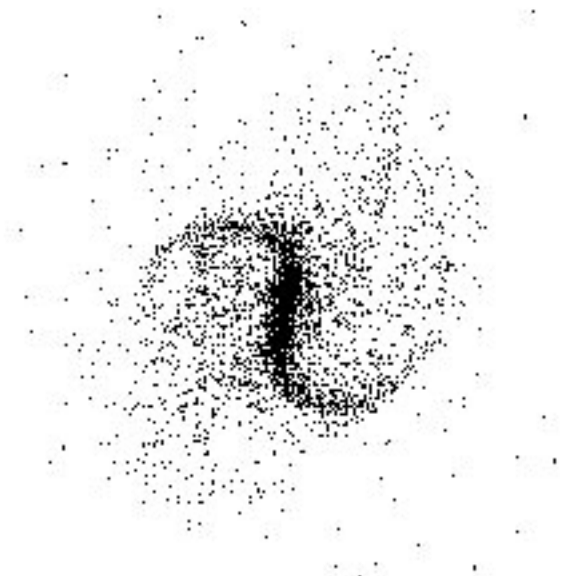

Fig.19 : Barred spiral lasting for 30 turns.

This result sheds light on the way non-colliding systems evolve, by exchange of angular momentum and energy. As these transfers cannot be done by collisions, they are played on a larger scale through density waves. The loss of momentum of the galaxy can be seen in the following figure.

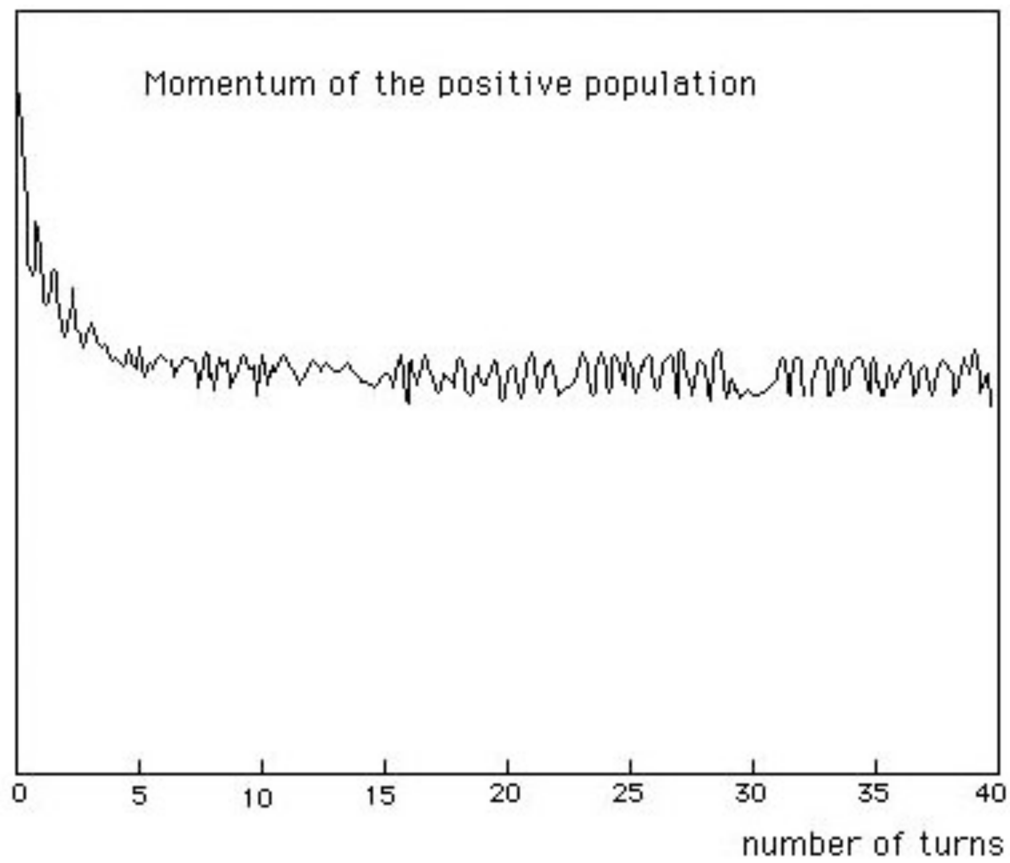

Fig.20 : Evolution of the angular momentum of the galaxy.

This evolution translates an intense braking during the first turns, followed by a regular decrease, weaker, of the angular momentum, translating the interaction of the positive mass galaxy with its negative mass environment, by density wave.

During the few months, at the beginning of the eighties, when we could, thanks to the student Frédéric Descamp, benefit from consequent computational means, before his hierarchy put an end to this wild research activity, we identified the possible cause of the pronounced winding of the spiral arms to the density contrast between the two populations, of positive and negative mass. The more the importance of the negative masses increases and the more the spiral arms are rolled up.

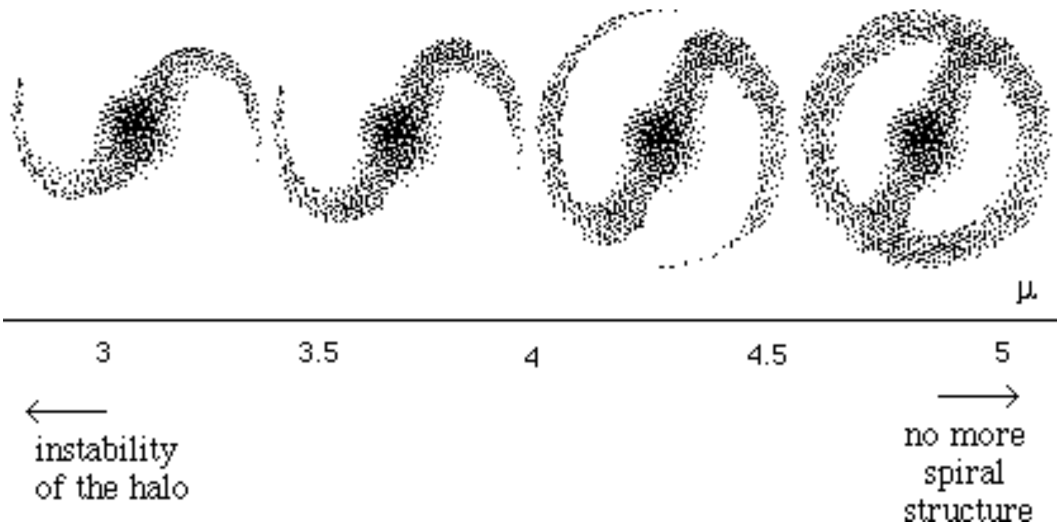

Fig. 21 : Effect of density contrast on arm wrapping.

Such results, resulting from a purely heuristic hypothesis, give us the conviction of the supposed form of the interaction according to the laws :

- Masses of the same sign attract each other according to Newton's law
-
- Masses of opposite signs repel each other according to " anti-Newton ".

is a track to follow. But it is necessary to concretize this approach by producing a complete cosmological model. At this stage it becomes obvious that we must depart from the classical General Relativity model, since Einstein's equation immediately generates interaction laws leading to the unmanageable runaway phenomenon.

To begin with, when we place two witness masses in a gravitational field, they must have a different behavior, thus follow different geodesics, resulting from two different metric tensor fields

$$g_{\mu\nu}^{(+)} \qquad \text{and} \qquad g_{\mu\nu}^{(-)}$$

From these two metrics we construct the corresponding Ricci tensor fields and the Ricci scalar fields

$$R_{\mu\nu}^{(+)} \qquad \text{and} \qquad R_{\mu\nu}^{(-)}$$

$$R^{(+)} \qquad \text{and} \qquad R^{(-)}$$

4 – **In search of a new model. Time to do-it-yourself** (1995-2014).

Einstein's model assumes that the universe is a Riemanian 4-manifold of signature:

(- + + +)

Let's start by recalling the approach of General Relativity:

We write its four variables assuming that they are lengths, measured in meters.

(15) $$X = \left\{ x^\circ , x^1 , x^2 , x3 \right\}$$

The metric is $g_{\mu\nu(X)}$, the Rocci tensor $R_{\mu\nu(X)}$, and the Ricci scalar $R_{(X)}$.

This metric is a solution of the Einstein equation:

(16) $$R_{\mu\nu} - \frac{1}{2} R\, g_{\mu\nu} + \Lambda g_{\mu\nu} = \chi T_{\mu\nu}$$

The right side is a tensor field representing the energy-matter. In mixed notation this tensor is:

(17) $$T_\mu^\nu = \begin{pmatrix} \rho c^2 & 0 & 0 & 0 \\ 0 & -p & 0 & 0 \\ 0 & 0 & -p & 0 \\ 0 & 0 & 0 & -p \end{pmatrix}$$

In this space-time hypersurface, we assume that the tangent metric is Lorentzian:

(18) $$ds^2 = -\left(dx^\circ\right)^2 + \left(dx^1\right)^2 + \left(dx^2\right)^2 + \left(dx^3\right)^2$$

In spherical coordinates with : $r = \sqrt{(x^1)^2 + (x^2)^2 \ (x^3)^2}$ we get

(19) $$ds^2 = -\left(dx^\circ\right)^2 + dr^2 + r^2 \left(d\theta^2 + \sin^2\theta\, d\varphi^2 \right)$$

Two scale factors are defined.

A space scale factor a , according to:

(20) $$r = a\, u$$

which involves a dimensionless radial distance u.

And a time space factor T defined according to:

(21) $$x^\circ = c\, T\, \tau$$

where x° is in meters, T is in seconds, c in meters per second, which makes appear a chronological time marker, ξ° without dimension. It is a simple number. We will see later why.

In General relativity it is assumed that these two quantities c and T are absolute constants and, on the basis of this assumption, the cosmic time is introduced:

(22) $$t = T\,\xi^{o}$$

This makes it possible to write the tangent metric :

(23) $$ds^2 = -c^2dt^2 + dr^2 + r^2\left(d\theta^2 + \sin^2\theta d\varphi^2 \right) = -c^2dt^2 + a^2\left(du^2 + u^2d\theta^2 + u^2\sin^2\theta d\varphi^2 \right)$$

From this point on, the model is enriched with solutions from the FRLW metric:

(24) $$ds^2 = -\,dx^{o\,2} + a^2\left[\frac{dr^2}{1-kr^2} + d\theta^2 + \sin^2\theta\, d\varphi^2 \right]$$

where k is the curvature index. By introducing this form of the metric into the field equation, with:

(25) $$\dot{a} = \frac{da}{dx^{\circ}} \qquad \ddot{a} = \frac{d^2a}{dx^{\circ\,2}} \qquad \chi = -\frac{8\pi G}{c^4}$$

we obtain a system of two field equations, called "Einstein equation:

(26) $$-\chi\,\rho c^2 = -\Lambda + \left[\frac{3k}{a^2} + \frac{3\dot{a}^2}{a^2} \right]$$

(27) $$-\chi\, p = -\Lambda + \left[\frac{k}{a^2} + \frac{\dot{a}^2}{a^2} + \frac{2\ddot{a}}{a} \right]$$

It is a system of two differential equations, which must be "compatible". This gives rise to the relation:

(28)

$$\frac{da}{a} + \frac{1}{3}\left(\frac{d\rho}{\rho + p/c^2} \right) = 0$$

In the case of a dust universe (p=0) this leads to a relation translating the conservation of energy (or mass, since c is considered as constant):

(29) $$\rho c^2 a^3 = Cst$$

and a differential equation, which provides three types of solution depending on the values of $k \in \left\{ -1, 0, +1 \right\}$.

In the case of a radiation universe:

(30) $$p_r = \frac{\rho_r c^2}{3}$$

there is only one solution with k = 0 and where a varies as $\sqrt{x^\circ}$. As x° is proportional to the "cosmic time": a varies in $\sqrt{t}$.

Let's see what happens in a bimetric configuration.

5 - **Notations.**

We will use the following notations, to stick with the article positioned on HAL:

https://hal.archives-ouvertes.fr/hal-03285671/document

In previous articles we have used (+) and (-) to designate what refers to positive and negative masses. Thus the metrics referring to positive and negative mass species are $g^{(+)}_{\mu\nu}$ and $g^{(-)}_{\mu\nu}$

In what follows, as in the HAL article, as we refer extensively to the work of Sabine Hossenfelder, we will take up her notations. Thus what refers to negative masses is designated by an underline.

For example, the energy-matter tensor designating the negative masses becomes:

$$\underline{T}_{\underline{\nu}\underline{\kappa}}$$

The metric tensors of the two species are:

$$g_{\kappa\nu} \quad \text{and} \quad \underline{h}_{\underline{\nu}\underline{\kappa}}$$

Their determinants:

$$g \quad \text{and} \quad \underline{h}$$

The resulting Ricci tensors are noted:

$$R_{\kappa\nu} \quad \text{and} \quad R_{\underline{\nu}\underline{\kappa}}$$

And the corresponding Ricci scalars:

$$^{(g)}R \quad \text{and} \quad ^{(\underline{h})}R$$

The space scale factors are :

- For positive masses, designated by the letter *a*

- For negative masses, designated by the letter *b*

6 - **First DIY, in the early nineties:**

We heuristically assume that the model could be derived from the system of coupled field equations :

(31)

$$
\begin{aligned}
{}^{(g)}R_{\kappa\nu} - \frac{1}{2} g_{\kappa\nu}\, {}^{(g)}R &= \chi \left[T_{\kappa\nu} + \underline{T}_{\underline{\kappa\nu}} \right] \\
{}^{(h)}R_{\underline{\nu\kappa}} - \frac{1}{2} \underline{h}_{\underline{\nu\kappa}}\, {}^{(\underline{h})}R &= -\, \underline{\chi} \left[T_{\nu\kappa} + \underline{T}_{\underline{\nu\kappa}} \right]
\end{aligned}
$$

Assuming that the two matter fields correspond to:

(32)

$$
T_\kappa^{\ \nu} = \begin{pmatrix} \rho c^2 & 0 & 0 & 0 \\ 0 & -p & 0 & 0 \\ 0 & 0 & -p & 0 \\ 0 & 0 & 0 & -p \end{pmatrix} \qquad \underline{T}_{\underline{\kappa}}^{\ \underline{\nu}} = \begin{pmatrix} \underline{\rho}\,\underline{c}^2 & 0 & 0 & 0 \\ 0 & -\underline{p} & 0 & 0 \\ 0 & 0 & -\underline{p} & 0 \\ 0 & 0 & 0 & -\underline{p} \end{pmatrix}
$$

with :

(33) $$\rho > 0 \quad p > 0 \quad \text{and} \quad \underline{\rho} < 0 \quad \underline{p} < 0$$

Such a system gives the desired interaction laws. Moreover, insofar as the masses of opposite signs are mutually opposede one can think that in the vicinity of the solar system the negative mass density must be negligible, i.e. that locally $\underline{T}_{\kappa\nu} \simeq 0$. Then the first of the two equations is identified with the Einstein equation, without its cosmological constant.

So the system verifies the local relativistic observations.

7 - **We try to build unsteady solutions giving**

$$a_{(x°)} \quad \text{and} \quad b_{(x°)}$$

Both metrics are defined on the same 4-manifold whose points are marked by :

- a common chronological coordinate $x°$
- Space coordinates (u , θ , φ) , simple numbers or angles.

Thus the two metrics are :

(34) $$ds^2 = - dx^{\circ 2} + a^2 \left[\frac{du^2}{1 - k u^2} + d\theta^2 + \sin^2\theta \, d\varphi^2 \right]$$

(35) $$d\underline{s}^2 = - dx^{\circ 2} + b^2 \left[\frac{du^2}{1 - \underline{k} u^2} + d\theta^2 + \sin^2\theta \, d\varphi^2 \right]$$

Two coupled FRLW solutions are introduced:

$$\mathrm{ds}^2 = - \mathrm{dx}^{\circ 2} + \mathrm{a}^2 \left[\frac{\mathrm{dr}^2}{1 - \mathrm{kr}^2} + \mathrm{d}\theta^2 + \sin^2\theta \, \mathrm{d}\varphi^2 \right] \quad (14a)$$

$$\mathrm{d}\underline{\mathrm{s}}^2 = - \mathrm{dx}^{\circ 2} + \mathrm{b}^2 \left[\frac{\mathrm{dr}^2}{1 - \underline{\mathrm{k}}\mathrm{r}^2} + \mathrm{d}\theta^2 + \sin^2\theta \, \mathrm{d}\varphi^2 \right] \quad (14b)$$

With :

(36) $$\dot{a} = \frac{da}{dx^{\circ 2}} \qquad \ddot{a} = \frac{d^2 a}{dx^{\circ}} \qquad \dot{b} = \frac{db}{dx^{\circ}} \qquad \ddot{b} = \frac{d^2 a}{dx^{\circ 2}}$$

we get two couples of differential equations :

(37) $$-\chi \left[\rho c^2 + \underline{\rho}\,\underline{c}^2 \right] = \frac{3k}{a^2} + \frac{3\dot{a}^2}{a^2}$$

(38) $$-\chi \left[\rho c^2 + \underline{\rho}\,\underline{c}^2 + p + \underline{p} \right] = - \frac{k}{a^2} - \frac{\dot{a}^2}{a^2} - \frac{2\ddot{a}}{a}$$

(39) $$\underline{\chi} \left[\underline{\rho}\,\underline{c}^2 + \phi \rho c^2 \right] = \frac{3\underline{k}}{\underline{b}^2} + \frac{3\dot{\underline{b}}^2}{\underline{b}^2}$$

(40) $$\underline{\chi} \left[\underline{\rho}\,\underline{c}^2 + \phi \rho c^2 + \underline{p} + \phi p \right] = - \frac{\underline{k}}{b^2} - \frac{\dot{b}^2}{b^2} - \frac{2\ddot{b}}{b}$$

We then apply the same calculation technique, inspired by the treatment of the two Einstein equations, and we obtain:

(41) $$\frac{\frac{d}{dx^{\circ}}\left[\rho c^2 + \underline{\rho}\,\underline{c}^2 \right]}{\left[\rho c^2 + \underline{\rho}\,\underline{c}^2 + p + \underline{p} \right]} + \frac{3}{a}\frac{da}{dx^{\circ}} = 0$$

(42)
$$\frac{\frac{d}{dx^{\circ}}\left[\rho c^2+\underline{\rho}\,\underline{c}^2\right]}{\left[\rho c^2+\underline{\rho}\,\underline{c}^2+p+\underline{p}\right]}+\frac{3}{b}\frac{db}{dx^{\circ}}=0$$

which gives us the constraint:

(43)
$$a\equiv b$$

Which does not correspond to the heuristic hypothesis that we had made, which was based on a deep dissymmetry between the two species.

