Twin Universes Cosmology

Jean-Pierre Petit

Marseille Observatory, France
jppetit1937@yahoo.fr

Astrophysics and Space Science, 226, 273-307, 1995

Abstract

Starting from the field equation **S** = χ (**T** - A(**T**)), presented in a former paper, we present last results, based on numerical simulations, giving a new model applying to the very large structure of the Universe. A theory of inverse gravitational lensing is developped, in which the observed effects could be mainly due to the action of surrounding "antipodal matter". This is an alternative to the explanation based on dark matter existence. Then we develop a cosmological model. Because of the hypothesis of homogeneity, the metric must be solution of the equation **S** = 0, although the total mass of the Universe is non-zero. In order to avoid the trivial solution R = constant x t , we consider a model with "variable constants". Then we derive the laws linking the different constants of physics: G , c , h , m in order to keep the basic equations of physics invariant, so that the variation of these constants is not measurable in the laboratory: the only effect of this process is the red shift, due to the secular variation of these constants. All the energies are conserved, but not the masses. We find that all the characteristic lengths (Schwarzschild, Jeans, Compton, Planck) vary like the characteritic length R, whence all the characteristic times vary like the cosmic time t. As the energy of the photon hn is conserved over its flight, the decrease of its frequency n is due to the growth of the Planck constant h ≈ t . In such conditions the field equations has a single solution, corresponding to a negative curvature and to an evolution law: R varies like $t^{2/3}$.

The model is no longer isentropic and s ≈ Log t. The cosmologic horizon varies like R, so that the homogeneity of the Universe is ensured at any time which constitues an alternative to the theory of inflation. We refind, for moderate distances, the Hubble's law. A new law: distance = f(z) is derived, very close to the classical one for moderate red shifts.

1- Introduction

In a former paper [1] a cosmological model was presented, based on a new field equation:
(1)

$$\mathbf{S} = \chi \left(\mathbf{T} - A(\mathbf{T}) \right)$$

which follows from the Lagragian (R+ - R-)
The Einstein equation:
(2)

$$\mathbf{S} = \chi \mathbf{T}$$

is a local equation, meaning that the local geometry of the universe (tensor **S**) is determined by the local content of energy-matter (tensor). In the equation (1) we assumed that space-time hypersurface had a S3 x R1 topology and that the local geometry of the universe was determined both by the local content of energy-matter and by the content of energy-matter of the associated antipodal fold, through the antipodality relationship A.

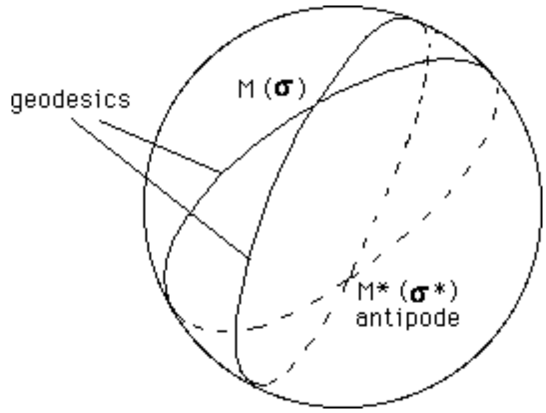

Figure 1: The coordinate-invariant antipodality relationship.

If **σ** represents the space coordinates, two geodesics starting from M focus at the antipodal point M*, or A(M). A is an involutive mapping. We can give a didactic image in order to schematize the physical meaning of the equation (1).

Consider a S2 hollow sphere made of some opaque material. We suppose that ,in this medium, the heat does not propagate, but causes dilatation. If we deposit thermal energy in in some places, the surface will be shaped by dilatation. In such a model, the heat represents the energy (tensor **T**). The dilatation materializes the impact of the local energy content on the local geometry. Light does not propagate in this medium, as assumed. But we can assume that sonic waves can propagate and may carry the information, from a point to another point.

In classical General Relativity, light is not "contained" in the model, for the electromagnetic energy is not explicitly present in the energy tensor (although radiative pressure terms can be present in the tensor **T**), so that the propagation of light along null geodesics is nothing but an hypothesis, well-confirmed by the observations and experiences. The analgue of the sonic waves, in the classical RG model, are the gravitational waves, that we can build, perturbing the field equation. However, we cannot build electromagnetic waves from the equation (2) and we assume that they follow the null-geodesics of the manifold, as the gravitational waves do .

In the equation (1) we assumed that light also follow the null-geodesic. Moreover, we assumed that the local geometry **S** was determined both by the local energy-matter content **T** and by the associated antipodal content A(**T**). In our former paper [1], using the classical low field and small velocities approximation, we have shown that the "antipodal matter" (located in **σ***) acted on the matter (located in **σ**) as "a repulsive negative mass distribution", due to the presence of the minus sign of the field equation (1).

We can schematize that in the following 2d model. Take a plane and put masses on the two sides, symbolized by small disks.

Two masses can collide, and exchange photons, if they are located in the same side. The cannot if they are located on different sides. Two masses located on the same side attract each other through Newtonian law. Two masses located on opposite sides repel each other, through a Newtonian law. Particules located on the same side can exchange photons, but not particules located on opposite sides (the plane is opaque). See figure 2.

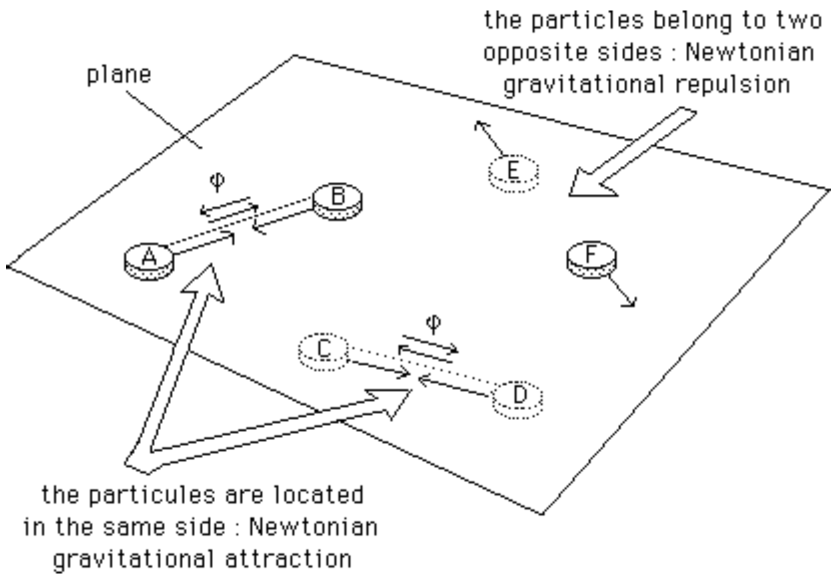

Figure 2: Two-dimensional image of the system of forces. If the particules are on the same side, they attract each other, according to the Newton law. If they belong to opposite sides they repel each other, according to the repulsive Newton law. Photons j can travel from A to B and from C to D and vice-versa, for they are located on the same side. The cannot travel from E to F, and vice-versa.

In our former paper we have shown, through analytic solution, that this mechanism provided a "missing mass effect", for an observer located on one side, if he ignores the existence of the particles located on the other one. Some results of 2d numerical simulations were presented [1]. They provided, ar large scale, a non-homogenous pattern. See reference [1], figure 7.