8 – 2013 : **Attempt to improve the system of the two Champs equations.**

We then consider the system (still using a heuristic approach):

(44)
$$\begin{aligned}{}^{(g)}R_{\kappa\nu}-\frac{1}{2}g_{\kappa\nu}\,{}^{(g)}R&=\chi\left[T_{\kappa\nu}+\varphi\underline{T}_{\underline{\kappa\nu}}\right]\\ {}^{(h)}R_{\underline{\nu\kappa}}-\frac{1}{2}\underline{h}_{\underline{\nu\kappa}}\,{}^{(\underline{h})}R&=-\underline{\chi}\left[\phi T_{\nu\kappa}+\underline{T}_{\underline{\nu\kappa}}\right]\end{aligned}$$

We then obtain the four equations:

(45)
$$-\chi\left[\rho c^2+\varphi\underline{\rho}\,\underline{c}^2\right]=\frac{3k}{a^2}+\frac{3\dot{a}^2}{a^2}$$

(46)
$$-\chi\left[\rho c^2+\varphi\underline{\rho}\underline{c}^2+p+\varphi\,\underline{p}\right]=-\frac{k}{a^2}-\frac{\dot{a}^2}{a^2}-\frac{2\ddot{a}}{a}$$

(47)
$$\underline{\chi}\left[\underline{\rho}\,\underline{c}^2+\rho c^2\right]=\frac{3\underline{k}}{\underline{b}^2}+\frac{3\dot{\underline{b}}^2}{\underline{b}^2}$$

(48)
$$\underline{\chi}\left[\underline{\rho}\,\underline{c}^2+\rho c^2+\underline{p}+p\right]=-\frac{\underline{k}}{b^2}-\frac{\dot{b}^2}{b^2}-\frac{2\ddot{b}}{b}$$

which leads this time to the compatibility equations:

(49)
$$\frac{\frac{d}{dx^{\circ}}\left[\rho c^2+\varphi\underline{\rho}\,\underline{c}^2\right]}{\left[\rho c^2+\varphi\underline{\rho}\,\underline{c}^2+p+\varphi\,\underline{p}\right]}+\frac{3}{a}\frac{da}{dx^{\circ}}=0$$

(50)
$$\frac{\frac{d}{dx^{\circ}}\left[\phi\rho c^2+\underline{\rho}\,\underline{c}^2\right]}{\left[\phi\rho c^2+\underline{\rho}\,\underline{c}^2+\phi p+\underline{p}\right]}+\frac{3}{b}\frac{db}{dx^{\circ}}=0$$

A dissymmetric solution can then be proposed by posing:

(51) $$\varphi = \frac{b^3}{a^2} \qquad \phi = \frac{a^3}{b^2}$$

If we assume that the two entities are dust universes $p = \underline{p} = 0$ then the two compatibility equations are reduced to a single equation :

(52) $$\frac{d}{dx^\circ}(\rho c^2 a^3 + \underline{\rho}\,\underline{c}^2 b^3) = 0$$

This corresponds to a generalized conservation of energy:

(53) $$\rho c^2 a^3 + \underline{\rho}\,\underline{c}^2 b^3 = E = Cst$$

The system of field equations then becomes [45] :

(53 bis)

$$^{(g)}R_{\kappa\nu} - \frac{1}{2} g_{\kappa\nu}\, {}^{(g)}R = \chi \left[T_{\kappa\nu} + \left(\frac{b}{a}\right)^3 \underline{T}_{\underline{\kappa}\underline{\nu}} \right]$$

$$^{(h)}R_{\underline{\nu}\underline{\kappa}} - \frac{1}{2} \underline{h}_{\underline{\nu}\underline{\kappa}}\, {}^{(\underline{h})}R = -\underline{\chi} \left[\left(\frac{a}{b}\right)^3 T_{\nu\kappa} + \underline{T}_{\underline{\nu}\underline{\kappa}} \right]$$

with :

(54) $$\chi = -\frac{8\pi G}{c^4}$$

et :

(54) $$\underline{\chi} = -\frac{8\pi \underline{G}}{\underline{c}^4}$$

which we show by linearizing the two metrics in the neighborhood of the Lorentzian metrics.

We obtain:

(54) $$\dot{a} = c\sqrt{-k - \frac{8\pi G}{3c^4}\frac{E}{a}}$$

(55) $$\dot{b} = \underline{c}\sqrt{-\underline{k} + \frac{8\pi \underline{G}}{3\underline{c}^4}\frac{E}{b}}$$

(56) $$a^2\ddot{a} = -\frac{8\pi G}{3c^2}E$$

(57) $$b^2\,\ddot{b} = \frac{8\pi\,\underline{G}}{3\underline{c}^2}\,E$$

We can then exploit the data of the acceleration of the cosmic expansion of positive masses: $\ddot{a} > 0$ which implies that both curvature indices are negative:

(58) $$\boxed{k = \underline{k} = -1}$$

and the total energy is negative:

(59) $$\boxed{E < 0}$$

So that's our dark energy! The idea that a negative mass content can replace both dark matter and dark energy is gaining credibility. The exact solution of (56) was given by William Bonnor [2] . As for the solution of equation (57), it is one of the three Friedmann models, the hyperbolic solution. The two scale factors tend to their respective asymptotes.

Let us express:

(60) $$\dot{a} = c\sqrt{1 + \frac{8\pi\,G}{3c^4}\frac{|E|}{a}}$$

(61) $$\dot{b} = \underline{c}\sqrt{1 - \frac{8\pi\,\underline{G}}{3\underline{c}^4}\frac{|E|}{b}}$$

The slopes of the two asymptotes are respectively c and $\underline{c}$. It is difficult to conceive mentally that, while the expansion of positive masses is accelerated, on the contrary that of negative masses is slowed down, at least in this material phase.

From this exact solution Gilles d'Agostini develops in the article [36] the comparison with the observational data from the 700 type Ia supernovae. The calculation is quite classical. The result corresponds to the figure below

:

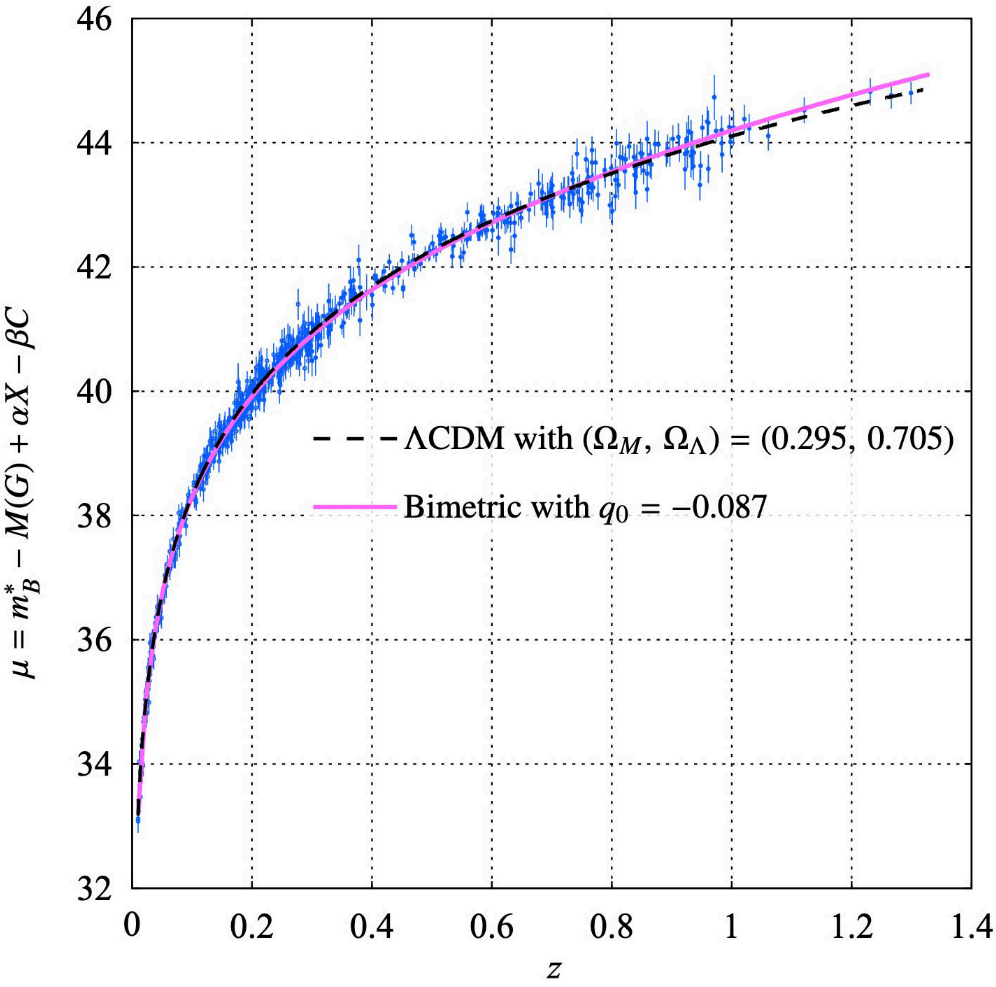

FiG.22 : Hubble diagrame compared with two models
(Linear redshit scal) [36]

Let us return to the system of equations used. At this point we notice that the determinants are:

(63) $$g = -\frac{a^6}{1+u^2} \qquad \underline{h} = -\frac{b^6}{1+u^2}$$

c:

(64) $$\frac{b^3}{a^3} = \sqrt{\frac{\underline{h}}{g}}$$

This suggests to switch (still heuristically!) to the system :

$$
\begin{aligned}
&{}^{(g)}R_{\kappa\nu} - \frac{1}{2} g_{\kappa\nu} \, {}^{(g)}R = \chi \left[T_{\kappa\nu} + \sqrt{\frac{\underline{h}}{g}} \, \underline{T}_{\underline{\kappa\nu}} \right] \\
(65) \quad & \\
&{}^{(\underline{h})}R_{\underline{\nu\kappa}} - \frac{1}{2} \underline{h}_{\underline{\nu\kappa}} \, {}^{(\underline{h})}R = -\chi \left[\sqrt{\frac{g}{\underline{h}}} \, T_{\underline{\nu\kappa}} + \underline{T}_{\underline{\nu\kappa}} \right]
\end{aligned}
$$

Note that we are still in a heuristic approach, since the construction of the system of equations from a Lagrangian is not given.

We then notice, in 2014, that this system has a strong kinship with the one published in 2008 in Physical Review D by the German mathematician Sabine Hossenfelder, which we discover at the time, and which we reproduce below:

$$
\begin{aligned}
&{}^{(g)}R_{\kappa\nu} - \frac{1}{2} g_{\kappa\nu} \, {}^{(g)}R = T_{\kappa\nu} - \underline{V} \sqrt{\frac{\underline{h}}{g}} \, a^{\nu}_{\underline{\nu}} \, a^{\kappa}_{\underline{\kappa}} \, \underline{T}_{\underline{\kappa\nu}} \\
(69) \quad & \\
&{}^{(h)}R_{\underline{\nu\kappa}} - \frac{1}{2} \underline{h}_{\underline{\nu\kappa}} \, {}^{(\underline{h})}R = \underline{T}_{\underline{\nu\kappa}} - W \sqrt{\frac{g}{\underline{h}}} \, a^{\underline{\kappa}}_{\kappa} \, a^{\nu}_{\underline{\nu}} \, T_{\nu\kappa}
\end{aligned}
$$

But the signs are not the same. There are coefficients $\underline{V}$ and W as well as matrices.

We try to establish a dialogue with her. We even proposed to go to Frankfurt to meet her. No answer.

9 - **The conditions for a solid mathematical basis of a cosmological model.**

A - A clear geometrical context must be defined.

At this stage it is done: We suppose that the universe is a 4-manifold equipped with two Remanian metrics, of common signature $(-,+,+,+)$ *Then the observables will be deduced from the analysis of the positive mass paths, following the geodesics of the first metric of non-zero length and of the paths of the photons of positive or negative energy. The observables will be deduced from the analysis of the positive mass paths, following the geodesics of the first metric of non-zero length and the trajectories of the photons of positive energy, excluding those of the photons of negative energy, that our instruments cannot capture, which path on disjointed trajectories. The structures composed of negative mass will be geometrically invisible and will reveal their presence only by anti gravitational effects*

B – The system of the two field equations should derive from a Lagrangian.

C – All tensors present in the equations must be defined.

D – The Newtonian approximation will have to provide the interaction laws that have proved fruitful in the heuristic approach.

It is done: positive masses attract each other according to Newton's law, as well as negative, self-attracting masses. Masses of opposite signs repel each other according to anti-Newton.

E – The field equations must satisfy the relations deriving from the Bianchi conditions, be of zero divergence.

The points B , C , E remain to be established.

10 – **Our own Lagrangian derivation** [42]

When we write the Einstein-Hilbert action, we immediately introduce the Lagrangian density $R\sqrt{-g}$. The action is then written:

(70) $$S = \int_{D4} [\; R - \chi L \;] \sqrt{-g}\; d^4x$$

With $\delta A = 0$ we get

(70) $$\delta S = \int_{D4} \left[\; R_{\mu\nu} - \frac{1}{2} R g_{\mu\nu} - \chi T_{\mu\nu} \;\right] \sqrt{-g}\; \delta g^{\mu\nu} d^4x = 0$$

Hence the Einstein equation (without its cosmological constant):

(71) $$R_{\mu\nu} - \frac{1}{2} R g_{\mu\nu} = \chi T_{\mu\nu}$$

So in 2015 we try to compose our own Lagrangian derivation [42] . We write the action in the form :

(72) $$A = \int_{D4} \left[\; ({}^{(g)}R - \chi L^{(g/g)} - \underline{\chi} L^{(g/\underline{h})}) \sqrt{-g} \; + \; ({}^{(\underline{h})}R - \underline{\chi} L^{(\underline{h}/\underline{h})} - \chi L^{(\underline{h}/g)}) \sqrt{-\underline{h}} \;\right] d^4x$$

In the derivation the two equations:

(73)
$$\delta \int_{D4} \left[\; {}^{(g)}R \sqrt{-g} \;\right] d^4x = \int_{D4} \left[{}^{(g)}R_{\mu\nu} - \frac{1}{2} {}^{(g)}R\, g_{\mu\nu} \right] d^4x$$
$$\delta \int_{D4} \left[\; {}^{(\underline{h})}R \sqrt{-\underline{h}} \;\right] d^4x = \int_{D4} \left[{}^{(\underline{h})}R_{\mu\nu} - \frac{1}{2} {}^{(\underline{h})}R\, \underline{h}_{\mu\nu} \right] d^4x$$

provide the first members of both equations.

In this approach we have only one set of indices

We then have four Lagrangian densities:

$\chi\, L^{(g/g)}\sqrt{-g}$ takes over the action of the positive masses on the positive mass

$\chi\, L^{(\underline{h}/g)})\sqrt{-\underline{h}}$ takes care of the action of the negative lasses on the negative masses.

The part:

(74) $$\delta \int_{D4}\left[-\chi\, L^{(g/g)}\sqrt{-g}\; -\chi\, L^{(\underline{h}/g)})\sqrt{-\underline{h}}\;\right] d^4x$$

provides the second member of the first field equation. Whence :

(75) $$\delta \int_{D4}\left[-\underline{\chi}\, L^{(\underline{h}/\underline{h})}\sqrt{-\underline{h}}\; -\underline{\chi}\, L^{(g/\underline{h})})\sqrt{-g}\;\right] d^4x$$

provides the second member of the second field equation.

In these two parts, two of the terms are not a priori problematic:

(76) $$\delta \int_{D4}\left[-\chi\, L^{(g/g)}\sqrt{-g}\;\right] d^4x = \int_{D4}\left[-\chi\, T_{\mu\nu}\sqrt{-g}\;\delta g^{\mu\nu}\right] d^4x$$

(77) $$\delta \int_{D4}\left[-\underline{\chi}\, L^{(\underline{h}/\underline{h})}\sqrt{-\underline{h}}\;\right] d^4x = \int_{D4}\left[-\underline{\chi}\, \underline{T}_{\mu\nu}\sqrt{-\underline{h}}\;\delta \underline{h}^{\mu\nu}\right] d^4x$$

These are the remaining terms that will have to be defined. They will define the tensors:

(78) $$\delta \int_{D4}\left[\,-\chi\, L^{(\underline{h}/g)})\sqrt{-\underline{h}}\;\right] d^4x = \int_{D4}\left[\,-\chi\, \widehat{\underline{T}}_{\mu\nu}\sqrt{-\underline{h}}\,\delta \underline{h}^{\mu\nu}\right] d^4x$$

(79) $$\delta \int_{D4}\left[\,-\underline{\chi}\, L^{(g/\underline{h})}\sqrt{-g}\;\right] d^4x = \int_{D4}\left[\,-\underline{\chi}\, \widehat{T}_{\mu\nu}\sqrt{-g}\,\delta g^{\mu\nu}\right] d^4x$$

We can see, at this stage, where the factors appear $\sqrt{\dfrac{\underline{h}}{g}}$ and $\sqrt{\dfrac{g}{\underline{h}}}$

It is sufficient to write the following two expressions:

(80) $$\int_{D4}\left[-\chi\sqrt{\frac{\underline{h}}{g}}\;\widehat{\underline{T}}_{\mu\nu}\sqrt{-g}\;\delta \underline{h}^{\mu\nu}\right] d^4x$$

(81) $$\int_{D4}\left[\,-\underline{\chi}\sqrt{\frac{g}{\underline{h}}}\;\widehat{T}_{\mu\nu}\sqrt{-\underline{h}}\;\delta g^{\mu\nu}\right] d^4x$$

To obtain the expected result we need to define a coupling between the metrics $\boldsymbol{g}$ and $\underline{\boldsymbol{h}}$. To do so, we are inspired by the properties of the stationary metric solutions, with spherical symmetry (outer Schwarzschild metrics) of the second member equations, from our heuristic approach

For that we will consider a situation where the space scale factors a and b are considered as constant and we pose:

(82) $$r = a u \qquad \underline{r} = b u$$

(83) $$\underline{r}_s = r_s \frac{b}{a}$$

Consider a region where the geometry in the vacuum is created by a mass contained in a sphere of radius r_s , filled with a positive mass of constant density ρ. The two external metrics will be written :

(84)

$$ds^2 = \left(1 - \frac{8\pi G \rho r_s^{\,3}}{3c^2 r} \right) dx^{\circ\,2} - \frac{dr^2}{1 - \frac{8\pi G \rho r_s^{\,3}}{3c^2 r}} - r^2 (d\theta^2 + \sin^2 d\varphi^2)$$

(85)

$$d\underline{s}^2 = \left(1 + \frac{8\pi \underline{G} \hat{\rho} \underline{r}_s^{\,3}}{3\underline{c}^2 \underline{r}} \right) dx^{\circ\,2} - \frac{d\underline{r}^2}{1 + \frac{8\pi \underline{G} \hat{\rho} \underline{r}_s^{\,3}}{3\underline{c}^2 \underline{r}}} - \underline{r}^2 (d\theta^2 + \sin^2 d\varphi^2)$$

By posing

`(86) $$\frac{8\pi G \rho r_s^{\,3}}{3c^2 r} = - \frac{8\pi \underline{G} \hat{\rho} \underline{r}_s^{\,3}}{3\underline{c}^2 \underline{r}}$$

The differentials of the two metrics are both proportional to $\delta \rho$ and we have :

(87) $$\delta \boldsymbol{g} = - \delta \underline{\boldsymbol{h}}$$

In particular:

(88) $$\delta g^{\mu\nu} = - \delta \underline{h}^{\mu\nu}$$

One can object that the relation (87) depends on the chosen coordinate system. It is therefore not covariant. This is the weak point of our own Lagrangian derivation, which is why we will refer to make the Janus system of equations depend on the method inspired by the article of Sabine Hossenfeder [37], which does not lead to the same results, because of the different choices of signs in its action.

The same reasoning can be made considering that the external geometries would be created this time by a sphere filled with a negative mass of constant density.

We could also do the same thing by considering the interior geometries, corresponding to the interior Schwarzschild metrics. Here when this interior geometry is created by a sphere filled with positive mass of constant density :

(89)

$$ds^2 = \left[\frac{3}{2}\left(1 - \frac{8\pi G\rho r_s^{\,2}}{3c^2}\right)^{\frac{1}{2}} - \frac{1}{2}\left(1 - \frac{8\pi G\rho r^2}{3c^2}\right)^{\frac{1}{2}} \right]^2 dx^{\circ\,2} - \frac{dr^2}{1 - \dfrac{8\pi G\rho r^2}{3c^2}} - r^2(\,\mathrm{d}\theta^2 + \sin^2\theta \mathrm{d}\varphi^2\,)$$

(90)

$$d\underline{s}^2 = \left[\frac{3}{2}\left(1 + \frac{8\pi \underline{G}\hat{\rho} \underline{r}_s^{\,2}}{3\underline{c}^2}\right)^{\frac{1}{2}} - \frac{1}{2}\left(1 + \frac{8\pi \underline{G}\hat{\rho}\, r^2}{3\underline{c}^2}\right)^{\frac{1}{2}} \right]^2 dx^{\circ\,2} - \frac{d\underline{r}^2}{1 + \dfrac{8\pi \underline{G}\hat{\rho}\, r^2}{3\underline{c}^2}} - \underline{r}^2(\,\mathrm{d}\theta^2 + \sin^2\theta \mathrm{d}\varphi^2\,)$$

Here again the variation of the metrics is proportional to the variation of the density. We will have again the non covariant relation $\delta\, \boldsymbol{g} = -\,\delta \underline{\boldsymbol{h}}$.

The metrics $\boldsymbol{g}$ and $\underline{\boldsymbol{h}}$ belong to the same functional space of signature Riemanian metrics . The link imposed between these two metric solutions is only valid if they are expressed in this particular coordinate system. This being the case, the system of field equations resulting from this assumption produces the inner and outer Schwarzschild solutions, modulo the constraint that they be expressed in the chosen coordinate system.

Under these conditions the two field equations become:

(91)

$$^{(g)}R_{\mu\nu} - \frac{1}{2} g_{\mu\nu}\, {}^{(g)}R = \chi \left[T_{\mu\nu} + \sqrt{\frac{h}{g}}\, \hat{\underline{T}}_{\mu\nu} \right]$$

$$^{(\underline{h})}R_{\mu\nu} - \frac{1}{2} \underline{h}_{\mu\nu}\, {}^{(\underline{h})}R = -\,\chi \left[\sqrt{\frac{g}{\underline{h}}}\, \hat{T}_{\mu\nu} + \underline{T}_{\mu\nu} \right]$$

It remains to determine the form of the tensors $\hat{T}_{\mu\nu}$ and $\hat{\underline{T}}_{\mu\nu}$, sources of an induced geometry (by one of the species on the geometry of the other).

It is the last constraint, that of satisfying the conservativity conditions resulting from the Bianchi conditions, which will impose the shape of these tensors, sources of the induced geometries. This calculation is rather tedious[46] .

We will just give the result:

We have the tensors :

(91)

$$T_\mu^\nu = \begin{pmatrix} \rho c^2 & 0 & 0 & 0 \\ 0 & -p & 0 & 0 \\ 0 & 0 & -p & 0 \\ 0 & 0 & 0 & -p \end{pmatrix} \quad \underline{T}_\mu^\nu = \begin{pmatrix} \underline{\rho}\,\underline{c}^2 & 0 & 0 & 0 \\ 0 & -\underline{p} & 0 & 0 \\ 0 & 0 & -\underline{p} & 0 \\ 0 & 0 & 0 & -\underline{p} \end{pmatrix}$$

The conservativity, derived from Bianchi relations, is satisfied if:

(92)

$$\widehat{T}_\mu^\nu = \begin{pmatrix} \rho c^2 & 0 & 0 & 0 \\ 0 & p & 0 & 0 \\ 0 & 0 & p & 0 \\ 0 & 0 & 0 & p \end{pmatrix} \quad \widehat{\underline{T}}_\mu^\nu = \begin{pmatrix} \underline{\rho}\,\underline{c}^2 & 0 & 0 & 0 \\ 0 & \underline{p} & 0 & 0 \\ 0 & 0 & \underline{p} & 0 \\ 0 & 0 & 0 & \underline{p} \end{pmatrix}$$

Concretely, it translates the physical property that, inside the masses, positive or negative, the force of gravity is balanced by the force of pressure. Outside the masses these identities are satisfied automatically, since the second members are zero and the first members are zero divergence.

We see that the satisfaction of the conservation relation from the Bianchi identities, in the second equation and in the portion of space with a constant positive mass density, determines the geometry, and we obtain the source tensor of the induced geometry by inverting the pressure terms. This should not be seen as something with any particular physical meaning. It is the simple result of a mathematical constraint to find there the balance between pressure force and gravity force inside this positive mass?

11 – **Link with other bimetric theories.**

The first attempt to build a bimetric model was made in 2004 by T.Damour and I.Kogan [38]. They imagine that our universe is interacting with another "brane", the whole being imbedded in a higher dimensional space. Any point of the first brane, the "right" brane, marked by the letter R is interacting with a conjugate point of the second brane "left", marked by the letter L. The authors write their action:

(93)

$$S = \int d^4x\sqrt{-g_R}\,(M_R^2 R(g_R) - \Lambda_R) + \int d^4x\sqrt{-g_L}\,(M_L^2 R(g_L) - \Lambda_L) + \int d^4x\sqrt{-g_R}\,L(\phi_R, g_R)$$
$$+ \int d^4x\sqrt{-g_L}\,L(\phi_L, g_L) + \int d^4x(g_R g_L)^{1/4} V(g_R, g_L)$$

Ils introduisent des densités lagrangiennes dans l'action : les termes de Ricci $R^R L^R\sqrt{-g^R}$, $R^L\sqrt{-g^L}$, the terms corresponding to positive matter $L^R\sqrt{-g^R}$ and negative matter $L^L\sqrt{-g^L}$, are based on the corresponding four-dimensional hypervolumes

$\sqrt{-g^R}\ dx^o dx^1 dx^2 dx^3$ and $\sqrt{-g^L}\ dx^o dx^1 dx^2 dx^3$. They introduce an interaction term : $\mu\left(g^R g^L\right)^{1/4} \sqrt{-g^L}\ dx^o dx^1 dx^2 dx^3$ based on an « average volume factor » $\left(g^R g^L\right)^{1/4}$.

They specify that their system of equations must satisfy the Bianchi identities. But their test does not lead to any model, because they cannot specify the nature of the interaction terms.

The second attempt was made by S. Hossenfeler in 2008 [37]. We therefore encourage specialist readers to refer to her article and the commentary we give in section II.3 of the reference [37]. Her action is:

(94)
$$S = \int d^4x\left[\sqrt{-g}\ \left({}^{(g)}R/8\pi G + L(\Psi)\right) + \sqrt{-h}\ P_{\underline{h}}(\underline{L}(\phi))\right]$$
$$+\int d^4x\left[\sqrt{-\underline{h}}\ \left({}^{(\underline{h})}R/8\pi G + \underline{L}(\underline{\Phi})\right) + \sqrt{-\underline{g}}\ P_g(L(\psi))\right]$$

Her work does not lead to a possibility of confronting her model with observations. Indeed, when she builds it, the fact that we observe an acceleration of the cosmic expansion has not yet been clearly accepted by the scientific community. This result will be considered as accepted only in 2011 ([39], [40], [41]). So the author makes choices, essentially those of the signs of the terms which, in her Lagrangian, allow her to stick with what she considers as a standard model. To do this, she is obliged to opt for the non-satisfaction of the equivalence principle in the way she treats this second matter.

When she performs her variation calculation she also introduces a coupling between the two metrics, through a relation :

(95)
$$\delta h_{\kappa\lambda} = -\left[a^{-1}\right]_{\kappa}^{\mu}\left[a^{-1}\right]_{\lambda}^{\nu}\delta g_{\mu\nu}$$

similar to ours, but more general in the sense that its presentation maintains the covariance. Thus it arrives at the system of coupled field equations:

(96)
$${}^{(g)}R_{\kappa\nu} - \frac{1}{2}g_{\kappa\nu}\,{}^{(g)}R \;=\; T_{\kappa\nu} - \underline{V}\sqrt{\frac{h}{g}}\;a_{\nu}^{\underline{\nu}}\,a_{\kappa}^{\underline{\kappa}}\,\underline{T}_{\underline{\kappa\nu}}$$
$${}^{(h)}R_{\underline{\nu\kappa}} - \frac{1}{2}\underline{h}_{\underline{\nu\kappa}}\,{}^{(\underline{h})}R \;=\; \underline{T}_{\underline{\nu\kappa}} - W\sqrt{\frac{g}{\underline{h}}}\;a_{\kappa}^{\underline{\kappa}}\,a_{\underline{\nu}}^{\nu}\,T_{\nu\kappa}$$

In her analysis the speeds of light are taken equal to the unit, as well as the Einstein constants. We see that the different signs differ. For a detailed analysis of his article, see reference [16]. We will quote some sentences from her article:

In her section VII she writes:

> *The model we laid is purely classical. We will assume that the field content for both, the g-field and the h-field, is identical, such as we have two copies of the Standard Model.*

In her section VIII, we quote:

The kinetic energies are still strictly positive and conserved.

As kietic energies are $\frac{1}{2}\rho < v^2 >$ and $\frac{1}{2}\underline{\rho} < \underline{v}^2 >$ we see that she opted for positive gravitational masses, in both populations: $m_g > 0$ and $\underline{m}_g > 0$

To obtain an antigravity effect it opts for a negative inertial mass, for the second population: $\underline{m}_i < 0$. Thus the principle of equivalence is abandoned for the second species, which differs from the Janus model.

She specifies :

Bimetric theories generically violate the equivalence principle because now have two different ways of coupling to gravity.

Thinking that this violation of the equivalence principle would be a generic property of bimetric models.

v:

Both types of fields only interact gravitationally, so the h-fields constitute a kind of very weakly interacting dark matter.

Its second matter does not interact more weakly, than do the positive masses, interacting with their similar.

We regret that Sabine Hossenfelder systematically rejected any proposal for collaboration, obviously because of the link that we invoked between our model and the UFO dossier. In 2021, she insisted on affirming her conservative position by criticizing [47] the remarks of Avi Loeb, and by affirming, as a conclusion, about the Oumuamua object:

- *What we know for sure is that we don't know what it is.*

12- **Summary of the Janus model achievements**.

We have satisfied the conditions 9. The model can therefore be considered as mathematically consistent. It represents a profound paradigm shift, in the form of an extension of General Relativity. The observational conformations are:

- (1) Objects like dark matter and dark energy are replaced by a negative mass content, which produces all the effects attributed to these two hypothetical components.

- (2) This negative mass obeys the equivalence principle.

- (3) Masses of the same sign attract each other according to Newton's law

- (4) Masses of opposite signs repel each other according to "anti-Newton".

  (5) The universe is the seat of joint gravitational instabilities, which produce a separation of the two types of masses, making them occupy different portions of space.

  (6) It is assumed that these masses interact at the end of a common radiative phase, not described, and that the absolute value of the negative mass density is large before that of the positive mass.

- (7) A large scale structure is then created where the negative mass forms a regular network of spheroidal clusters. The phenomenon of the Great Repeller betrays the presence of one of these clusters, escaping the optical observations.

- (8) Indeed the negative masses, emitting photons of negative energy, escape our observations and reveal their presence only by an antigravitational action.

  (9) Negative masses create a negative gravitational lensing effect on positive energy photons.

- (10) This effect attenuates the magnitude of high redshift galaxies, which would not be dwarf galaxies.

  (11) Finer observations, highlighting a contrast in magnitude of these objects, in the vicinity of the Great Repeller should allow to determine its diameter.

  (12) When the very large scale structure is formed, the positive mass is compressed according to plates, which facilitates, after its heating by compression, its rapid cooling by radiation. This suggests the construction of a new model of galaxy formation.

- (13) At the moment when galaxies are formed, the negative mass infiltrates between them and, exerting on them a counter pressure, ensures their confinement.

- (14) Galaxies are not therefore sets of mass-dots, of positive mass (visible mass or dark matter) orbiting inside their gravitational field. If we try to build such a model thanks to a system of two Vlasov equations, or a Vlasov equation and a Boltzmann equation (for the dark matter) these systems will have infinite masses.

- (14) On the other hand, galaxies, made of positive mass, have finite masses. Their confinement is ensured by their negative mass environment.

- (16) In this configuration the rotation curves of the gas present a plateau in periphery .

- (17) The matter, arranged in a structure reminiscent of a system of joined soap bubbles, gives rise to filaments (at the junction of three cells) and to clusters (at the junction of four of these cells) by continuation of the gravitational instability.

- (18) The gaps at different scales in the negative mass distribution, in which galaxies and clusters of galaxies are located creates a positive gravitational lensing effect. The strong gravitational lensing effects are thus explained.

- (19) The hypothesis of the dominance of negative mass, whose energy is negative, causes the acceleration of the cosmic expansion. The distribution of the different components is then summarized as :

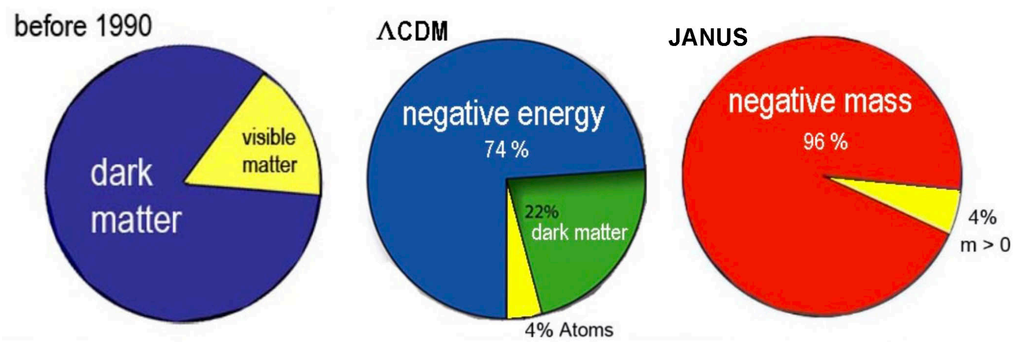

Fig.23 : Distribution of the components in the different models.

- (20) Galaxies interact with their negative mass environment by density waves which constitute their spiral structure.

- (21) As the negative mass density is practically non-existent in the vicinity of the Sun, the first equation is identified with the Einstein equation. The model agrees with the local relativistic observations: advance of Mercury's perihelion, gravitational lensing effect due to the mass of the Sun

To continue the construction of a cosmological model integrating all the observational data there remain many points to elucidate.

13- **The question of the non-observation of primordial antimatter**.

In 1967 the Russian Andrei Sakharov ([48] , [49] , [50]) had a very strange idea. So strange that one can wonder if he had taken it out of his imagination or if someone had suggested it to him. As the primordial antimatter refuses to be observed. Sakharov suggests that at the time of the Bing bang it was not one universe that is created, but two, symmetrical with respect to what he sees as a singularity.

Moreover the arrows of time of these two universes, which he designates as cosmic twins, are opposite. Hereafter a 2D didactic image of the model of twin universes of Sakharov.

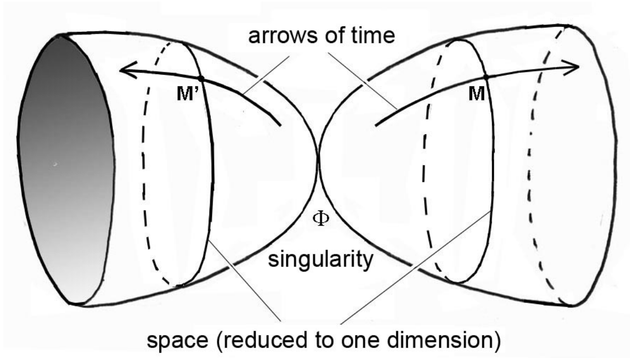

Fig.24 : 2D didactic image of Andrei Sakharov's universe

Sakharov imagines that, in these two universes, matter and antimatter were formed by combination of triads of quarks and antiquarks. At the same time the matter-antimatter pairs annihilate each other by giving photons. Then these photons give birth again to matter-antimatter pairs. But the wavelength of photons distends at the same time as these universes themselves what reduces at the same time the energy of which are carriers, to the point that the annihilation of the pairs gains on their creation.

Sakharov imagines then that the synthesis of matter, from quarks, was faster in our universe, at the expense of the synthesis of antimatter, from antiquarks. Thus in our universe fold remain:

- Photons from annihilations.

- A mixture of matter and antiquarks (in a ratio three to one), at a rate of one matter element for one billion photons.

In the twin universe, the opposite situation. One finds there:

- Photons resulting from the annihilation of the twin matter and its sister, the twin antimatter

- A mixture of antimatter and quarks, (in a ratio three to one), at a rate of one element of matter for one billion photons.

Moreover, without giving any reason for that, Sakharov proposes that these two twin universes are enantiomorphic, "in mirror".

14- **Matter and groups.**

At this stage the space-time is that of Minkowski with his Lorentzian metric. Let's go back to the older choice of the signature, which does not change the result, but saves us from having to repeat everything in the appendix of reference [51].

(97) $$ds^2 = c^2 dt^2 - dx^2 - dy^2 - dz^2$$

We have the metric matrix:

(98)
$$\mathbf{G} = \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & -1 & 0 & 0 \\ 0 & 0 & -1 & 0 \\ 0 & 0 & 0 & -1 \end{pmatrix}$$

We use this letter **G** because it is a Gramm matrix.