But this does not look like the known Universe, which appears to be fairly spongy. In 1970 Zel'dovich proposed his well-known theory of the pancakes [2]. The pancake effect was first demonstrated in numerical models for the evolution of the three-dimensional mass distribution by Doroshkevich and al. (1980), Klypin and Shandarin (1983), and Centrella and Mellot (1983) [3, 4, 5]. Mellot and Shandarin (1990) gave an elegant demonstration of the effect by using two-dimensional computations that afforded considerably better resolution for given particule number, see reference [6]. Shandarin (1988) and Kofma, Pogosyan and Shandarin (1990) presented a powerful semianalytic method for predicting the positions of pancakes from the initial conditions [7 and 8]. More recently (1992) Mellot used a 3d set of 643 particules, with periodic boundary conditions. From Mellot, the density fluctuations remains small. As pointed out by Peebles in 1993

[9]: " This cannot be the whole story, for the pancakes found are a transient effect: with increasing time the mass in the pancakes drains into clumps that are concentrated in all the three dimensions. This means that if the local sheet of galaxies were a pancake, it must have been formed recently". Then Peebles asked: "could there be a second generation of pancakes that form by the collective collapse of the groups of the clumps that formed out of the first generation? " But he concluded immediatly: "This does not follow from the analysis given, for it depends on the continuity of the velocity field that allows to write down a series expansion for the evolution of the relative positions. After the formation of the first generation of clumps, which might be the galaxies or their progenitors, the velocity field in general does not have the coherence length , and the analysis from the continuity does not apply".

As a conclusion the pancake theory cannot describe, in its present state, the observed large scale structure.

2- Large scale structure and "twin universe model"

We assumed in the previous paper [1] that the Universe had a S3 x R1 geometry. Any region of the universe interacts antigravitationnaly with its associated antipodal region, through equation (1). There is a single kind of positive matter m, filling the S3 sphere. Then the total mass of the Universe is non-zero. In the reference [1] several didactic 2d images (figures 10, 11 and 12) were given, in order to explain the mechanims of the interaction of the two adjacent folds.

Using a boosted HP workstation and a set of 2 x 5000 interacting points, F. Lansheat confirmed the work of Pierre Midy (reference [1], figure 8) . Then he focussed on a smaller region, indicated on the figure 3, in which the density of the matter in the "adjacent fold" was much higher that in the other fold.

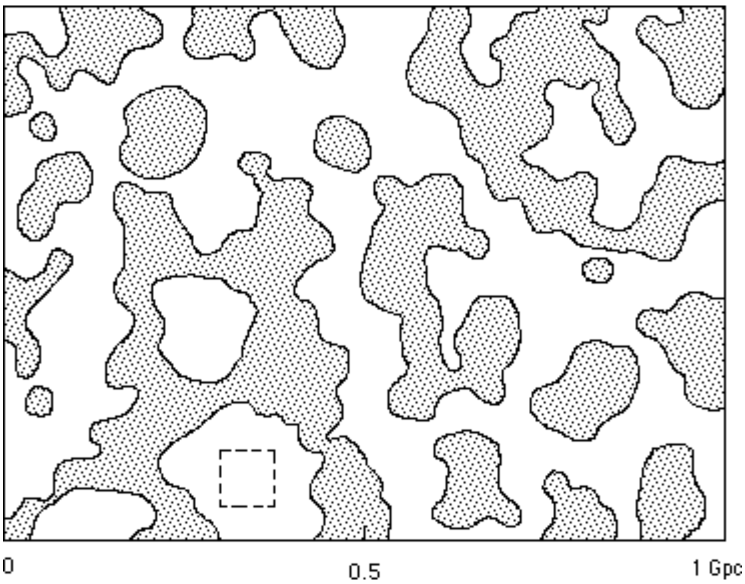

Fig 3 . Dotted square: focussing on some portion of the very large scale structure in wich the density of matter in the first fold (supposed to be ours, grey color) is supposed to be smaller that the density of matter in the adjacent fold (white color).

As expected the gravitational instability still occurs and provides new conjugated structures. See figure 4 and 5 .

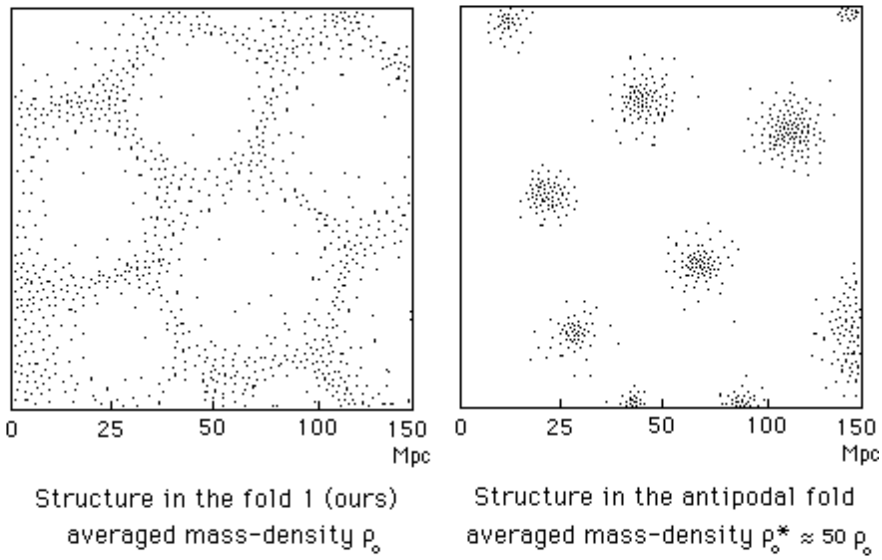

Figure 4: Results of simulations performed by F. Lansheat, showing the large structure of the Universe, due to the interaction of the two adjacent folds. Mean value of ρ* = 50 times the mean value of ρ (left). Left: cellular structure. Right: cluster structure.

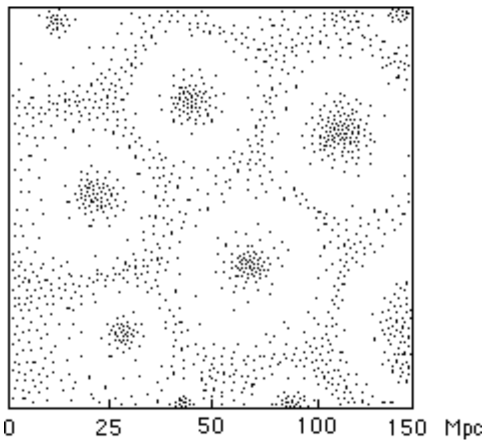

Figure 5: The same, superposed

The matter of the twin fold forms big stable clumps, which repel the matter of our fold of the universe, this last taking place in the remnant space. By opposition to the pancake model numerical simulations, this pattern is fairly non-linear. After its formation, corresponding to the Jeans time of the high density system (2.10^9 years) , there is no significant evolution of the general pattern over a time comparable to the age of the Universe so that this model could be a good candidate to explain the observed spongy aspect of our fold of the Universe, at large scale.

3- 2d and 3d simulations

From the results of the 2d simulation, F. Lansheat performed a 2 point correlation and compared to the 2d correlation obtained from a grey distribution of points (Poisson distribution). The result is shown on the figure 6. The left hand of the curve is not relevant, for the distance between the points becomes comparable to the mean distance of the random distribution. The growth on the right hand is just an artefact due to the border of the field (periodic boudary). This result cannot be compared directly to the empirical law derived from observational data (slope -1.8), see the surveys of Bahcall (1988) [31], Bahcall and Soneira (1983) [32], Bahcall and West (1992) [33], Luo and Schramm (1992) [34]. Three-dimensional simulations have to be performed, with a larger number of points. If possible, the fitting with the observational data would provide the ratio of the mass densities of the two universes.