It is easy to construct the isometry group of the Minkowski space, which corresponds to the matrices: which constitute the Poincaré group, of dimension 10

(99)
$$\begin{pmatrix} \mathbf{L} & \mathbf{C} \\ 0 & 1 \end{pmatrix} \quad \text{with} \quad \mathbf{C} = \begin{pmatrix} \Delta t \\ \Delta x \\ \Delta y \\ \Delta z \end{pmatrix}$$

C is the space-time translation quadrivector. **L** is a group of matrices (4,4), of dimension 6, axiomatically defined by :

(100)
$$\mathbf{L}^T \mathbf{G} \mathbf{L} = \mathbf{G}$$

These are movements that "inhabit" Minkowski's space, which are as many geodesics of this space. The group acts on these movements. Let:

(101)
$$\xi = \begin{pmatrix} t \\ x \\ y \\ z \end{pmatrix}$$

be a point of the space-time. The group's action is:

(102)
$$\begin{pmatrix} \mathbf{L} & \mathbf{C} \\ 0 & 1 \end{pmatrix} \times \begin{pmatrix} \xi \\ 1 \end{pmatrix} = \begin{pmatrix} \mathbf{L}\xi + \mathbf{C} \\ 1 \end{pmatrix}$$

The group of matrices **L** , the Lorentz group, axiomatically defined by (100) has four related components.

- There are the matrices $\{ L_n \}$ which do not invert either space or time. As it contains the neutral element, this component is called the "neutral component".

- There are the matrices $\{ L_s \}$ that reverse the space, but not the time.

We can then form:

- The orthochronic subgroup $\{ L_o \} = \{ L_n \} \cup \{ L_s \}$ or restricted Lorentz group

There are two more components:

- The matrices $\{ L_t \}$ that reverse time, but not spac.
- The matrices $\{ L_{st} \}$ which reverse both time and space.

The union of the two forms the antichronic subset $\{ L_a \} = \{ L_t \} \cup \{ L_{st} \}$

The complete Lorentz group corresponds to $\{ L \} = \{ L_o \} \cup \{ L_a \}$

Using the orthochronous subgroup we form the restricted Poincaré group:

(102)
$$\begin{pmatrix} \mathbf{L}_o & \mathbf{C} \\ 0 & 1 \end{pmatrix}$$

Insofar as the Poincaré group allows us to decline the different possible motions, physics seems to have to banish antichronic motions, taking place backwards in time.

If we start from the data of an orthochronous motion, suitable for physics, and if we make an element of the restricted Poincaré group act on its points, we will obtain another orthochronous motion.

This is the reason why theoretical physicists considered that only the orthochronous components of the Poincaré group could have a physical meaning.

In 1970 the French mathematician Jean-Marie Souriau associated to the action of a matrix group a second action on the dual of its Lie algebra, or space of moments [10]. This is a space of the same dimension as the group: ten. The quantities which constitute this moment space are the parameters which characterize the motions.

Among these, four constitute the energy-impulse quadrivector:

(103)
$$P = \begin{pmatrix} E \\ p_x \\ p_y \\ p_z \end{pmatrix}$$

Among the six other quantities, only three, constituting the spin vector:

(104)
$$\mathbf{s} = \begin{pmatrix} s_x \\ s_y \\ s_z \end{pmatrix}$$

which completes the attributes characterizing a particle. The three remaining components:

(105)
$$\mathbf{f} = \begin{pmatrix} f_x \\ f_y \\ f_z \end{pmatrix}$$

which constitute the "passage" vector can be cancelled by choosing a system of axes accompanying the particle in its motion.

The restricted Poincaré group handles only positive energy states.

15 - **Geometric translation of the matter-antimatter symmetry** [10]..

It is sufficient to add a fifth dimension to the space, noted ζ. The points of the space are then marked by the pentavector :

(106)
$$\begin{pmatrix} \zeta \\ t \\ x \\ y \\ z \end{pmatrix} = \begin{pmatrix} \zeta \\ \xi \end{pmatrix}$$

The group associated with this space is then represented by the matrices:

(107)
$$\begin{pmatrix} \mu & \mathbf{0} & \phi \\ \mathbf{0} & \mathbf{L}_o & \mathbf{C} \\ 0 & \mathbf{0} & 1 \end{pmatrix} \qquad \text{with} \quad \mu = \pm 1$$

It is a group with 10 + 1 = 11 dimensions. We have a subgroup of translations along the fifth dimension, of the quantity ϕ. Noether's theorem indicates that a scalar must be conserved. The corresponding group action is :

(108)
$$q' = \mu q$$

q is the electric charge. The elements corresponding to invert both the fifth dimension and the electric charge. This translates the geometrical representation of the C-symmetry, of the matter-antimatter symmetry

16 – **Dynamic group of positive and negative mass movements**

It is sufficient to implement the complete Poincaré group, noting that it is reconstituted by integrating the complete Lorentz group:

(109) $$\{\, L \,\} = \{\, \lambda L_o \,\} \text{ with } \lambda = \pm 1$$

in the matrix:

(110) $$\begin{pmatrix} \lambda \mathbf{L}_o & \mathbf{C} \\ \mathbf{0} & 1 \end{pmatrix} \text{ with } \lambda = \pm 1$$

We have then two types of movements:

- Orthochronic, those of matter with positive mass and energy
- Antichronic, those of matter with negative mass and energy.

17 – **Integration of the matter-antimatter symmetry. Janus Group.**

The group is :

(111) $$\begin{pmatrix} \lambda\mu & \mathbf{0} & \phi \\ \mathbf{0} & \lambda \mathbf{L}_o & \mathbf{C} \\ 0 & \mathbf{0} & 1 \end{pmatrix} \quad \text{with} \quad \begin{matrix} \lambda = \pm 1 \\ \mu = \pm 1 \end{matrix}$$

The action of the group on its space of moments is enriched by an additional action:

(112) $$q' = \lambda \mu q$$

Let's start from the motion of a particle of matter, of positive mass.

- The terms ($\lambda = +1 ; \mu = +1$) allow to decline all the range of movements of positive masses, electrically charged or not charged.

- The terms ($\lambda = +1 ; \mu = -1$) operate a C-symmetry, invert the charge, change this particle into antimatter of positive mass. Let us call it "antimatter in the Dirac sense".

- The terms ($\lambda = -1 ; \mu = +1$) operate a PT-symmetry. The presence of T-symmetry results in an inversion of the charge, of the fifth dimension, of the energy E and of the mass m of this matter. It is antimatter, enantiomorphic (P-symmetry) and of negative mass (T-symmetry). As the fifth dimension is inverted it is therefore antimatter. These movements will be those of what we will call "antimatter in the sense of Feynman".

- The terms ($\lambda = -1 ; \mu = -1$) operate a CPT-symmetry. The fifth dimension is not reversed. These movements are thus those of matter, enantiomorphic (P-symmetry) and negative mass (T-symmetry).

The universe described by this dynamical group has therefore two types of matter, positive mass and negative mass, and two types of antimatter, positive mass and negative mass.

Antimatter in the sense of Dirac is the one we know how to produce in laboratory. Its mass is positive.

We predict that this matter will behave like ordinary matter in the Earth's gravitational field, in experiments conducted at CERN.

18 – **Geometric framework of the Janus model.**

If the didactic image of the Andréi Sakharov universe model corresponds to figure 23, the geometry that goes with this dynamic group is that of the two-sheet covering of a projective. This idea had been sketched in 1994 in the publication that we had made in the journal Nuovo Cimento [12].

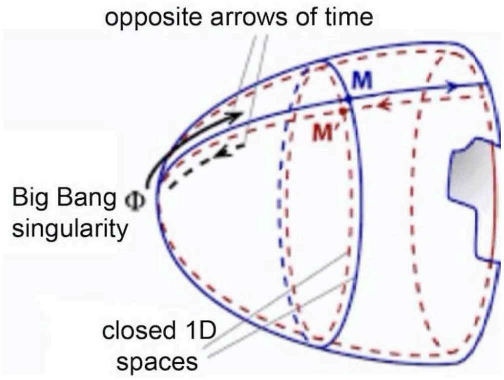

Fig.25 : 2D didactic image of the Janus universe

The two sides of the universe are in a CPT-symmetry relationship.

In this model, if in the world of positive masses and energies remained :

- Photons of positive energy
- Matter of positive mass
- Antiquarks of positive energy

The world of negative masses and energies will be constituted by :

- Photons of negative energy
- Antimatter of negative mass
- Quarks of negative energy

The Janus cosmological model gives a precise identity to the invisible components of the universe. It is a copy of our own antimatter, of negative mass.

19 – **Nature of the objects of the negative universe.**

We can consider that this world of negative energies and masses has also known a radiative phase, followed by a situation where fusion would have formed light elements, such as anti-hydrogen and anti-helium of negative mass. But the synthesis of heavy elements could not occur. Indeed the spheroidal clusters of this negative mass world can be compared to huge protostars, with a cooling time exceeding the age of the universe. These giant protostars will never become stars, seats of fusion.

Consequently, in this world of negative masses, there are neither galaxies, nor stars, nor planets. Life is absent. An observer constituted of negative mass would observe these objects under the aspect of blurred masses emitting in the red and the infra-red.

20 – **The problem of origin.**

If we replace the BiG Bang by a space bridge, the model provides an original answer, of topological nature, to the question of the origin:

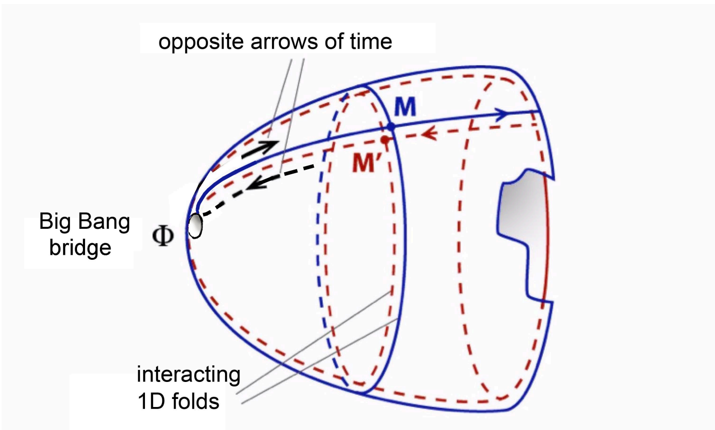

Fig.26 : A universe where the Big Bang is replaced by a space bridge

Thus, "at the time of the Big Bang" there would be a triple inversion:

- Of the arrow of time
- Of space (enantiomorphy)
- Of quantum charges.

21 – **The problem of CMB inhomogeneity.**

In 1988 the first images of the cosmological background radiation, transmitted by the COBE satellite, created a surprise by revealing an extraordinary homogeneity and isotropy. This immediately raised the problem of the cosmological horizon, supposed to grow proportionally to the speed of light c.

Currently, the explanation is based on the hypothesis of a fantastic expansion of the universe at a distant moment of its history. This expansion must then be due to a new field, itself associated with a hypothetical particle, the inflaton.

However, for more than thirty years, no credible model of inflation has been available. The only virtue of such a model is that there is no alternative model.

In 1988, even before the results of the COBE satellite were known, we published in Modern Physics Letters A an article [13] presenting the first variable speed of light model where the cosmological horizon grows at the same rate as the universe itself and which therefore justifies the homogeneity of the universe at all times. Let us add that this work went completely unnoticed and remains totally ignored by specialists.

This attempt to account for the extreme homogeneity of the universe by invoking a variation of the speed of light was then taken up by several authors ([14], [15]). As they conceive it, this approach suffers from defects. The main one is geometrical. If we vary c, Lorentz invariance is no longer guaranteed. Moreover, this quantity c intervenes in many characteristic quantities of physics, such as the Bohr radius, or even through numbers like the fine structure constant. Such variations are then hardly compatible with the observations.

The originality of our approach has been to consider corner variations of all the equations of physics, leaving all the equations of physics invariant. If this was sketched in the 1988 paper, the approach was specified in the 1995 paper, published in Astrophysics and Space Science [5]. The details of the establishment of these generalized gauge laws are given in Appendix C of [16].

Physicists and engineers practically use what is called dimensional analysis. For example, the Navier-Stockes equations involve different coefficients, such as the viscosity of the fluid, its thermal conductivity, etc. Theoreticians then render these equations as a generalized gauge law. Theorists then make these equations dimensionless so as to show the relative importance of different terms, which are then weighted by numbers: the Reynolds number, the Prandtl number, the Knudsen number.

The treatment to which we subjected all equations: Field equation, Maxwell equations, quantum equations consisted in a generalized adimensional form, by introducing large characteristics for:

- The constant of gravitation: $G = G^* \Gamma$
- The mass: $m = m^* \vartheta$
- The pseed of light: $c = c^* \gamma$
- The Planck' constant : $h = h^* \theta$
- The elementary electric charge: $e = e^* \varepsilon$
- The magnetic permeability of vacuum: $\mu_o = \mu_o{}^* \sigma$

To this we added:

- A space scale factor : $x = a\,\xi^1$, $y = a\,\xi^2$, $z = a\,\xi^3$
- A time scale factor : $t = t^*\xi^o$

All the basic equations of our physics, depending on the eight quantities:

$$\left\{ G^*, m^*, c^*, h^*, e^*, \mu_o^*, a, t^* \right\}$$

It appears then that their invariance can be ensured if all these quantities are linked together by what we have called:

A generalized gauge relationship.

Different properties then appear.

- All forms of energy are conserved. For example $m^*c^{*2} = \text{Cst}$, etc

- All characteristic lengths vary as a. For example the Schwarzschild length:

$$\frac{2G^*m^*}{c^{*2}} = \text{Cst}$$

The same is true for the Compton length, the Planck length, the Bohr radius, etc.

- All characteristic times vary as t*. Example: the mean free path time, the Planck time, the Jeans time, etc.

We can then, by choosing one of the eight quantities as the directing parameter, express the variations of the seven others as a function of it. If we take the space factor a we get:

(113) $$G^* \propto \frac{1}{a} \;;\; m^* \propto a \;;\; h^* \propto a^{3/2} \;;\; c^* \propto \frac{1}{\sqrt{a}} \;;\; e^* \propto a \;;\; \mu_o^* \propto a \;;\; t^* \propto a^{3/2}$$

We can see that the Lorentz invariance is assured, because:

(114) $$ds^2 = c^2dt^2 - dx^2 - dy^2 - dy^2 = c^{*2}\,t^{*2}\,d\xi^{O2} - a^2\left[(d\xi^1)^2 + d(d\xi^1)^2 + d(d\xi^1)^2\right] \propto a^2$$

Kepler's laws are also preserved. For example :

(115) $$(\text{ orbit period })^2 \propto (\text{ orbit radius })^3$$

The fine structure constant α behaves as an absolute constant. The vacuum dielectric constant is not another constant because it is related to the speed of light and the magnetic permeability of vacuum. It is then found that it is not affected by this gauge process either.

Insofar as all the laws of physics remain invariant in this generalized gauge process, it is not possible to conceive of an instrument that would make it possible to show the variation of one of these "constants" of physics over time.

If nothing is observable, what would be the interest of such a vision of things?

At any moment a photon in this universe, travels in a time dt the distance dl according to :

(116) $$dl = c\,dt$$

By integrating, we will find the evolution of the cosmological horizon. But then:

(117) $$\text{cosmological horizon } = \int c\,dt \propto \int \frac{1}{\sqrt{a}} d(a^{3/2}) \propto a$$

The cosmological horizon expands at the same rate as the universe itself. This is the only property that emerges from this mode of evolution with variable constants. But its observational confirmation is ... the remarkable homogeneity of the early universe, revealed by the image of its CMB:

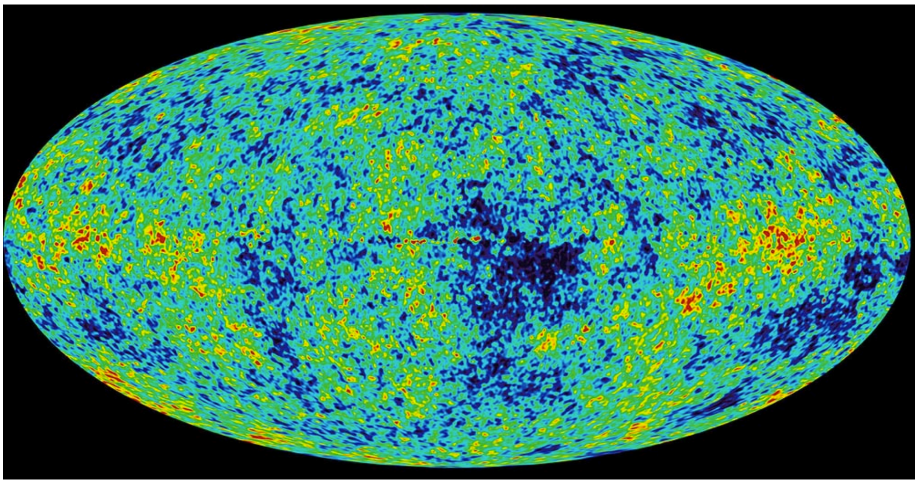

Fig.27 : Cosmic Background.

The following images represent a 2D didactic image of the two evolutionary modes.

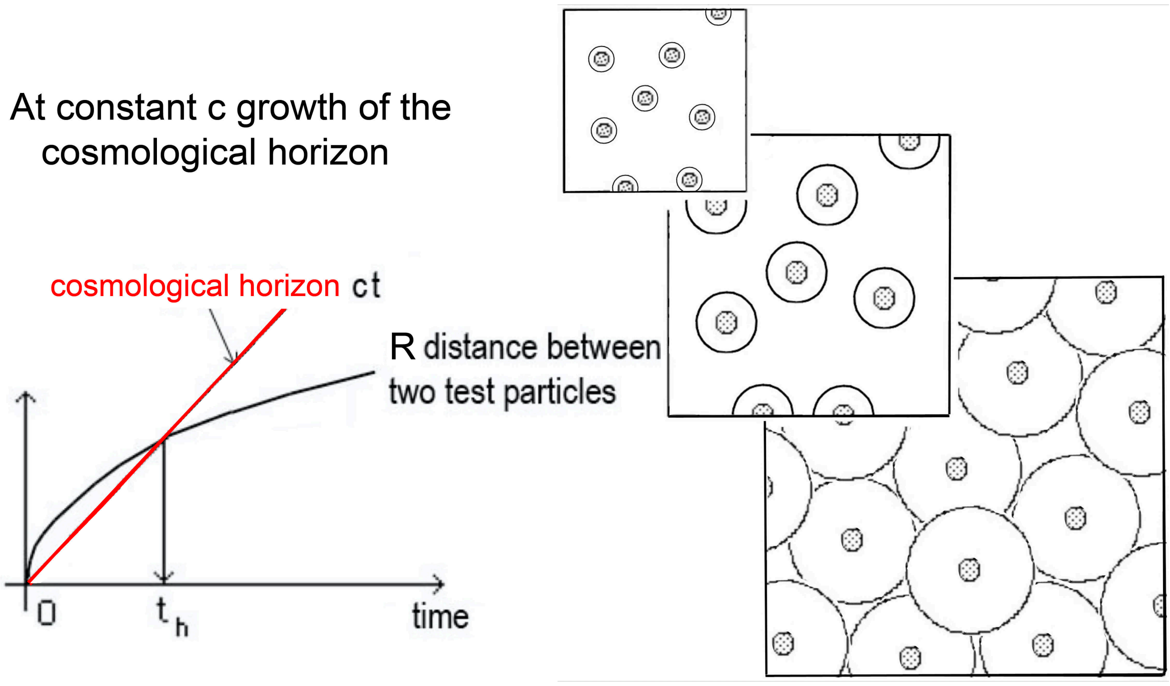

Fig.29 : Horizon growth at c constant

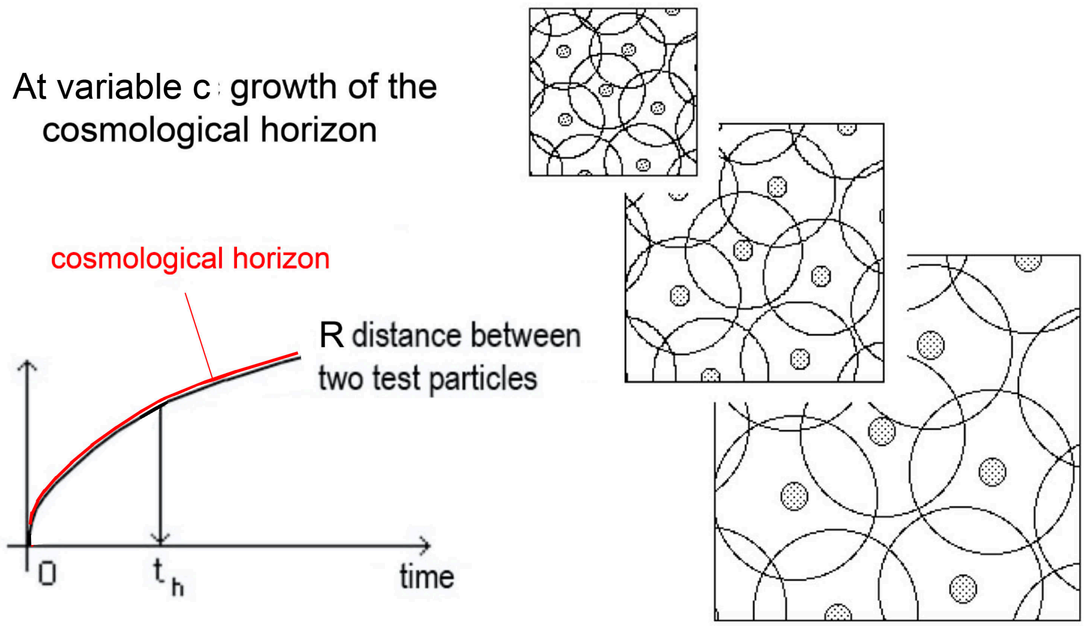

Fig.30 : Horizon growth at variable c

Such a theory may seem very heavy on speculation. But it is neither more nor less speculative than the theory of inflation.

Note : A redshift measurement is above all an energy measurement. However, in this "variable constant" scheme, where the energies are conserved, there is no more redshift. We must therefore conclude that if this regime with variable constants has its place in the cosmic scenario, it can only occur before the decoupling, during the radiative era, precisely at a time when we cannot measure such a phenomenon.

When would this regime with variable constants manifest itself? This remains an open question. We can only make a suggestion;

- When the Compton distance of the elements in the cosmic soup becomes of the order of the distance between them.

But this remains a speculation.

The figure below shows the variations of the different "constants", according to this scheme.

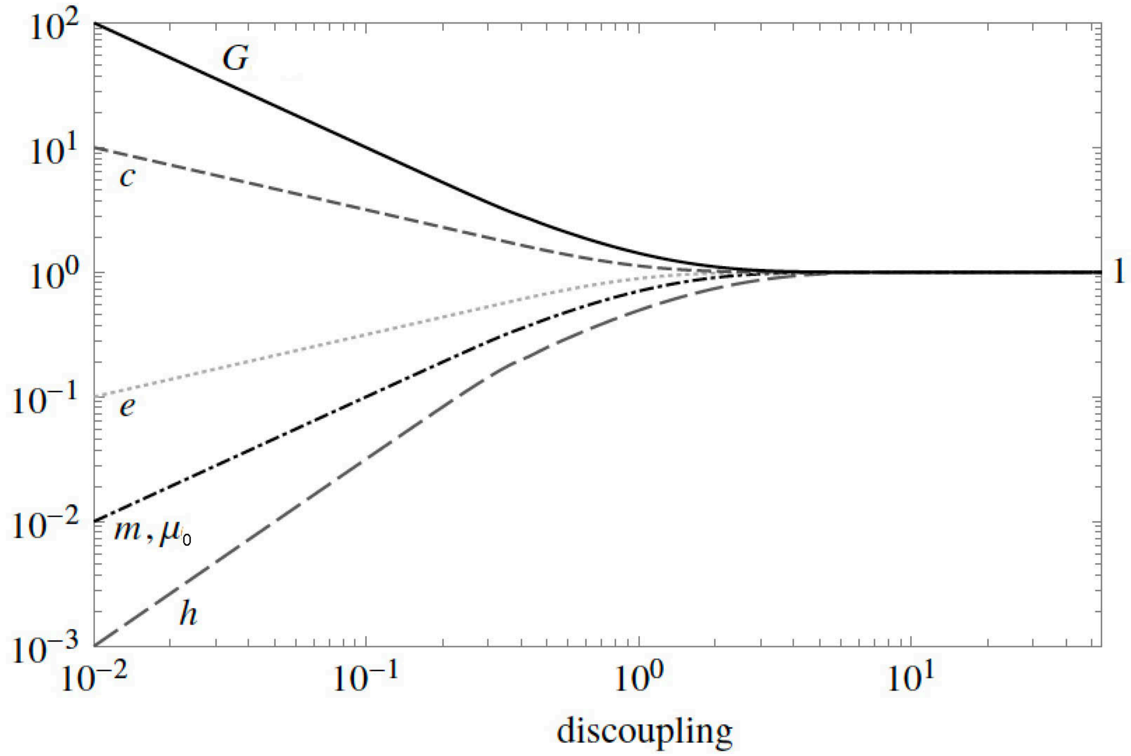

Fig.31 : Schematic evolution of the « constants »

This mode of evolution of the early universe raises many questions about time.

22 – **A redefinition of cosmic time, far in the past.**

In fact, how to envisage a time at a time when its measurement becomes problematic. How to consider a time when it is difficult to build a clock? Indeed, when we go back in the past of the universe, the temperature increases, and with it the speed of thermal agitation of the components endowed with a mass. Before the first hundredth of second the universe is only composed of photons and particles of matter and antimatter animated by relativistic speeds. How then to measure time.

One system consists in considering two masses m orbiting around their common center of gravity. One can imagine that such an object could cross time without interacting with its neighbors, which remains purely conceptual, of course.

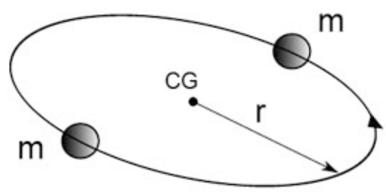

Fig.32 : Basic conceptual clock.

It is easy to link a measure of time to an angular measure. It is the rotation of the hands of our wristwatch, that of the Earth around its axis, or around the sun. In a scheme with absolute constants the rotation period of this conceptual elementary clock is invariable. If we decide to identify cosmic time with the number of revolutions made by this elementary clock, then we can attribute a page to the universe, from a hypothetical "instant zero". Between this instant and today our clock will have made a finite number of turns.

It is quite different in a regime "with variable constants" because, the more we go back in the past and the more this period decreases, according to:

(118) $$\text{period} \propto a^{3/2} \propto t^*$$

Thus the number of revolutions made by our elementary clock when we make a tend to zero becomes infinity.

(119) $$N \propto \int \frac{dt}{t} \propto L_n\, t \propto L_n\, a \quad \rightarrow \quad \infty$$

We find in passing this "conformal time" of cosmology. The relation (114) also corresponds to a "conformal metric".

All this is an interesting way to get rid of the problem of the origin of the universe. See figure 26.

23 – **How to develop this model**?

At this stage the guideline has always been to report observational data. There remain those corresponding to CMB fluctuations, of which we will give another interpretation as a reaction of positive masses to fluctuations occurring in the underlying world of negative masses. To do this we will make different assumptions. First, we will assume that the negative mass and energy content had a similar history in its radiative phase, in the sense that it also took place in a regime of variable constants:

(120) $$\left\{ G^{(-)}*, m^{(-)}*, c^{(-)}*, h^{(-)}*, e^{(-)}*, \mu_o{}^{(-)}*, b, t^{(-)}* \right\}$$

I retain the letter b to denote the space scale factor of the negative slope.

The use of dynamical group theory has suggested that the negative species correspond to anti-hydrogen and possibly anti-helium and anti-lithium of negative mass. It is assumed that these species are governed by the same equations of physics, but with a different set of constants. In these conditions the evolution of the negative world, in its radiative phase, would correspond to:

(121)

$$G^{(-)}* \propto \frac{1}{b} \;;\; m^{(-)}* \propto b \;;\; h^{(-)}* \propto b^{3/2} \;;\; c^{(-)}* \propto \frac{1}{\sqrt{b}} \;;\; e^{(-)}* \propto b \;;\; \mu_o{}^{(-)}* \propto b \;;\; t^{(-)}* \propto b^{3/2}$$

We can see that in this model, not only do we give a very precise identity to the objects that the negative sector contains, but we also establish the physical laws that animate these objects, which we suppose are similar to ours. It is obvious that we hope that other phenomena and other observations will make it possible to confirm (or to refute) this hypothesis.

We conjecture that the strong dissymmetry present in the model could have emerged from a situation that is, on the contrary, totally symmetrical due to the fundamental instability of the system. We conjecture that this "symmetry breaking" could have developed in the early universe, in its regime with its two sets of variable constants. All this will have to emerge from a system of two coupled field equations.

But there is a regime change at stake which is not yet mastered. The description of this primitive state remains a conjecture.

Here is what we assume:

Until we pass into a regime where the constants of physics behave as absolute constants, after the decoupling, in the "matter phase", which is in line with the observations, these previously behave as "variable constants". Each set of constants is indexed on the value of the space scale factor, according to:

(122)

$$G^{(+)}* \propto \frac{1}{a} \;;\; m^{(+)}* \propto a \;;\; h^{(+)}* \propto a^{3/2} \;;\; c^{(+)}* \propto \frac{1}{\sqrt{a}} \;;\; e^{(+)}* \propto a \;;\; \mu_o{}^{(+)}* \propto a \;;\; t^{(+)}* \propto a^{3/2}$$

$$G^{(-)}* \propto \frac{1}{b} \; ; \; m^{(-)}* \propto b \; ; \; h^{(-)}* \propto b^{3/2} \; ; \; c^{(-)}* \propto \frac{1}{\sqrt{b}} \; ; \; e^{(-)}* \propto b \; ; \; \mu_o^{(-)}* \propto b \; ; \; t^{(-)}* \propto b^{3/2}$$

It is assumed that this asymmetric state arises from an initially symmetric state where all these constants were equal, as well as the space and time factors.

(123)
$$G^{(+)}* = G^{(-)}* \; ; \; m^{(+)}* = m^{(-)}* \; ; \; h^{(+)}* = h^{(-)}* \; ; \; c^{(+)}* = c^{(-)}*$$
$$e^{(+)}* = e^{(-)}* \; ; \; \mu_o^{(+)}* = \mu_o^{(-)} \; ; \; t^{(+)}* = t^{(-)}* \; ; \; a = b$$

It is also conjectured that in this primitive phase an exchange of energy can occur. This implies that, in the system of field equations adapted to this phase, the first members are:

(124)
$$R^{(+)}{}_{\mu\nu} = \ldots$$
$$R^{(-)}{}_{\mu\nu} = \ldots$$

These joint developments go hand in hand with the relationships:

(135) $$G^{(+)}* a = G^{(-)}* b$$

(136) $$\frac{m^{(+)}*}{a} = \frac{m^{(-)}*}{b}$$

(137) $$\frac{h^{(+)}*}{a^{3/2}} = \frac{h^{(-)}*}{b^{3/2}}$$

(138) $$c^{(+)}*\sqrt{a} = c^{(-)}*\sqrt{b}$$

(139) $$\frac{\sqrt{e^{(+)}*}}{\sqrt{a}} = \frac{\sqrt{e^{(-)}*}}{\sqrt{b}}$$

(140) $$\frac{\mu_o^{(+)}*}{a} = \frac{\mu_o^{(+)}*}{b}$$

(141) $$\frac{t^{(+)}*}{a^{3/2}} = \frac{t^{(-)}*}{b^{3/2}}$$

24 – **Between two points: two very different distances.**

The taking into account of multiple observational aspects led us to consider that these are the result of a strong dissymmetry between the two entities:

(142) $$\rho^{(-)} >> \rho^{(+)}$$

ch a situation arises from the symmetry breaking, to be constructed, giving the values (122). From these laws of variation comes:

(143) $$\rho^{(+)}a^{(+)2} = \rho^{(-)}a^{(-)2}$$

From this it follows that (142) leads to :

(144) $$a^{(-)} << a^{(+)} \qquad c^{(-)} >> c^{(+)}$$

Consider two points A and B of the manifold, with spatial coordinates:

(145) $$(\xi_A^1, \xi_A^2, \xi_A^3) \qquad (\xi_B^1, \xi_B^2, \xi_B^3)$$

Let us consider a displacement according to the coordinate ξ^1 and pose

(146) $$\xi_B^1 = \xi_A^1 + \Delta\xi \qquad \xi_B^2 = \xi_A^2 \qquad \xi_B^3 = \xi_A^3$$

Thus we will have two distances to cover, very different.

(147) $$\begin{matrix} d_1 = a\,\Delta\xi \\ d_2 = b\,\Delta\xi \end{matrix} \quad \rightarrow \quad d_2 << d_1$$

If a vehicle managed to reverse its mass, then the distance it would have to travel from point A to point B would be much shorter. Moreover its speed limitation, by using the geodesics associated to the negative masses, will be limited to:

(148) $$c^{(-)} >> c^{(+)}$$

Hence a double gain in travel time, which would make it possible to remove the impossibility of carrying out interstellar voyages because of their excessive duration.

It remains to find the way to evaluate this gain. For that we will consider:

25 – **An alternative interpretation of CMB fluctuations** [52]

It is assumed that the two evolutions are similar, i.e. that the transitions between the radiative era and the matter era occur at the same time.

At any moment the two populations are interacting. In the matter era this leads to joint gravitational instabilities which produce all observables. But what about in the radiation era.

The only thing that can produce density fluctuations is gravitational instability. When we refer to the matter era we can take James Jeans' approach by assuming that a radiation density fluctuation occurs over a distance. What produces the curvature is not only the matter, but the energy in all its forms. If in a universe of unlimited extension we had a region of diameter where the density of radiation would be higher, this phenomenon would create a gravitational field acting on the photons of the environment.

The photons are deflected by a gravitational field. This corresponds to the positive gravitational lensing effect. We can build this effect through geodesics of zero length. But one can also consider a gravitational action between dense and less dense regions, and deduce an accretion time of this radiation and a corresponding Jeans length.

This has never been taken into consideration because this value is then identified with the cosmological horizon. Therefore, if such fluctuations occur, they are automatically beyond our observational possibilities.

Thus, if a fluctuation in radiation density were to occur in the population of positive energy photons, due to the gravitational instability of the radiation field within this population, it would be unobservable by an observer with positive mass.

Similarly, if a fluctuation of radiation density occurred in the population of negative energy photons, due to the gravitational instability of the radiation field within this population, it would be unobservable by an observer with negative mass.

We have seen that in the "variable constant" evolutions the cosmological horizon is of the same order of magnitude as the scale factor of the population considered. Thus:

(149) $$\text{horizon}^{(+)} \simeq a^{(+)} \qquad\qquad \text{horizon}^{(-)} \simeq a^{(-)}$$

As a(-) << a(+) the fluctuations in the negative radiation field will be able to create their imprint in the distribution of the radiation field corresponding to photons of positive energy. This "response" will remain weak. Indeed, the "photon gas" is much less compressible than the matter gas. By reaction to this compression it is necessary to understand the way in which, locally, the value of the radiation pressure rises when one tries to "compress" this fraction of the photon gas.

Let L be the diameter of a lump of gas. When this one compresses, its pressure follows the variation

(150) $$p_m \propto \frac{1}{L^3}$$

If we consider a compression of a photon gas, its radiation pressure will follow

(151) $$p_r \propto \frac{1}{L^4}$$

This difference in behavior comes from the fact that the wavelength of photons (so the energy they carry) follows:

(152) $$\lambda_r \propto \frac{1}{L}$$

We can therefore suggest that the fluctuations observed in the gas of positive energy photons reflect the perturbation occurring in the gas of negative energy photons, underlying, whose wavelength corresponds to the value of the cosmological horizon, in this medium, thus of the scale factor b. Considering the wavelength of the fluctuations, which is of the order of the degree, we deduce the order of magnitude of the ratio of the two scale factors and the order of magnitude of the ratio of the speed of light:

(153)
$$\frac{a^{(-)}}{a^{(+)}} \simeq \frac{1}{100} \qquad \frac{c^{(-)}}{c^{(+)}} \simeq 10$$

Hence a priori a gain of a factor of a thousand on the interstellar travel times.

These become then not impossible if a vehicle can invert its mass.

26 – **In search of a mass inversion technology.**

A vehicle of mass M represents an energy Mc^2. If reversing its mass consists in providing an energy $2Mc^2$ it is hopeless.

We will consider things from a geometrical point of view. The drawing below evokes two regions with different space scale factors:

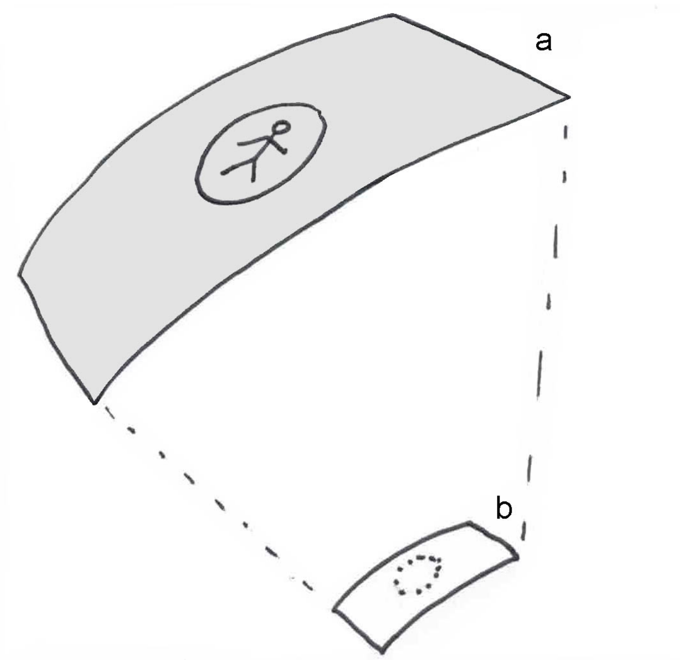

Fig.33 : A vehicle and two adjacent regions of space.