How to outline a scenario for the formation of large-scale cosmological structure in this model? As long as the coupling between mass and light remains strong ($t < 10^5$ years), the Universe remains homogeneous and all the processes linked to the gravitational instability (formation of clumps, galaxies, stars and spongy structure) are frozen. When the Universe becomes transparent we can assume that all these processes occur, with their proper charateristic times of formation and evolution. All that we can say is that the suggested very large structure forms in 2.10^9 years.

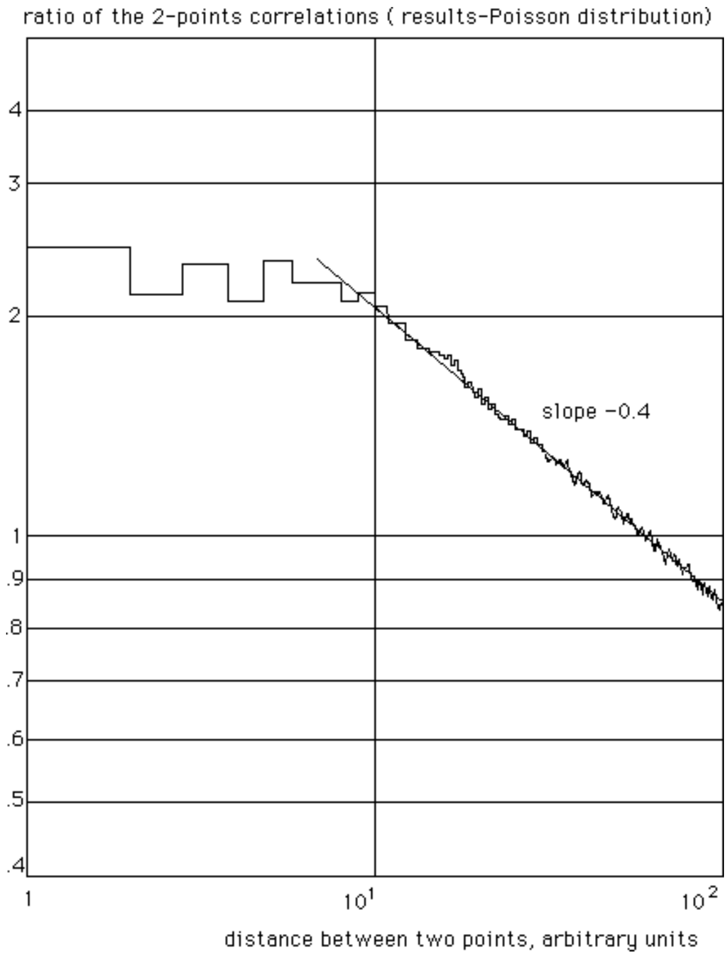

Figure 6: The slope of the curve of the 2-points correlations ratio (numerical simulation versus Poisson random distribution)

4- Inverse gravitational lensing

The problem of the gravitational lensing must be reconsidered. As suggested in the previous paper [1], in the present model the confinement of the galaxies is mainly due to the action of the surronding antipodal matter, located in the twin fold, to be consistent to the strong missing mass effect. Numerical simulations provided some description of a galaxy, surrounded by halos of antipodal matter [1]. See figure 7:

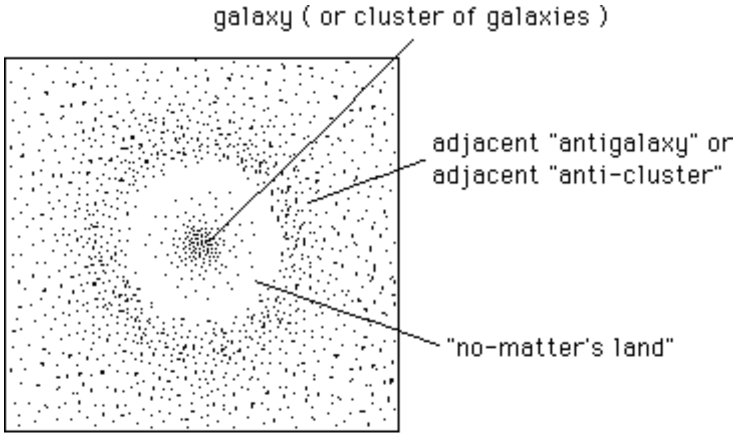

Figure 7: Concentration of mass confined by the action of the surrounding antipodal matter from 2d numerical simulations.

As a confirmation of this confinement effect, if we remove the antipodal matter from the system, the central object dissipates immediatly. Although this figure concentrate on the surronding halo, all the surrounding antipodal matter contributes to this confinement effect, so that we can figure schematically the galaxies as nested in some sort of holes of the antipodal matter, as suggested in the figure 8. The intensity of the confinement effect depends obviously on the density ρ^* of the antipodal matter distribution, which should be at least ten times larger than ρ.

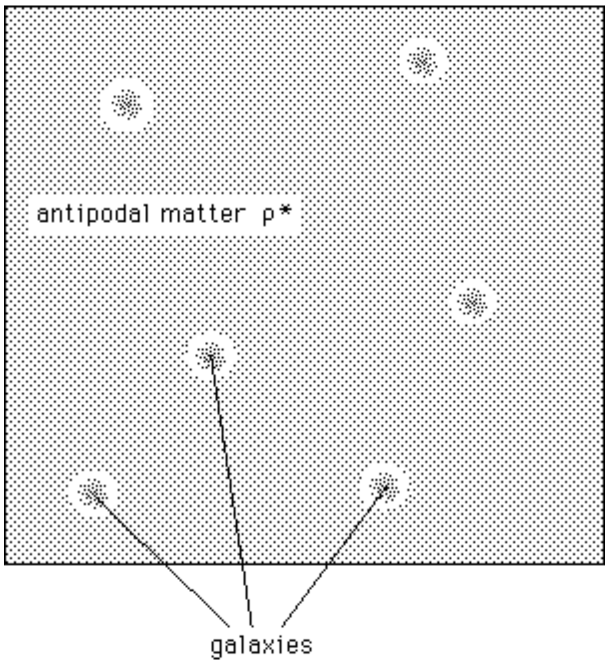

Figure 8: Galaxies nesting in a wide antipodal matter cloud (the galaxy and the antipodal matter repel each other)

Classically, matter "attracts" photons and produces gravitational lensing. The trajectory of photons, bent by the presence of a positive point-mass can be computed from a Schwarzschild solution:

(3)

$$ds^2 = (1 - \frac{2m}{r})(dx^\circ)^2 - \frac{dr^2}{1 - \frac{2m}{r}} - r^2(d\theta^2 + \sin^2\theta d\varphi)$$

Notice that m is an arbitrary constant of integration. For weak fields and slowly miving bodies we can link the goo term of the metric to the gravitational potential Ψ through:

(4)

$$g_{oo} \approx 1 + \frac{2\Psi}{c^2}$$

The gravitational potential, due to a mass M is:
(5)

$$\Psi = -\frac{GM}{r}$$

whatever this mass M would be positive or negative. If M is negative, it repels the test particle. Then:

(6)

$$g_{oo} \approx 1 - \frac{2GM}{rc^2}$$

whence:
(7)

$$m = \frac{GM}{c^2} \text{ (positive or negative)}$$

If M is positive the characteristic Schwarzschild length is
(8)

$$R_s = \frac{2GM}{c^2}$$

As pointed out above, m is nothing but an arbitrary constant of integration is the Schwarzschild solution. If we take m < 0 then the associated mass M becomes negative. We can define a characteritic length, positive (the Schwarzschild radius Rs) from:

(9)

$$m < 0 \qquad M = \frac{mc^2}{G} < 0 \qquad R_s = -\frac{2GM}{c^2} > 0$$

The trajectory, in polar coordinates, corresponds to:
(10)

$$\varphi = \varphi_o + \int_{u_o}^{u} \frac{du}{\sqrt{\frac{c^2 l^2 - 1}{h^2} + \frac{2m}{h^2} u - u^2 + 2 m u^3}}$$

See reference [10] page 203. For the photon, following the null geodesics, we get

(11)

$$\varphi = \varphi_o + \int_{u_o}^{u} \frac{du}{\sqrt{\frac{c^2 l^2}{h^2} - u^2 + 2 m u^3}}$$

Φ is the polar angle for this plane trajectory. u = 1/r

A positive mass (M > 0 ; m > 0) produces a positive gravitational lensing:

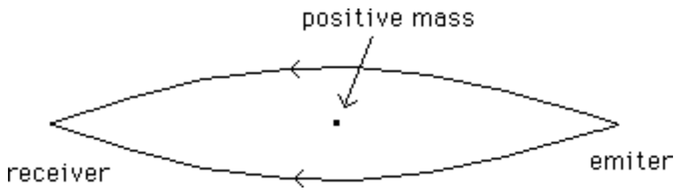

Figure 9: Classical (positive) gravitational lensing

For a test particle, located in one fold, a mass located in the adjacent fold behaves like a repulsive negative mass (M < 0 ; m < 0) and then produces a negative lensing effect:

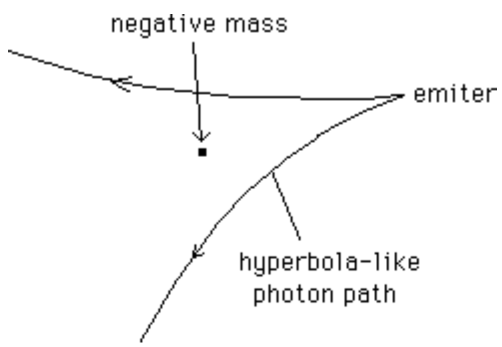

Figure 10: Negative lensing effect due to a "negative" mass

Notice that these hyperbolic pathes are familiar to the specialists of plasma physics (e-e or p-p scatterings)

Let us schematize the situation. Consider an homogeneous distribution of antipodal matter. In this distribution we find, in some places, holes in whicht the galaxies nest.

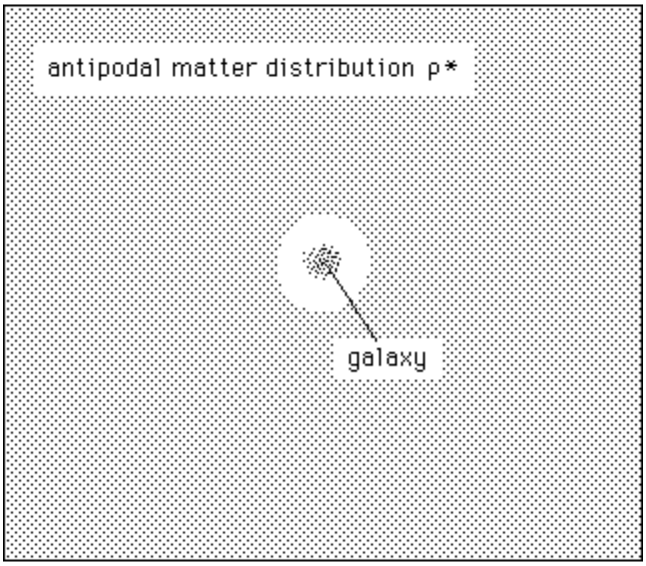

Figure 11: A galaxy nesting in an homogeneous cloud of antipodal matter.

A hole in a distribution of negative mass produces a positive gravitational lensing effect.

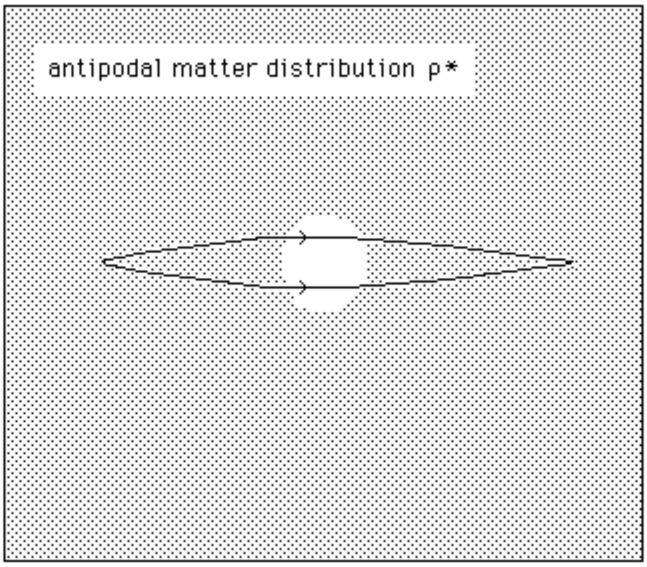

Figure 12: Induced positive gravitational lensing effect.

Qualitatively this equivalent to the effect due to an homogeneous sphere of positive mass. See figure 13:

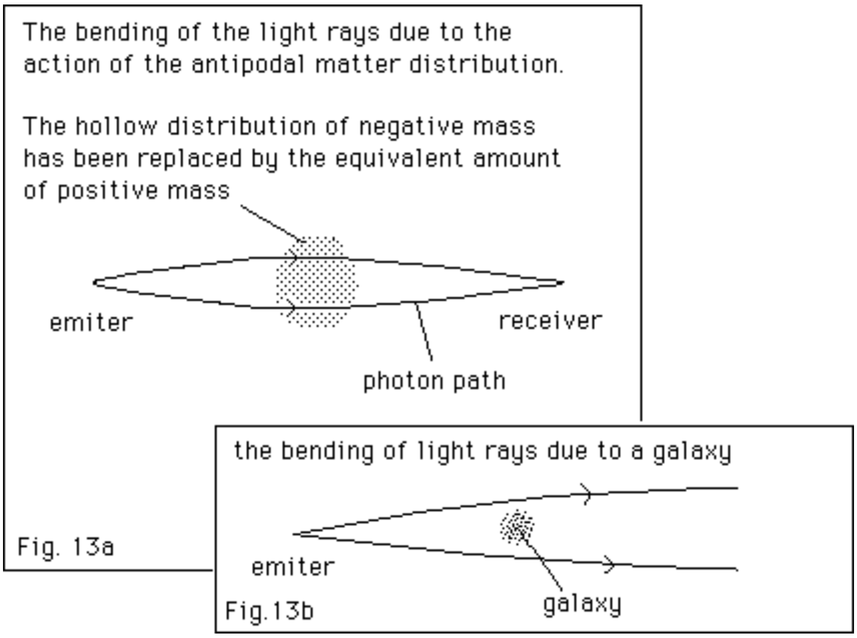

Figure 13.
13a: Positive gravitational lensing effect due to the distribution of antipodal matter (acting like a negative mass). We have replaced the hollow by an equivalent amount of positive mass. Compared positive lensing due to a galaxy (Fig. 13b).