The portion of space representing the positive masses has been represented in gray, as it is non-empty. The vehicle is a simple closed curve. The adjacent portion of the universe of negative masses has been represented in white, because it is ultra-reflected, like everything in the vicinity of the Sun, these particles having been rejected far away by the repulsive action of the star. Particles which, in fact, acquire an important density only between galaxies.

Keeping in mind that these two space scale factors differ by a factor of one hundred, we will move on to the following, more readable drawing.

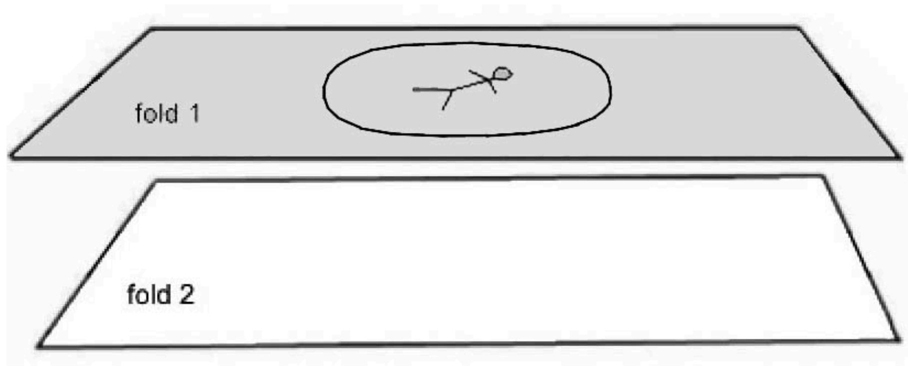

Fig.34 : Same figure, ignoring the contrast between the space scale factors.

If we concentrate energy in a region of space, we will alter the curvature in that region. We will imagine that we can concentrate energy in the vicinity of the hull of our vehicle:

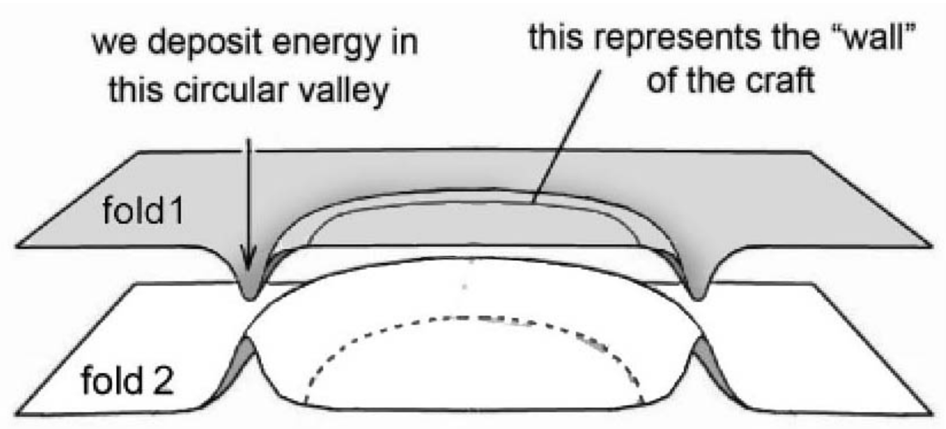

Fig.35 : On concentre de l'énergie au voisinage de la coque de la nef.

This concentration of energy, in the positive mass sector, will create an effect of induced geometry in the negative mass space, adjacent to it, according to the system of field equations:

$$R^{(+)}_{\mu\nu} - \frac{1}{2} g^{(+)}_{\mu\nu} R^{(+)} = \chi^{(+)}\, T^{(+)}_{\mu\nu}$$

(154)

$$R^{(-)}_{\mu\nu} - \frac{1}{2} g^{(-)}_{\mu\nu} R^{(-)} = -\,\chi^{(-)} \sqrt{\frac{g^{(-)}}{g^{(+)}}}\, \hat{T}^{(+)}_{\mu\nu}$$

We conjecture that beyond a certain threshold of energy concentration the two universes "communicate locally:

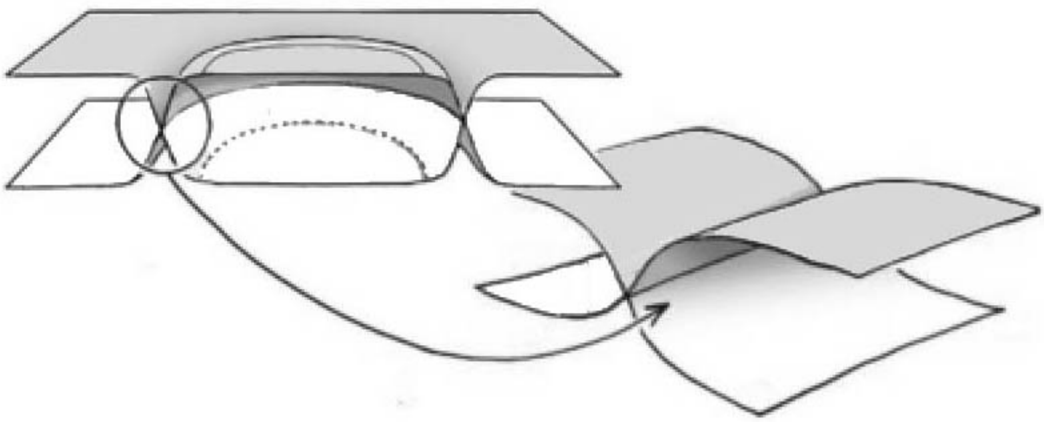

Fig.36 : A topological "surgery" takes place between the two sheets of space-time.

This involves a change in the way the surface portions connect. This will be more readable by isolating these two surface portions:

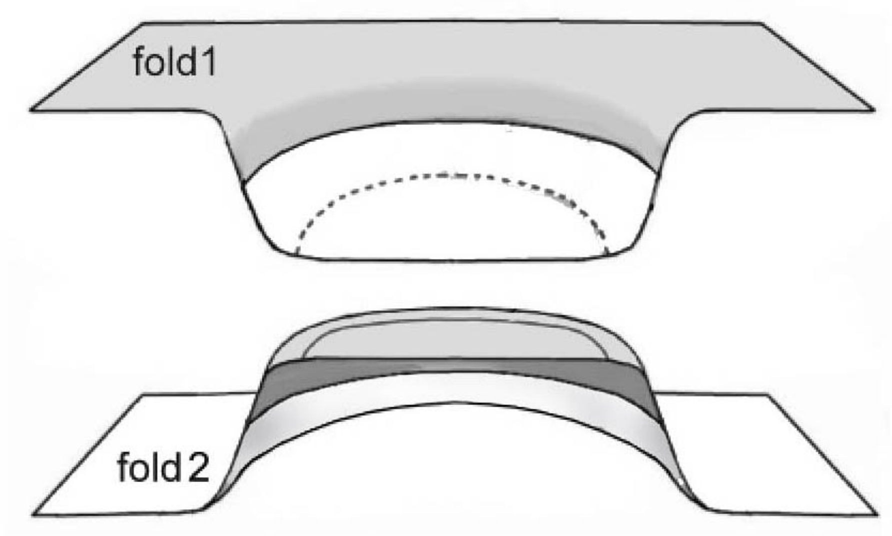

Fig.37 : The "surgery" grafts a grey part in the white space and vice versa.

The two sheets will then resume a more regular curvature. This will result in the sending of gravitational impulses that will dissipate this energy.

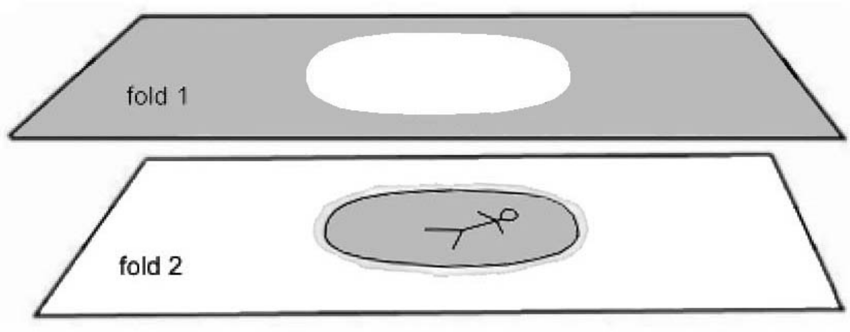

Fig.38 : After dissipation of the energ.

In this configuration the contents of the two "sides of the universe" have been exchanged. In the matter universe there is then an almost empty region, which is populated only by rare molecules of anti-hydrogen and anti-helium. By annihilating with the matter molecules of the surrounding air (gray space) this will lead to a slight production of gamma rays. Thus, if UFOs function in this way, this could represent a first signature betraying their presence. But as a general rule, we attribute the luminosity surrounding the UFOs to this mass inversion mechanism.

In any case, this empty space will fill up very quickly, which will be accompanied by an aerodynamic disturbance. By respect for the environment, and the possible witnesses, this inversion of mass, durable, will be carried out only at a certain distance from the ground and the witnesses.

This will give the impression that the object disappears in their eyes. Jacques Vallée would say "that these machines leave in another dimension". Yes and no. As described, this phenomenon loses all paranormal character. It is only an extension of our physics, not a "metaphysics".

This mention of the aerodynamic disturbance evokes the destruction of aircraft in flight, which would have come too close to a large volume nave. One can suggest that this is what led to the dislocation of Mantell's aircraft in 1948.

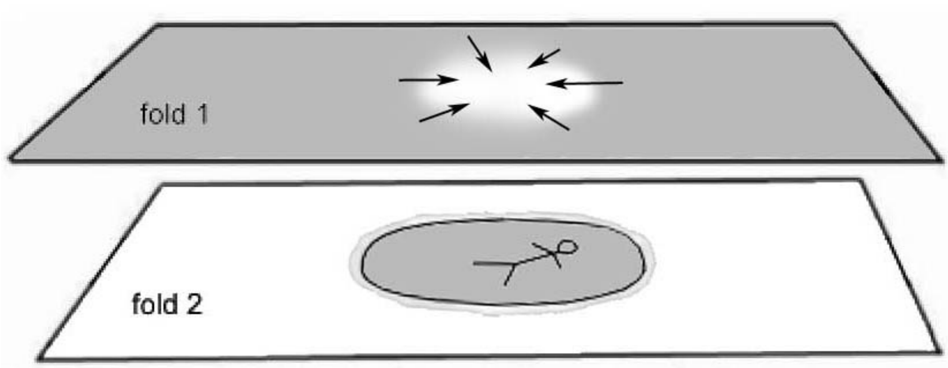

Fig.39 : Filling the void in the positive mass portion.

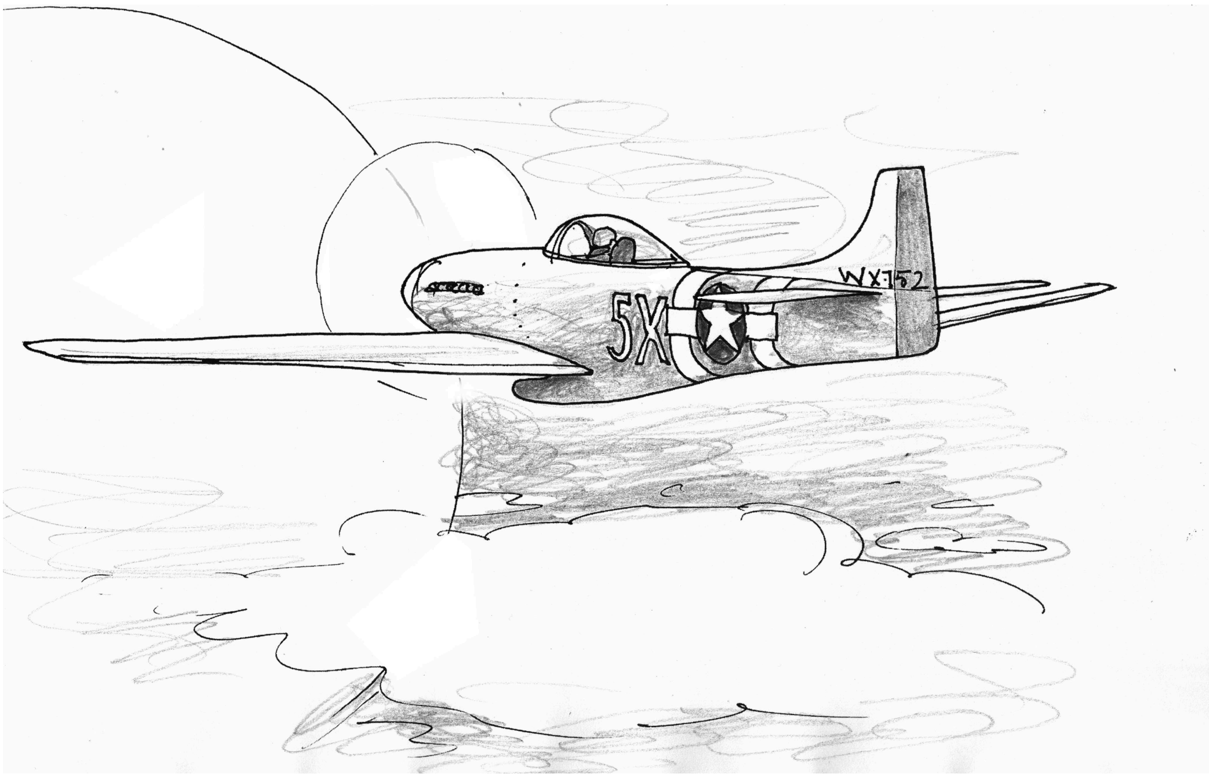

Fig.40 : Mantell approaching the alien ship.

In all that preceded we started from the observational aspects resulting from astronomical data. Here we refer to the accounts of UFO witnesses.

Returning to figure 38, when the nave has transferred to the world of negative masses it is accompanied by a thin layer made up of air molecules which dissipate rapidly in the quasi ambient vacuum. As a result:

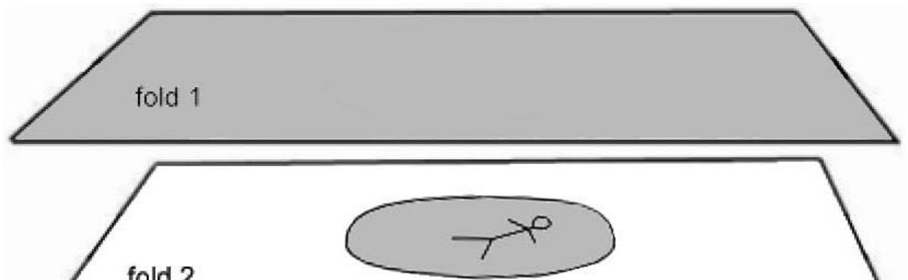

Fig.41 : After the transfer of the nave into the world of negative masses.

If a nave approaching any place, moving in the world of negative masses manifests itself in the positive world, it will seem to "emerge from nothingness".

27 – **Antigravitation.**

When the nave is in the world of negative masses, it is then pushed back by the Earth. If the nave operates a cyclic variation of presence alternatively in the world of the positive masses and that of the negative masses, by modulating carefully the brief times of presence in these two "worlds", by undergoing an alternation of attraction and repulsion it will be able to cancel the effect of the gravitation, and thus to levitate without that involves movement of the surrounding air, as it would be the case if one had recourse to the MHD. This modulation of gravity will allow to negotiate vertical movements. It is possible that the MHD is used to create a horizontal component of thrust..

28 – **Creation of gravitational waves.**

Such a manipulation of the mass generates gravitational waves. If UFOs want to bring concrete proof of their presence to a specific population, i.e. within the scientific sphere, and if their functioning is in conformity with such a model, it will suffice for them to evolve in the vicinity of installations like LIGO, which will then record their signature in the form of gravitational waves.

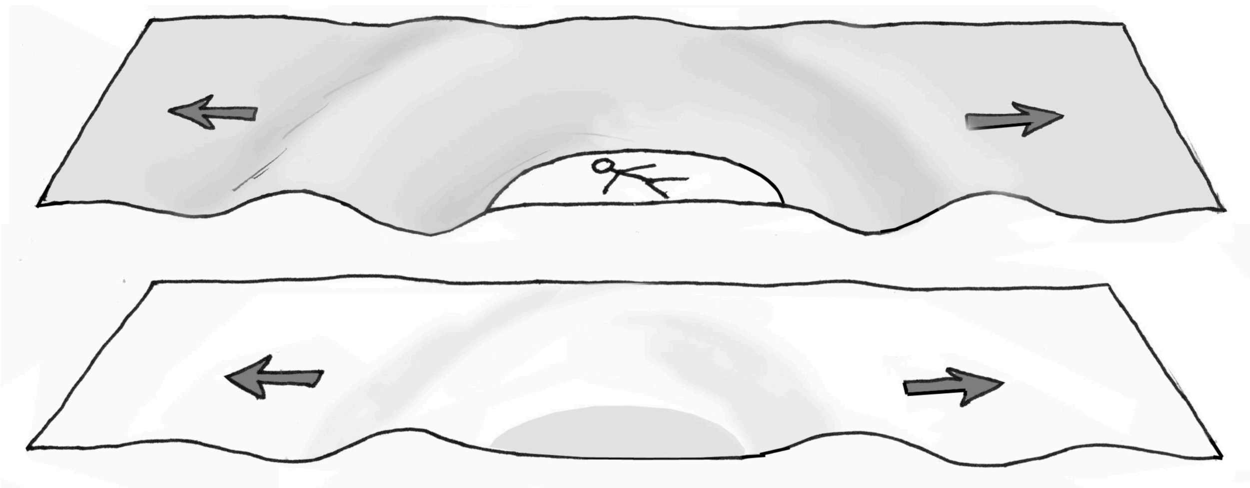

Fig. 41 bis : Emission d'ondes gravitationnelles.
Ici après un retour dans le monde positif.

It is only since a very recent date that we know how to detect gravitational waves. A system which operates a cyclic inversion of mass thus creates a generator of gravitational waves. In terms of communication, these waves know no barrier, unlike electromagnetic waves which are absorbed by matter, especially when it is in the form of plasma..

29 – **Use of MHD propulsion.**

The thrust exerted by a discoidal nave is then directed along its axis of symmetry. See the various publications we have made on MHD propulsion of discoidal MHD aerodynes.

The MHD propulsion consists in acting on the ambient air, or the sea water, by creating in the environment of the craft both a magnetic field and an electric current circulation. Hereafter the acceleration of salt water by an MHD device around a cylinder. The magnetic field, dipolar, is created by the object, in this case a simple permanent magnet of cylindrical shape. Two electrodes placed on the wall, diametrically opposed, create the electric current. The model below is placed in a fluid current going from the left to the right. The Lorentz force field sucks the fluid upstream, accelerates it at the electrodes, and then tends to press it against the wall downstream. The result is a suction effect upstream and a recollection of the fluid threads downstream which opposes the appearance of a turbulent wake, generating noise. These are experiments in hydraulics carried out in 1975 and presented in 1983 at the international conference of MHD in Moscow [17]..