Classically one use the gravitational lensing to evaluate the so-called invisible mass contained in a galaxy. People uses to say: "the dark matter exists in our galaxy: we measure it, through the missing mass effect". In this twin cosmological model a strong lensing effect should not be a proof of the existence of invisble mass in a galaxy, but could be due to the action of the invisible surrounding antipodal matter, which could be evaluated from the measured effects. See the figure 14:

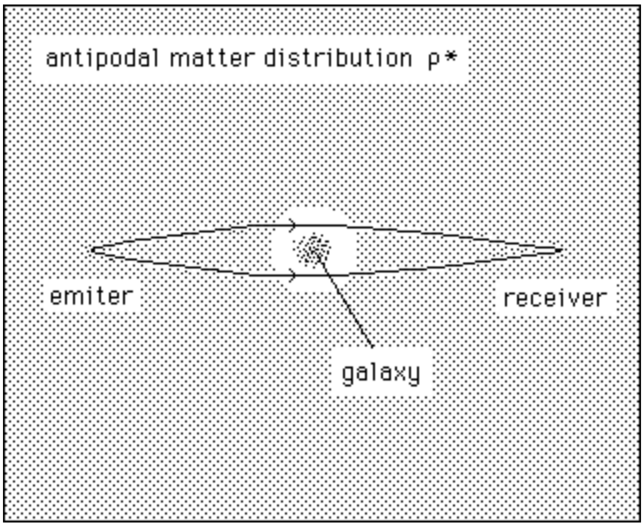

Figure 14: Combination of the two positive gravitational lensing effect due to the galaxy and to the surrounding antipodal matter.

In our galaxy the mass necessary to prevent the explosion by centrifugal force is about 10 times higher that the observed mass. If the confinement effect is due to the action of surrounding invisible antipodal matter, it means that the effect of this invisible matter is important. This could be general in the region of the universe we live in. Then all the neigbour galaxies could be surronded by dense halos of antipodal matter, and the observed gravitational lensing should be mostly due to the antipodal material than to the galaxies themselves.

The model based on the equation (1) gives a new insight on the missing mass problem [1] and on the very large structure of the Universe. This work was based on the low field and weak velocities hypothesis and refered to a quasi-steady Universe, at cosmologic scale, with respect to space and time.In order to complete this cosmological model we have now to study the evolution of the Universe as a whole.

5- About the constancy of G and c

Consider the two quantities G (gravitation) and c (velocity of the light). They are involved in the constant of Einstein χ. This last is classically determined as the following:

The metric is expressed as:
(12)

$$g_{\mu\nu} = g^{(L)}_{\mu\nu} + \varepsilon\, \gamma_{\mu\nu}$$

where $g_{\mu\nu}^{(L)}$ is the Lorentz metric tensor and ε; $\gamma_{\mu\nu}$ represents a very small time-independant perturbation (nearly Lorentzian metric tensor). Furthermore, in order to make a close connexion with classical theory, one supposes that the velocity of a particle along a geodesic is much less than c, i.e:

(13)

$$\left(\frac{ds}{dx^o}\right)^2 \cong (1 + \varepsilon\, \gamma_{oo})$$

One next applies the same approximation to the differential equation of a geodesic:

(14)

$$\frac{d^2 x^\alpha}{ds^2} + \left(\begin{smallmatrix} & \alpha & \\ \eta & & \tau \end{smallmatrix}\right) \frac{dx^\eta}{ds}\frac{dx^\tau}{ds} = 0$$

And then we get:

(15)

$$\frac{d^2 x^\alpha}{ds^2} + \left\{\begin{smallmatrix} & \alpha & \\ o & & o \end{smallmatrix}\right\} \left(\frac{dx^o}{ds}\right)^2 = 0$$

Beyond the steady state conditions, one uses to write:

(16)

$$dx^\circ = c\ dt$$

which introduces both the light velocity c and the time t. In addition:

(17)

$$\left\{ {}^{\alpha}_{0\ \ 0} \right\} = \frac{1}{2}\varepsilon\ \gamma_{00|\alpha}$$

The geodesic equation becomes:

(18)

$$\frac{d^2x^\alpha}{dt^2} = -\frac{c^2}{2}\varepsilon\ \gamma_{00}|_\alpha$$

If we identify to the Newtonian model, we can relate the gravitational pertubation potential to the metric through:

(19)

$$\Psi = \frac{c^2}{2}\varepsilon\gamma_{00} \quad \text{or} \quad g_{00} \cong 1 + \frac{2\Psi}{c^2}$$

If we consider a medium with low density ρ_o and low velocity, the matter energy tensor reduces to:

(20)

$$\mathbf{T} = \begin{vmatrix} \rho_o & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{vmatrix}$$

whose trace is ρ_o . Then the second member of the field equation becomes:

(21)

$$\chi\,(T_{\mu\nu} - \frac{1}{2} g_{\mu\nu}\ T\ ) = \frac{\chi\,\rho_o}{2}\ \delta_{\mu\nu}$$

Still in steady hypothesis condition, we get:

(22)

$$\varepsilon \sum_{i=1}^{3} \gamma_{oolili} = - \varepsilon \chi \delta \rho$$

Identifying with Poisson equation, we determine the unknown constant χ of the field equation:

(23)

$$\chi = - \frac{8 \pi G}{c^2}$$

If χ is not considered as an absolute constant, the zero-divergence of the field equation (1) is no longer ensured, according to the hypothesis $\Delta = 0$, which provides conservations equations of physics. But let us point out that the constancy of χ does not require separatly the constancy of G and c, for we determined (23) from a time-independent metric (12). Then we can shift towards the less restrictive condition:

(24)

$$\frac{G}{c^2} \approx \text{constant}$$

This idea which was suggested by the author in 1988-89 in the papers [12,13,14]. But, as far as we know, the idea of a secular variation of the light velocity, was introduced earlier by V.S.Troistkii [11].

6- The Roberston-Walker metric

Assuming that the Universe is isotropic and can be described by a Riemanian metric we get the classical Robertson metric:

(25)

$$ds^2 = (dx^o)^2 - e^{g(x^o)} \frac{1}{\left(1 + \frac{k}{4} \frac{r^2}{r_o^2}\right)^2} \left(dr^2 + r^2 d\theta^2 + r^2 \sin^2\theta \, d\varphi^2 \right)$$

If the Universe is assumed to be homogeneous, then **T** = A(**T**) and the spatially homogeneous cosmological solution comes from:

(26)

$$\mathbf{S} = \chi (\mathbf{T} - A(\mathbf{T})) = 0$$

This metric must be introduced in the equation (1), with a zero second member. Then we get the following set of two equations:
(27)

$$\left(\frac{dR}{dx^\circ} \right)^2 + k = 0$$

(28)

$$\frac{2}{R} \frac{d^2R}{dx^{\circ 2}} + \frac{k}{R^2} - \frac{1}{R^2} \left(\frac{dR}{dx^\circ} \right)^2 = 0$$

From (27) and (28) we get
(29)

k = - 1 (negative curvature) and R = x°

x° is a "chronological marker". Notice that one have a single solution (k = -1). If we identify, classically, x° to ct, c being considered as an absolute constant, we get the well-known trivial solution R = ct. Doing that, we define somewhat arbitrarily the cosmic time t. But it can be defined differently, in a non-standard way, as will be shown in the following.

7- A model with "variable constants"

The hypothesis of the constancy of the so-called constants of physics was first challenged by Milne [15]. Then others authors: P.A. Dirac [16 and 17], F. Hoyle and J.V. Narlikar [18] , V. Canuto and J. Lodenquai [19], T.C. Van Flandern [20], V. Canuto and S.H. Hsieh [20], A. Julg [21], developped ideas mainly based on the variation of G. Time-dependent G has also considered by Brans and Dicke [22] ; time dependent e by Ratra [23]. Guth [24], Sugiyama and Sato [25] and Yoshii and Sato [26] considered a time-variable cosmological constant. In general these approach focus on the variation of a certain number of "constants", not of all the constants, in a combined fashion, as developped is the present paper. H. Reeves [27] studied the impact of the separate variation of the constants, one after they other. V.S. Troistkii [28] first suggested in 1987 the possible variation of c, and, in general, of all the "constants", but, after choosing a leading parameter he just triedy to adjust the different exponents, associated to a priori polynomial empiric laws, to fit with observational features.

In the present paper we are going to build a cosmological where all the "constants" vary conjointly. This will be made consistent with the field equation (1). We are going to search laws that let the equations of physics invariant, so that these variations cannot be evidenced in local lab's experiments. These equations are the following:

The Schrödinger equation:
(30)

$$- \frac{h^2}{2\,m} \Delta \Psi + U \Psi = i \frac{h}{2\,\pi} \frac{\partial \Psi}{\partial t}$$

The Boltzmann equation:

(31)

$$\frac{\partial f}{\partial t} + \mathbf{v} \cdot \frac{\partial f}{\partial \mathbf{r}} - \frac{\partial \phi}{\partial \mathbf{r}} \frac{\partial f}{\partial \mathbf{v}} = \int (f' f'_1 - f f_1) \, g \, a \, da \, d\omega \, d^3\mathbf{v}$$

where f is the distribution function of the velocity **v** , **r** = (x,y,z), t the time, (g, a, ω) the classical impact parameters of a binary collison.

The (new) Poisson equation for gravitation (see fererence [1]) is:

(32)

$$\Delta \Phi = 4 \pi \; G (\rho - \rho^*)$$

ρ is the mass density in our fold of the Universe and ρ* the mass-density in the twin fold.

The (new) field equation:

(33)

$$\mathbf{S} = \chi (\mathbf{T} - \mathbf{T}^*)$$

where:

(34)

$$\chi = - \frac{8 \pi G}{c^2}$$

is the Einstein constant, G the "constant" of gravity and c the velocity of the light.

The Maxwell equations are:

(35)

$$\nabla \times \mathbf{B} = \frac{1}{c^2} \frac{\partial \mathbf{E}}{\partial t}$$

(36)

$$\nabla \times \mathbf{E} = - \frac{\partial \mathbf{B}}{\partial t}$$

(37)

$$\nabla . \mathbf{B} = 0$$

(38)

$$\nabla . \mathbf{E} + \frac{\rho_e}{\varepsilon_0} = 0$$

E and **B** are respectively the electric and magnetic fields. We consider the Maxwell equation for a neutral medium, for we assume that the Universe is electrically neutral. These equations are not all independent. For and example the Poisson equation, for gravitation (32), comes from the field equation (33), see [1].

Introducing a characteritic length R and a characteristic time T we can write these characteristic equations into an adimensional form:

The Schrödinger equation (30), with:
(39)

$$\mathbf{r} = R\, \boldsymbol{\xi} \qquad \nabla = \frac{1}{R}\,\delta \qquad t = T\,\tau$$

(40)

$$U = \frac{h^2}{2\,m\,R^2}\,u$$

becomes:
(41)

$$- \frac{h^2}{2\,m\,R^2}\left(\delta^2\Psi + u\,\Psi \right) = i\,\frac{h}{2\,\pi\,T}\,\frac{\partial\Psi}{\partial\,\tau}$$

The Boltzmann equation (31), with:

(42)

$$\mathbf{v} = c\,\boldsymbol{\zeta} \qquad \mathbf{r} = R\,\boldsymbol{\xi} \qquad g = c\,\gamma \qquad a = R\,\alpha$$

(43)

$$f = \frac{n}{<V>^3}\, e^{\frac{-\,V^2}{<V>^2}}$$

(44)

$$f = \frac{1}{R^3\,c^3}\,\eta$$

(45)

$$f = \frac{1}{R^3 c^3} \eta \qquad n = \frac{1}{R^3} \varpi \qquad \phi = \frac{G m}{R} \varphi$$

becomes:

(46)

$$\frac{1}{T}\frac{\partial \eta}{\partial \tau} + \frac{c}{R}\frac{\partial \eta}{\partial \xi} - \frac{Gm}{R^2 c}\frac{\partial \phi}{\partial \xi} \cdot \frac{\partial \eta}{\partial \zeta} = \frac{c}{R}\int (\eta'\eta'_1 - \eta\eta_1) \gamma \alpha \, d\alpha \, d\omega \, d^3\boldsymbol{\zeta}$$

The Poisson equation for the gravitational potential (32), with:

(47)

$$\phi = \frac{Gm}{R}\varphi \qquad n = \frac{1}{R^3} \varpi \qquad n^* = \frac{1}{R^3} \varpi^*$$

(48)

$$\frac{Gm}{R^3} \delta^2\varphi = 4\pi \frac{Gm}{R^3} (\varpi - \varpi^*)$$

becomes:

(49)

$$\delta^2\varphi = 4\pi (\varpi - \varpi^*)$$

The Maxwell equations (35), (36), (37), (38), with:

(50)

$$\nabla = R\, \boldsymbol{\delta} \qquad t = T\tau \qquad \mathbf{B} = B^* \boldsymbol{\beta} \qquad E = E^* \varepsilon \qquad \rho_e = \frac{e}{\varepsilon_0 R^3} \varpi_e$$

where e is the electric charge (we assume that the number of electric charges is conserved) become:

(51)

$$\frac{B^*}{R} \delta \times \boldsymbol{\beta} = \frac{E^*}{c^2 T} \frac{\partial \boldsymbol{\varepsilon}}{\partial \tau}$$

(52)

$$\frac{E^*}{R}\ \delta \times \boldsymbol{\varepsilon} = -\frac{B^*}{T}\frac{\partial \boldsymbol{\beta}}{\partial \tau}$$

(53)

$$\Delta . \beta = 0$$

(54)

$$\frac{E^*}{R}\ \boldsymbol{\delta} . \boldsymbol{\varepsilon} + \frac{e}{\varepsilon_0\ R^3}\ \varpi_e = 0$$

In these equations we find a certain number of physical constants:

(55)

$$h , m , c , G$$

The invariance of the Schrödinger equation is ensured if:
(56)

$$\frac{h\,T}{m\,R^2} = Cte$$

The Boltzmann equation is invariant if:

(57)

$$\frac{1}{T} \approx \frac{c}{R} \approx \frac{Gm}{R^2\,c}$$

The Poisson equation for gravitation arises no peculiar problem and just becomes

(58)

$$\delta^2\varphi = 4\,\pi\ (\varpi - \varpi^*)$$

From the Maxwell equations we get:

(59)

$$R \approx cT$$

(60)

$$\frac{E^*}{R} = \frac{e}{\varepsilon_0 R^3}$$

which is consistent to the definition of an electric field due to an electric charge.