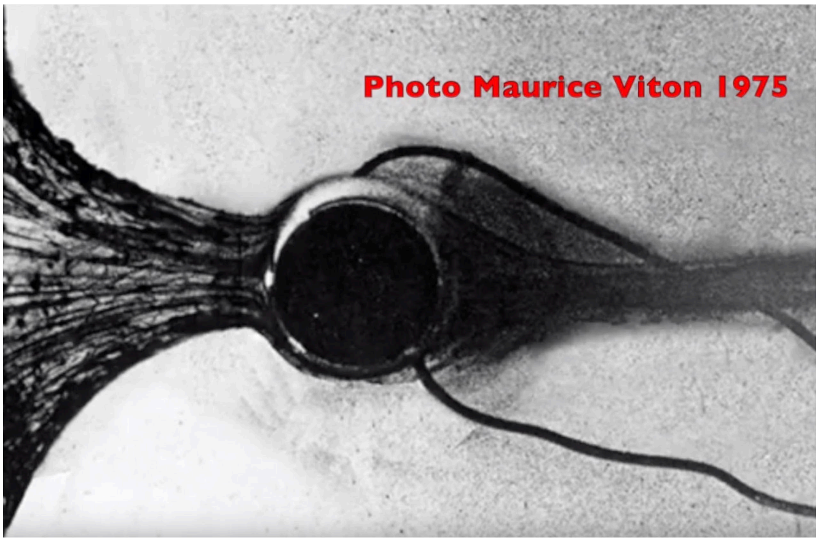

Fig.42 : MHD flow around a cylinder (1975)

The principle of MHD propulsion of discoidal aerodyne has been presented at the Académie des Sciences de Paris in 1975 [18] and 1977 [19]. The MHD induction aerodyne is the most advanced. We will find its operating principle in the article [20], dating from 2009. Let's reproduce hereafter the figures.

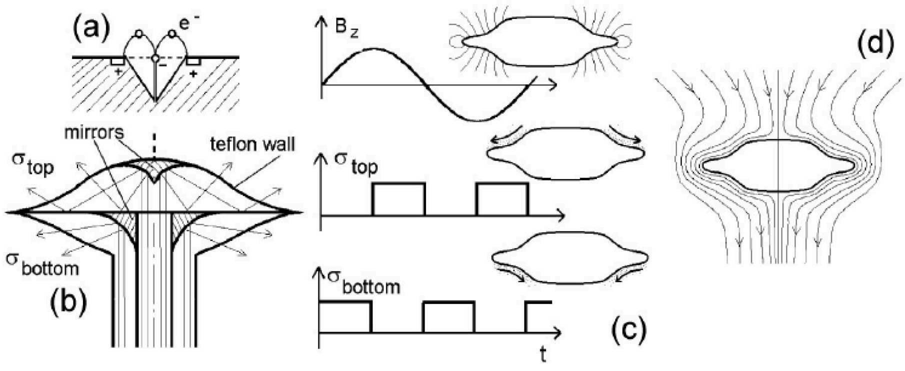

Fig. 2. Induction MHD aerodyne. (a) — wall ionizer, (b) — pulsed ionization by microwaves, (c) — varying magnetic field, ionization currents and appearing forces. (d) — induced airflow.

Fig.43 : Indution aerodyne, operating diagram

A system of coaxial coils, traversed by synchronous variable currents, creates an induced electric field directed perpendicular to the wall. This variable current generates an electric field, also variable, alternating and synchronous, whose radial component is exploited. A system of parietal ionizers creates a pulsed ionization, which is located alternately on the upper and lower part.

This pulsed ionization is synchronized in such a way that the Lorenz forces are active on the upper part when they are centrifugal and active on the lower part when they are centripetal. The obtained flow corresponds then to the figure (d). In practice, the ionization was created by two pulsed microwave beams, injected along the axis by two coaxial cylindrical waveguides and then reflected and directed towards Teflon walls. Thus the pulsed ionization was located in the immediate vicinity of the upper and lower walls.

The concave shapes of the walls correspond to the parietal confinement system of the plasma by inversion of the magnetic field gradient. See figure below:

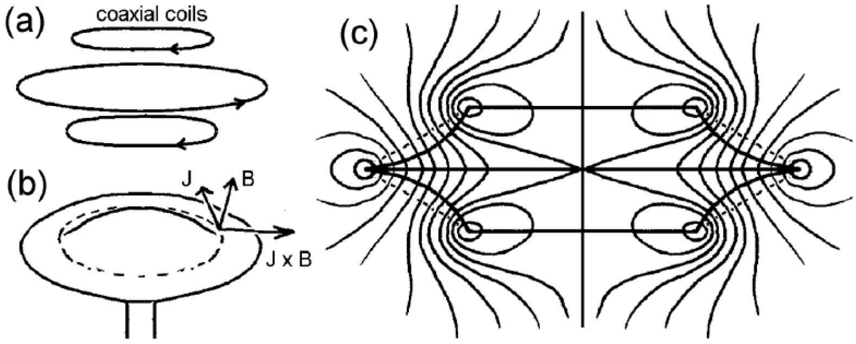

Fig. 1. (a) — coaxial coils, (b) — Lorentz force $\boldsymbol{J} \times \boldsymbol{B}$, (c) — magnetic field lines pattern.

Fig.44 : Induction aerodyne. Wall plasma confinement.

The confinement is obtained by creating the magnetic field with three coaxial solenoids. The alternating field created by the equatorial solenoid, the largest, is opposed by the counter field created by the two smaller solenoids, of confinement. The magnetic geometry then corresponds to figure (c). We have then a maximum of magnetic field intensity on two trunks of cone, whose generators are represented in dotted line. This causes a strong plating of the plasma on the wall, the generatrix of the latter being orthogonal to the field lines. The white line shows how the plasma sheet is blown away from the wall by the magnetic pressure.

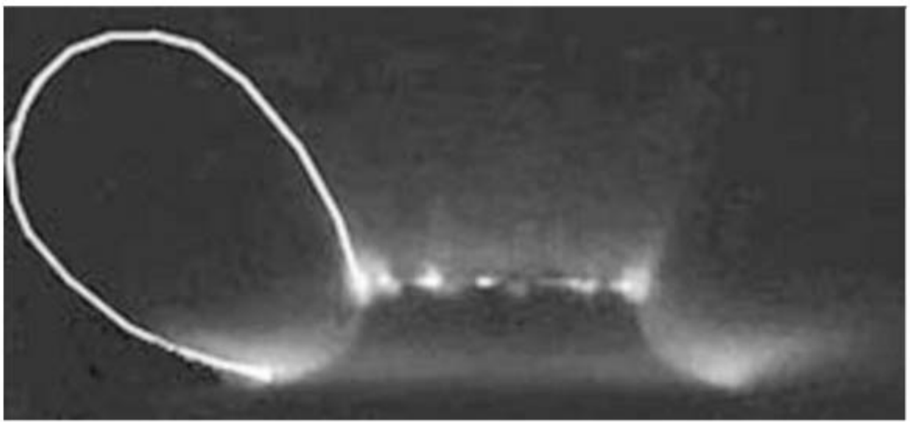

Fig.45 : Le plasma est soufflé loin de la paroi par la pression magnétique

Photographs of experiments are given in reference [21]. It is then an MHD aerodyne with spiral currents, but the parietal confinement system by magnetic field gradient is the same.

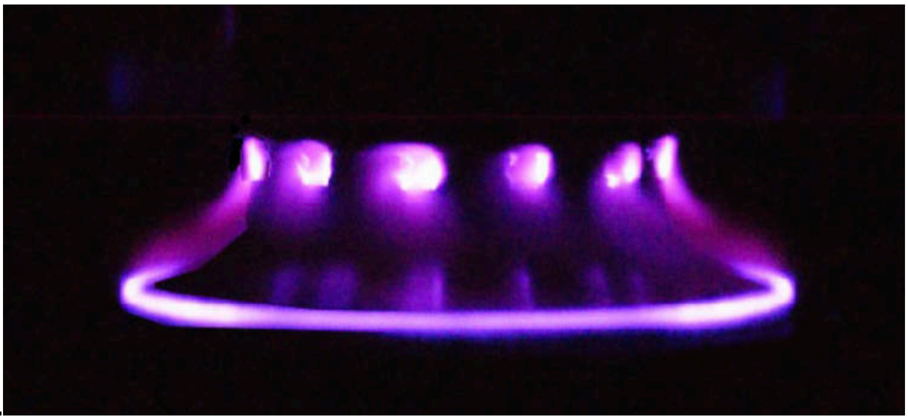

Fig.46 : Plasma confined to the wall by magnetic confinement.

Hereafter, spiral current system [22] , [24]

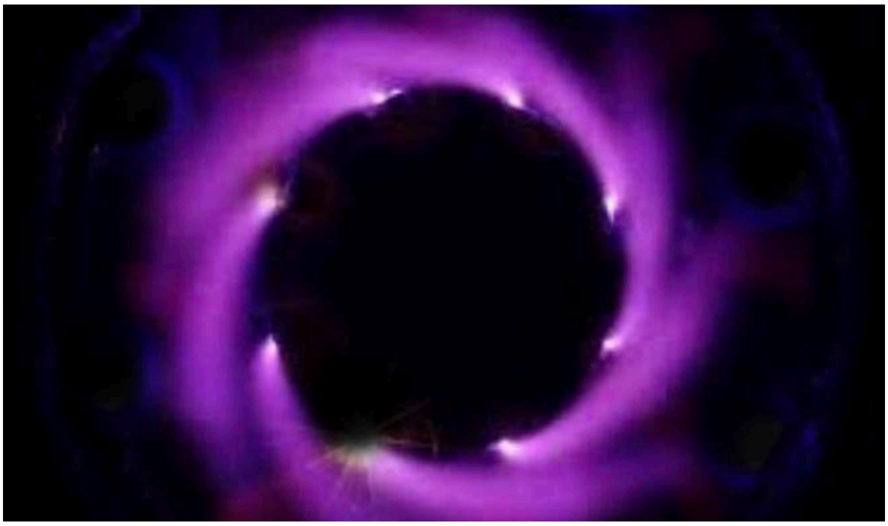

Fig. 47 : Aerodyne à courants spiraux.

MHD represents an extremely efficient way of acting on gases. To fix the ideas, let us consider a linear vein, of square section, 1m x 1m, subjected to a transverse magnetic field of only 1 tesla. We ionize the air which allows us to create in this vein an electric current density of only one ampere per square centimeter. In this cubic meter of air we will then have a current of 10,000 amperes. The Lorentz force acting on this area will therefore be I x B = 10,000 newtons, or one ton-force. By applying it to air at atmospheric pressure, the mass of this air will be of the order of a kilo. This air will therefore be subjected to an acceleration of 1000 "g". We discover through these figures, that by making electromagnetic forces act on the air, the flow of the fluid is totally constrained. The detachments and turbulences cannot occur.

If UFOs use MHD to move, then their behavior will be similar to that of a helicopter rotor. When engaging in translation there will be tilting, as shown in the following figure

.

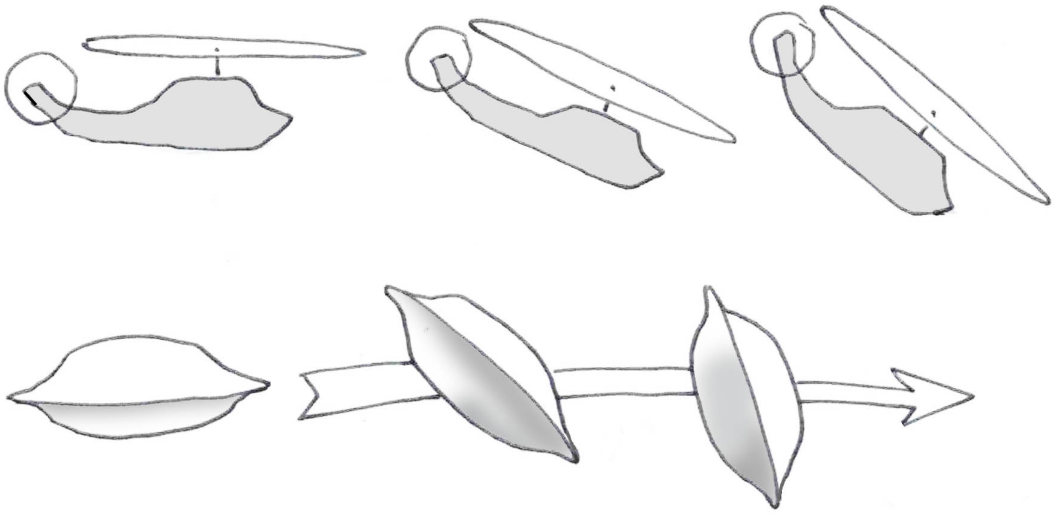

Fig.48 : Tilting of the helicopter and the MHD aerodyne
With transition to a translational motion

The lights observed by the witnesses can indeed be electrodes, corresponding to the MHD mode of operation, associated to the levitation by cyclic inversion of mass. But let us remember that these are only models, which simply militate for the non-absurdity of the scenes reported by witnesses. What has just been explained can also be extended to spheroidal machines, equipped with an equatorial crown of electrodes and a rotating magnetic field, created by a set of three solenoids at 120°, the operating diagram of which can be found in figure 14 of reference [23].

This being said, it is difficult to see how all these ideas can be applied to objects such as triangles, flying pyramids, objects made of Tic-Tac candy or any other more unusual object. But perhaps these different devices implement totally different systems.

The fact remains that the implementation of MHD technology immediately poses two problems. The first is related to the instability of these bitemperature plasmas in the presence of a high magnetic field, which creates locally important values of the Hall parameter, thus immediately causing the rapid growth of the instability discovered by the Russian Evgueni Velikhov in 1964. To implement these MHD systems it is therefore necessary to be able to control this phenomenon. For the theory, see reference [25].

The first instability control technique emerged in 1968 [26]. A second one was born in 1981 [27], much more interesting. Its principle is simple. By means of a magnetic geometry confining the current streamers, the value of the electronic temperature is locally increased, which makes the plasma pass into the coulombic regime in these streamers, and the Hall parameter falls below its critical value, which stabilizes the plasma in these streamers immediately. The experiment immediately confirmed the theoretical model. Various works related to this concept can be found in reference [28] .

The action of Lorentz forces on the air surrounding an MHD aerodyne immediately gave rise to the concept of MHD control of supersonic and hypersonic flows, by preventing shock waves from originating in the vicinity of the objects subjected to this flow. The principle is extremely simple. When a gas is flowing at supersonic speed, Mach lines can be drawn within it. Example around a biconvex wing profile:

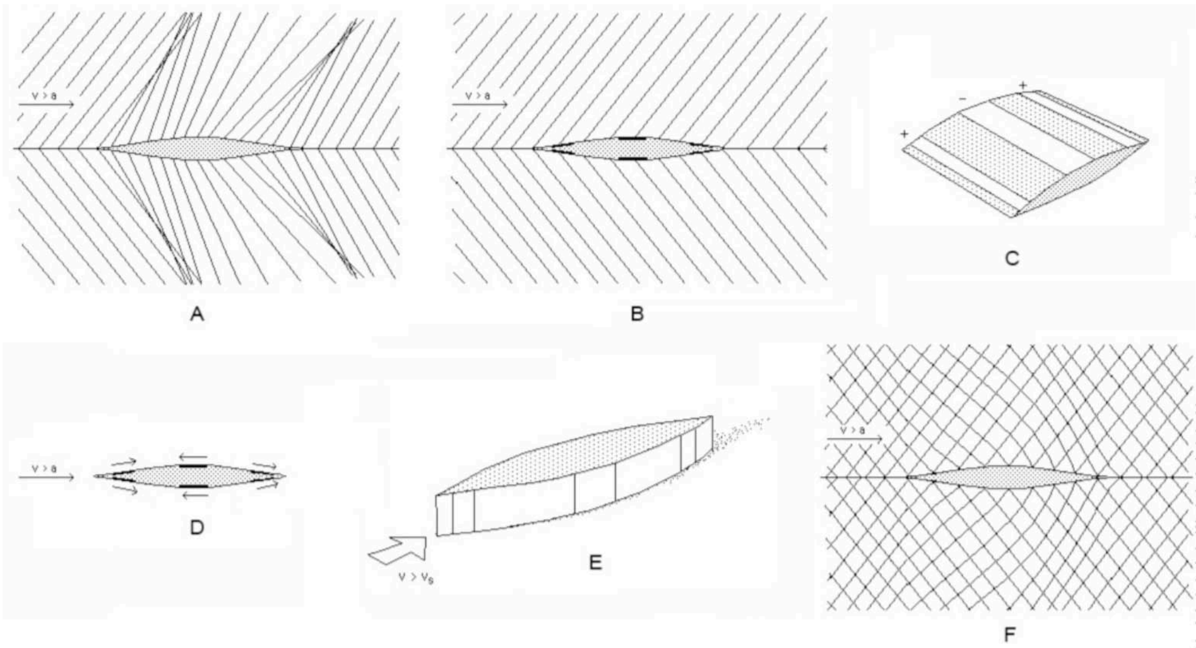

Fig.49 : Mach line network. Figure 12 of the reference [23].

In A the birthplaces of Mach lines, line of propagation of aerodynamic disturbances. Where they accumulate, shock waves are born. Here two couples of plane waves, attached to the leading edge or bottom. In B the ideal flow, regulated by the MHD where Mach waves are prevented from colliding. Hence an absence of shock waves. In C the model equipped with three pairs of parietal electrodes. In D the forces to be applied. In E a successful hydraulic simulation: absence of bow and stern waves. In F the complete system of characteristics regularized by a Laplace force field.

This idea has led to years of theoretical developments and successful experiments of hydraulic simulations, as well as to the conduct of a phd. See articles [17], [29], [30], [31], [32]

It is impossible to make machines evolve at hypersonic speed (beyond Mach 7) without having to overcome the enormous constraints linked to the establishment of shock waves. First of all, there is the development of a wave drag, which consumes most of the energy to be used, and then the thermal flux that the most advanced materials cannot endure. The Russians were the first to successfully install MHD shock wave annihilation devices on their missiles. They will undoubtedly be quickly followed by the Chinese. For these devices, the Velikhov instability is automatically present (dual-temperature plasma, high Hall parameter)

The Russians use my method of stabilization in the MHD part of their hypersonic missiles (mach 10 for the missile operating in dense air Kinjal, and Mach 30 for the hypersonic piloted glider Avangard). These configurations are covered by the thickest defense secrecy, to the point that no real photo of these devices is available.

The second technique, where the Russians are masters, is the generation of a strong electric power with the help of MHD generators using as energy source the gases produced by the combustion of a solid propellant enriched in caesium, to obtain strong ionizations with temperatures in the nozzle of 3000° (and an operation of limited duration). The Avangard spacecraft is a glider, which produces its electric power with the help of parietal generators, exploiting the strong electric conductivity of the ultra-rare air.