From the Einstein equation, as pointed out earlier, we get:

(61)

$$G \approx c^2$$

If not, the equation is no longer divergenceless.

If the quantities:

(62)

$$h , m , c , G, R , T$$

obey these relations, it will not be possible to evidence their variations in any in lab's experiments..

So what?

From (57) we get immediatly:

(63)

$$\frac{Gm}{c^2} \approx R$$

which is nothing but the characteristic Schwarzschild length, so that:

(64)

$$Rs \approx R$$

Examine now the Jeans' length:

(65)

$$L_j = \frac{<V>}{\sqrt{4 \pi G \rho m}}$$

where:

(66)

$$<V> = c < \zeta >$$

(66b)

$$L_j = \frac{c R^{3/2}}{\sqrt{G m}} \frac{< \zeta >}{\sqrt{4 \pi \varpi}}$$

(66t)

$$\frac{G m}{c^2} \approx R \qquad \frac{c}{\sqrt{Gm}} \approx \frac{1}{\sqrt{R}} \qquad L_j = R \frac{< \zeta >}{\sqrt{4 \pi \varpi}}$$

(67)

$$L_j \approx R$$

Combine the equations (56) and (57), we get:

(67b)

$$\frac{h T}{m R^2} = \frac{h}{m R^2} \frac{R}{c} = Cte$$

(68)

$$\frac{h}{m c} \approx R$$

The Compton Length varies like R:

(69)

$$R_c \approx R$$

The Planck length is:

(70)

$$L_p = \sqrt{\frac{h G}{c^3}} = \sqrt{\frac{h}{c} \frac{G}{c^2}}$$

(70b)

$$L_p \approx R$$

The Planck time is:

(71)

$$t_p = \sqrt{\frac{h G}{c^5}} = \frac{R}{c} \approx T$$

The Jeans time is:

(72)

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

Combining (61) and (63) we get:

(73)

$$m \approx R$$

The variation of the constants does not conserve the mass.

If we conserve the number of species, the mass density ρ is found to obey:

(74)

$$\rho = n m = \frac{\varpi}{R^3} m \qquad \rho \approx \frac{1}{R^2}$$

Same law for the contribution ρr of the radiation to the density ρ. The conservation of the radiative energy gives:

(75)

$$pr^{3} = \text{constant}$$

Then:

(76)

$$p_r = \frac{\rho_r c^2}{3} \quad \rightarrow \quad \rho_r \approx \frac{1}{R^2}$$

10- The problem of the cosmological horizon

Clasically this the cosmologic horizon is defined as is ct., which arises a paradox. The observed Universe is very homogeneous, at large scale. If we compare any characteristic distance R (t) (for an example the mean distance between particles), with the horizon, we get:

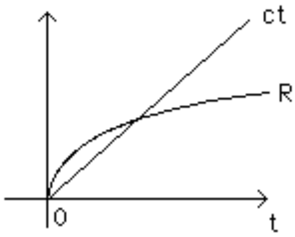

Fig. 17: Comparizon of the evolution of the characteristic length of the Universe with the cosmological horizon, in an Eintein-de Sitter model.

In the present model the cosmological horizon becomes the following integral:

(87)

$$H = \int_0^t c(\tau)\, d\tau \approx t^{2/3} \approx R$$

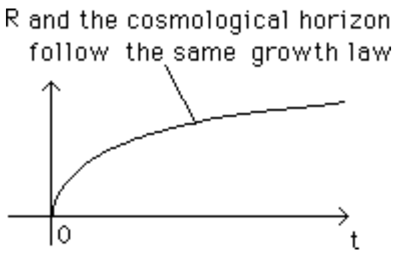

Fig. 18: Comparizon of the evolution of the characteristic length R of the Universe with the cosmological horizon, in the present model. They have the same variation in time.

If the Universe was homogeneous at the begining, the collisional process, always present, tends to maintain this homogeneity. It it was not, it tends to smooth it. This constitues an alternative to the theory of inflation.

This law between $R \approx t^{2/3}$ must not be considered as an expansion process but as a consequence of the secular variation of the constants of physics, a gauge process, whose single observable effect is the red shift.

11- The link with the Robertson-Walker geometry

All this is compatible with the solution (34) if we give the following non-standard definition of the cosmic time:

(88)

$$t = \text{constant} \quad (x^{\circ})^{3/2}$$

The dimension of the constant is:
(88b)

$$\text{constant} = \frac{\text{time}}{(\text{ length })^{3/2}}$$

In the standard definition of the cosmic time from

t = constant x° (x° = ct)

the dimension of the constant is

(88t)

$$\text{constant} = \frac{1}{c} = \frac{\text{time}}{\text{length}}$$

12- Entropy as a better chronological marker

The detailed calculation of the entropy per baryon, as defined by:

(89)

$$s = \frac{k}{n}\int f \text{ Log } f \, du \, dv \, dw$$

where f is the velocity distribution function, was given in a former paper, with "variable constants". See [13], section 2.
As a result, we found:

(90)

$$s \approx \frac{3}{2} k \text{ Log } R \approx \text{Log } t$$

If R(t) is an increasing function of t, the cosmic entropy grows like the cosmic time. In lab's experiments we usually relate entropy with time and consider that, according to the second principle, there is no possible strictly isentropic phenomenon. We consider that the time flux depends on the entropy change. In the classical model it is somewhat paradoxal to notice thet such enormous change in time would go with zero entropy variation. In the present model when the time t tends to zero, s tends to - ∞

We have s = constant Log t . If we change the measure of the entropy (modifying the value of the constant) and write:

(91)

$$\sigma = \frac{2}{3} \text{Log}\, t$$

we get:

(92)

$$dt = 3/2\ t\ d\sigma$$

Let us return to the Robertson Walker metric.

(92b)

$$dS^2 = c^2\, d\, t^2 - R^2 \frac{du^2 + u^2 d\theta^2 + \sin^2\theta\, d\varphi^2}{\left(1 - \frac{u^2}{2}\right)^2}$$

We get, with R = 3/2 ct:

(93)

$$dS^2 = R^2 \left\{ d\sigma^2 - \frac{du^2 + u^2 d\theta^2 + \sin^2\theta\, d\varphi^2}{\left(1 - \frac{u^2}{2}\right)^2} \right\}$$

In the representation { entropy, space variables } the metric becomes conformally flat and we have:

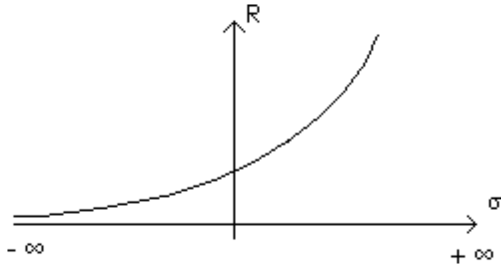

Figure 19: The evolution of the curvature radius R of the Universe versus the entropy.

In the classical description (t , **σ**) the physicist, when t tends to zero, has some difficulty to define any material clock, for the velocities of the particles tend to c. In a "variable constant cosmologic model" the entropy per baryon (99) is no longer constant and never fails to describe the events of the Universe. Notice that in a (s , **σ**) description, the problem of the origin of the Universe falls down. In addition, if we describe the Universe in a phase space (position plus velocity) we found that the associate characteristic hypervolume R^3c^3 varies like t.