Finally, the Russians can use hypervelocity MHF torpedoes (2500 km/h) where the electrical production is still ensured thanks to the MHD generator coupled to the nozzle of a solid rocket. Unless, for longer range UAVs, it is produced by an onboard nuclear reactor.

We abandoned our MHD work around 1990, because we did not have the support to be able to carry out this work on an experimental level. In fact, it was mainly because I categorically refused to develop the weapons aspect in France, under the cover of defence secrecy

30- **Back to the mass inversion technique.**

How to accumulate energy in a layer surrounding a nave, to the point of causing a disruption. The conditions of this disruption will be clarified through the work that our collaborator, the Belgian mathematician Nathalie Debergh, is currently conducting. She joined us in 2018 by reacting to the remark I had written at the end of page 4 of our 2014 article [33].

A remark that anyone can make upon reading Steven Weinberg's basic work [34]. Still, it was necessary to be sensitive to the question of the inversion of time as I had been when reading the work of Jean-Marie Souriau [10].

Quantum mechanics involves three types of operators:

C: inversion of quantum charges, synonymous with matter-antimatter symmetry

P : for "parity", the space inversion operator.

T: Time inversion operator.

As Quantum Mechanics is related to the world of complexes these operators can be

- Linear and unitary

- Antilinear and antiunitary.

In all the books on Quantum Mechanics, we immediately find chapters with the title: "Reversals of space and time".

We then notice that if the operator P is antilinear and antiunitary, its action creates a state of negative energy, considered from the start as physically impossible. Quantum mechanics physicists therefore opt for a linear and unitary operator P "to avoid the emergence of negative energy states, considered as non-physical".

But this time it is the choice of a linear and unitary operator T that creates these unacceptable negative energy states. Physicists therefore opt for antiunitary and antilinear T, once again to avoid the emergence of these "non-physical" states.

What is the astronomical observation that has suddenly brought to light the existence of negative energy states?

It is this dark energy, which we have identified with the energy of negative masses.

Nathalie Debergh, who specializes in the mathematical basis of quantum mechanics, has rebounded on this remark and very quickly reconstituted in 2018 the lawfulness of negative energy states associated with the Dirac equations [34] . In 2021 she extended this result to the Schrödinger equation [35]. For more details refer to the section of the reference [16].

It is through this development of Quantum Mechanics that we will begin to have a grip on the conditions that generate a disruption.

We can envisage different ways of creating regions of very high energy density. To do this, it is sufficient to fill atomic nuclei with energy in a very long-lived metastable state. In their fundamental state the atomic nuclei acquire a spherical symmetry. When excited, they become deformed and take on the appearance of rugby balls.

The lifetimes of metastable excitation levels of nuclei are generally very short, of the order of 10-12 seconds. However, many atoms have astonishingly long nuclear excitation levels, which can be measured in milliseconds, seconds and even higher.

The phenomenon of nuclear magnetic resonance is a way to communicate energy to these nuclei. As they cannot get rid of it, it is possible to reach energy densities that could cause a disruption. To do this, it is necessary to create a very intense magnetic field

.

31- **A constraint related to the conservation of energy.**

This can be read from the compatibility relations associated with the coupled field equations.

A particle is a wave packet. The characteristic wavelength associated with a particle at rest is the Compton wavelength:

(154)
$$\lambda_c = \frac{h}{mc}$$

Let's consider all the atoms that are contained in the volume that will be transferred to the negative world. We can give ourselves an image by imagining that this volume contains all these small oscillations, all these wave packets, oriented in random directions.

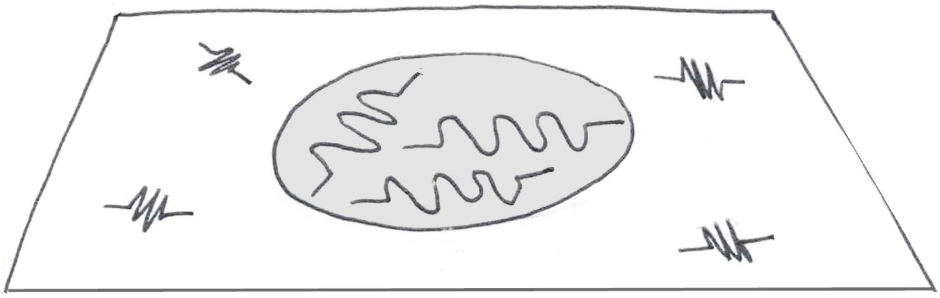

Fig. 50 : Gulliver effect.

When all these elements are transferred to a space where the scale factor is smaller, we have a kind of Gulliver effect. These particles look like giants. Their wavelengths are multiplied by 100, which means that the energy is not conserved. It makes them adapt their wavelength to those of their neighbors. They have to decrease their spatial extension. And the solution is the Lorentz contraction. It is necessary that they rematerialize in this relativistic side with a speed so close to the local value of the speed of light that the contraction which results from it corresponds to a factor 100. That means a contraction such as:

(155)
$$\sqrt{1-\frac{v^{(-)2}}{c^{(-)2}}} = \frac{1}{100}$$

Clearly, the speeds with which the particles are endowed differ by one ten thousandth of the speed of light. It is practically the speed of the negative energy photons.

. But as it is, these speeds are randomly distributed. If one does not operate a preliminary manipulation on the components of the vessel, this transfer would disperse these particles to the four winds of the cosmos, at a speed almost equal to the speed of light.

It should be noted that it would be a convenient way to get rid of radioactive waste, for example, by reversing their mass. There would then only be to make a turbine of amission of the air in the chamber produce electricity!

For the velocity vises to correspond to parallel vectors, the spins of all the particles must first be aligned by placing them all in a strong magnetic field. But this field must be in the same direction everywhere. We can not create it with solenoids because the field would be distorted in the vicinity of the spins.

The solution will be to electrically charge the hull, and to put it in fast rotation. To avoid that the passengers are centrifuged, it will be necessary to place them in a toroidal housing which can be disassociated from the hull.

32 - **How to put this hull in rotation**?

By providing at its equatorial periphery a toroidal chamber filled with a gas which, ionized, will be put in rotation. This will cause the hull to rotate in the opposite direction. We can thus see the plan of our nave taking shape:

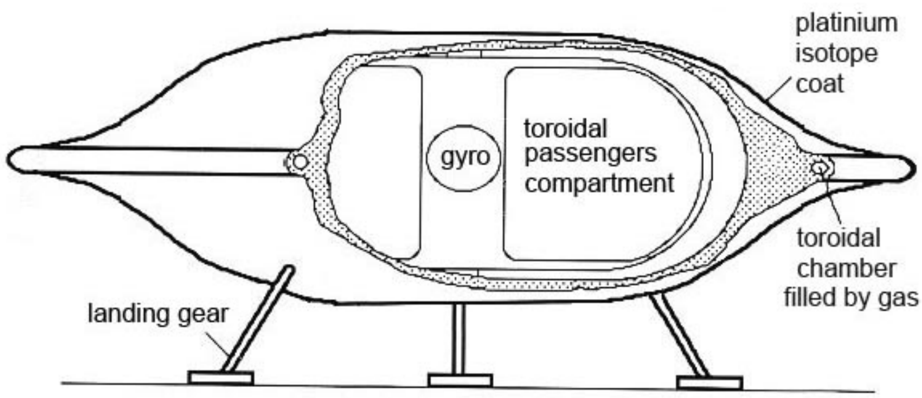

Fig.51 : Model of interstellar nave

The shape of its hull, almost uniformly electrically charged and rotated, produces a magnetic field whose lines form a parallel network inside the nave:

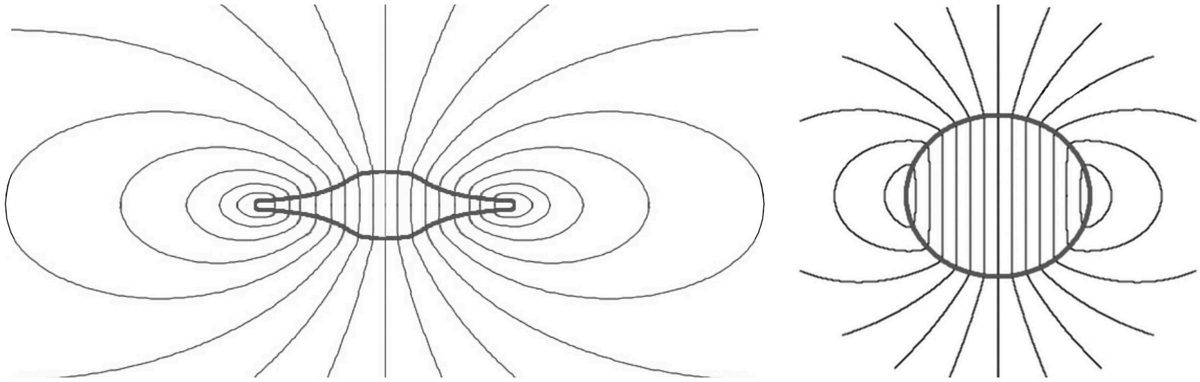

Fig.52 : Magnetic field of the charged shell during rotation.
On the left with an almost constant surface density of electric charges.

When the interstellar nave makes its journey in the negative world, it loses all visual cues from the positive world. Stars and galaxies are no longer visible. What the passengers of the ship see are the negative mass clusters, which have become visible, comparable to huge protostars. They appear as spheroidal objects with blurred contours, emitting in the red and infrared. The object with the largest apparent diameter would be the Great Repeller, the closest.

The nave has no contact with its original system: the star around which the planet from which it originated orbits. It does not receive any photons from the system towards which it is supposed to go, simply because these two objects emit positive energy photons that it is no longer able to capture.

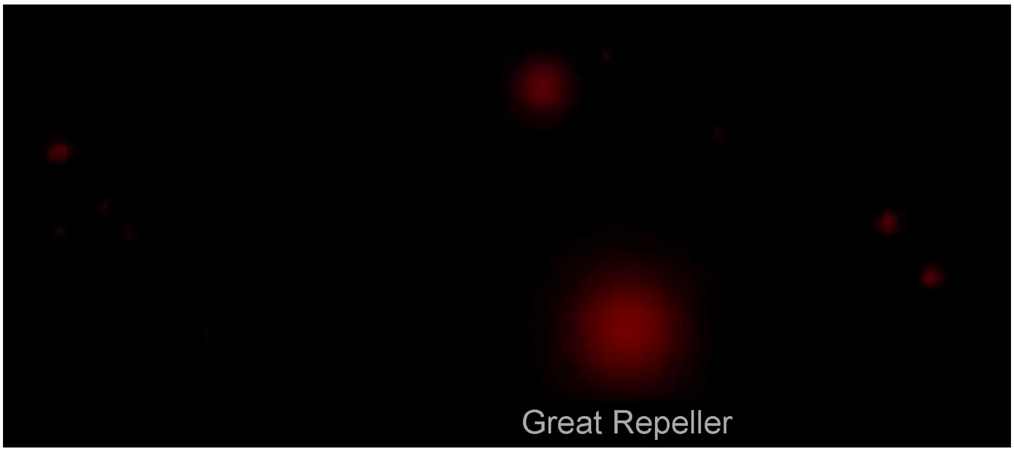

Fig.53 : What the passengers of a ship perceive
during its cruise in the negative world.

This world is indeed ultra rarefied and, in the region where this ship crosses, populated by antimatter atoms of negative mass which come to meet it at a relativistic speed. It is thus necessary to protect the nave from this bombardment, which will require to ionize the incident particles and to maintain the value of the high magnetic field produced by the rotation of the hull during all the voyage, in order to set up a magnetic shield.

When the ship reaches its destination, a new mass inversion allows it to materialize again in the world of positive masses.

There remains a risk of error of the followed direction. Readjustments of trajectory, automatic, will be operated during the journey, on the basis of an evaluation of the position of the nave, operated after determination of its position compared to sources known for their relativity fixity. At the end of the trajectory, the determination of the position will be done by locating itself compared to the targeted stellar system.

33 – **Right angle turns.**

All this remains very speculative. There are still many grey areas. They are only a few ideas, thrown on a sheet of paper. A conjecture emerges. According to this way of acquiring a speed through a hypothetical process, of quantum nature, the words acceleration and deceleration become empty of meaning. The speeding up and deceleration are simply instantaneous. Science fiction imagined interstellar ships equipped with "hyperthrusters" and here, according to this model, they would be deprived of them! Any change of direction would be made by an abrupt variation of the velocity vector, while keeping the value of its modulus.

If the direction of the velocity depends on the orientation of the magnetic dipole that constitutes the nave, one can imagine that the changes of course take place in three stages.

- The nave reverses its mass and materializes in the positive space
- A rotation is operated, with the help of a gyroscope.
- When it reverses its mass again, the nave finds its relativistic speed, but oriented in a different direction.

If the first inversion of mass was operated when the nave was immobile, each new inversion makes it find its initial state of immobility. But if the dematerialization of the nave is operated while the nave has acquired, by MHD propulsion, a certain speed, it will find its kinetic parameters during a new inversion.

If, when the nave is in the form of negative mass, it performs a rotation, when it rematerializes in the positive world it will regain the absolute value of the velocity vector (conservation of energy) but not its direction. For an observer made of positive mass, the nave will then seem to have operated at full speed a sudden change of direction, even a right-angle turn, or a reversal of its speed, whereas the centrifugal acceleration would have reached a value that should have dislocated it

.

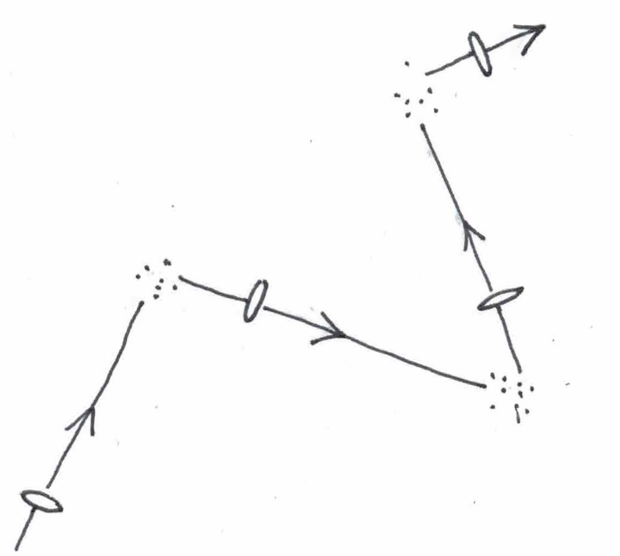

Fig.54 : Right angle turns.

34 – **How to consider highlighting a mass inversion**?

It is likely that the parameters to be implemented in this technology must reach high values. It is possible to create very high values of magnetic field in an impulsive way, using explosives, by magnetic compression effect. This was demonstrated experimentally by A.Sakharov in the sixties. It would therefore be possible to attempt to invert a small quantity of matter, a few milligrams, contained in an enclosure made of a metal whose nuclei have a long-lasting metastable nuclear excitation state. The device would be destroyed during the explosion, but if the mass inversion occurs, a gravitational wave would be emitted which could be detected thanks to the extreme sensitivity of current detectors, such as LIGO. The seismic signal from the explosion would only disturb the measuring instruments after reception of the gravitational wave, propagating at the speed of light.

34 – **Conclusion**

We are coming to the end of this long case, where different approaches have been implemented.

The argument in favor of the Janus cosmological model is the very large number of open problems it solves and the very large number of observational confirmations on which it relies.

This model implies a deep paradigm shift, which translates into an extension of the geometrical context of General Relativity. In this model, General Relativity only takes into account local relativistic phenomena, in the vicinity of the Sun, when the observations can be based on a single field equation, the Einstein one.

An enormous work remains to be done to complete this model, which also calls into question all that has been conjectured, concerning the universe in its primitive state.

But the variable constant scheme is neither more nor less speculative than the inflation model.

The observations reveal a deep dissymmetry between these two entities, the positive and the negative masses. It remains to discover the origin of this state of affairs. We conjecture that it results from a fundamental instability of a system of two masses, initially in equal proportions.

One is then given the role of positive mass, allowing the emergence of a nucleosynthesis with the creation of heavy atoms, including stars, planets and galaxies. It is in this positive world that life is born.

The world of negative masses then plays a role of accomplice, by becoming behind the scenes, the craftsman of the large-scale structure of the cosmos, by ensuring the confinement of galaxies and by being responsible for their spiral structure. But it is also him who makes possible the implementation of the guiding principle which seems to be at work in the whole universe, whether it is the inanimate world or the living:

To become more complex in order to expand its relational field.

In this sense it makes interstellar travel possible.

In passing, let us mention a concept that today's scientists are trying to include in the panorama of science today, that of the multiverse. The Janus model offers this possibility, but in a totally different way. The gravitational instability present in the universe of positive energies, in its primitive phase, theoretically allows to give birth to cells, whose diameter order of magnitude is the length of Jeans in the radiation, that is to say the cosmological horizon. From one bubble to another the values may indeed differ but the relationships between the constants will remain the same and the physics at work in these cells will remain governed by the same equations. Thus, even if the values of the gravitational constant, of the speed of light, of the electric charge can differ from ours, the same scenario will take place in these cells, i.e. constitution of a large scale structure, birth of stars, nucleosynthesis by fusion, planets, bioelements giving birth to life.

As a general rule, Nature seems to have much less imagination than science fiction authors and now some scientists trying to make up for their lack of consistent work. In the universe accessible to our observations we will find only the hundred or so atoms of the Mendeleiev table, and the same will be true in the adjacent bubbles of our version of the multiverse. The world of life is probably centered on the chemistry of carbon. The evolved beings in the universe appear to be bipeds with pairs of eyes, ears, arms, and legs, although their number of fingers may be four or six. There are probably no planets populated by intelligent invertebrates.

Returning to this Janus model, the construction of the primitive state of the universe will perhaps allow us to understand why we have failed for decades to demonstrate the existence of superparticles, while the colliders produce the energies corresponding to their masses. Maybe because these experiments do not reproduce, as we like to say, all the conditions of the early universe, the missing parameter being the density. Theoretical progress should allow us to determine the value of the parameters jointly leading to the inversions of the mass and the arrow of time, that is to say the moment of the "Big Bang".

From a philosophical point of view, the topological structure of the Janus universe makes the problem of the origin of the universe disappear, as if by the gesture of a magician, by calling into question the meaning of the adverb "before". The approach to this hypothetical "instant zero" then leads to a paradoxical situation evoking the paradox of Achilles and the turtle of Zeno of Elia.

We finally conjecture that the theoretical construction of the primitive state of the universe, not only will produce the explanation of its deep dissymmetry, but also will generate phenomena of joint fluctuations of the metrics, likely to lead to a new palette of phenomena accessible to our observations. Jean-Pierre Petit

Pertuis, France, 15 août 2021

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