13- The red shift and the Robertson-Walker metric with a variable light velocity

The derivation of the distance frome the red shift z, with "variable constants", has already been presented. See reference [13], sections 3 to 7. The indix 1 refers to the emiter and the indix 2 to the receiver. For an example c_2 is the today's value of the velocity of the light, as measured in the observatory. It is assumed that the Rydberg constant (ionization energy of the hydrogen) follows:

(94)

$$E_i \approx R^{\gamma}$$

Then we find:
(95)

$$1 + z = \left(\frac{R_2}{R_1}\right)^{\gamma}$$

The value $\gamma = 1$ is chosen in order to fit the classical value.

Then, expanding the function 1/R(t) into a series with respect to

(96)

$$\varepsilon = \frac{c_2 \, (t - t_2)}{R_2}$$

we get:
(97)

$$c_2 \, z \cong (2 - \gamma) \frac{R'_2}{R_2} \, d_2$$

Which is nothing but the Hubble's red shift law, which still applies in this variable light velocity conditions. From mesurement of d_2, c_2 and z we can derive the so called Hubble's constant, i.e. the age of Universe.

(98)

$$t = \frac{2}{3} \frac{d_2}{c_2 \, z}$$

identical to the standard value. Then the distance to the objet d_2 is evaluated:

(99)

$$d_2 = R_2 u = \frac{3}{2} c_2 t_2 \frac{(1+z)^2 - 1}{(1+z)^2 + 1}$$

When z tends to infinite we find the cosmological horizon 3/2 c_2 t_2, which is twice smaller than the standard value 3 c_2 t_2. If we compare the present model to the EdS model, we get, for the distances, the ratio:

(100)

$$\eta = \frac{(1+z)^2 - 1}{(1+z)^2 + 1} \frac{1}{2 - \frac{2}{\sqrt{1+z}}}$$

They are similar for weak z values, as shown on the next figure. For weak z values, the distances, as derived from the present model, are a weakly larger. η is close to unity for z = 1.5. Then η tends to 0.5 when z tends to infinite. For z < 2.5 the difference of the two distance evaluation is less than 5% .

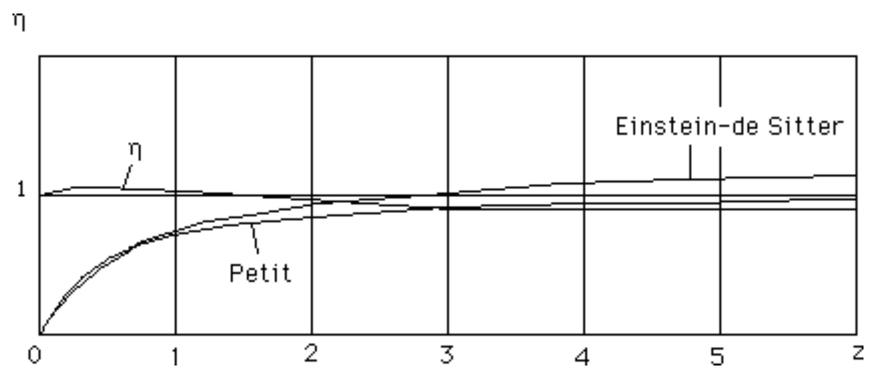

Figure 20 : The distances for the present model and for the Einstein-de Sitter model, and the ratio η of theses distances, versus the red shift.

If the reference [14], section 3 the evolution of the angular size of a distant object, versus z, was computed. For the EdS model and constant size objects, the law is:

(101)

$$\phi = \phi_o \frac{(1+z)^2}{(1+z) - \sqrt{1+z}}$$

This function of z has a minimum for z = 1.25 and then Φ tends to grow linearly versus z. The figure 21 explains why it provides an overestimation of Φ , for large z values:

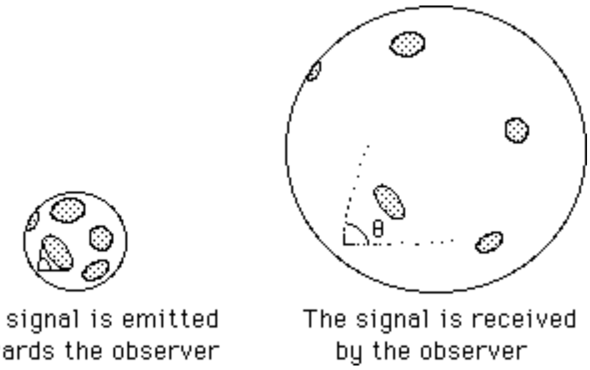

Figure 21: Why the classical model overestimates the angular size of large red shift objects. The measure, at the reception time, corresponds to a "fossil" angular size, when the object was closer.

In the present model, the situation is basicly different for the objets are supposed to expand with the Universe. See figure 22:

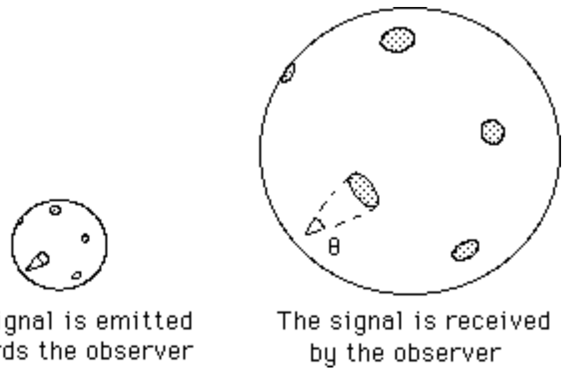

Figure 22: Present model: The light moves along geodesics. The angular size is unchanged.

The corresponding formula is:

(102)

$$\phi = \phi_o \frac{(1+z)^2 + 1}{(1+z)^2 - 1}$$

When z tends to infinite, Φ tends to be constant.

Notice that in our model:

$$\phi \approx \frac{1}{d}$$

In the reference [14] this was used to compare the present model to the EdS model, applying to radio-QSO data (Barthel and Miley, 1988 [35]), giving a slight advantage to the first. Obviously, a single test, implying many assumptions about the nature of the observed objects, could not valid the model. See the discussion in reference [14].

14- The light emission problem

Assume the energy production of light sources would proceed through collisions. The collision frequency may be written as:

(103)

$$\nu = n\, Q\, v$$

n is the number density, Q is the collision cross-section and v the thermal velocity. Assume all these quantities follow our set of relations, i.e:

(104)

$$n \approx \frac{1}{R^3} \qquad Q \approx R^2 \qquad v \approx \frac{1}{\sqrt{R}}$$

which gives:

$$\nu \approx R^{-\frac{3}{2}} \approx \frac{1}{t}$$

Assume now that the characteristic amount of energy Ei, for this energy production reaction would vary like R(t). The energy emission rate varies like:

(105)

$$P \approx \frac{R}{t} \approx c \approx \frac{1}{\sqrt{R}}$$

Such as the emission rate would have been higher in the past. As, in this model, the energy is saved during the photon flight, the receiver would measure a higher luminosity, which would vary like $(1+z)^{1/2}$.

If we look at the data presented by Barthel and Miley when and plot Log (P) - 0.5 Log (1+z) when find something quite constant.

15- Some remarks about other possible comparizon to observational material

15.1) Local relativistic effects:

From the classical model of General Relativity have been imagined a large number of tests. The first were devoted to local tests, like the precession of the perihelia of Mercury or the time-delay of radar echos. There is no a priori incompatibility between these test and the present model. In effet, according to the results of the numerical simulations, the matter-density in the region of the twin fold corresponding to the vicinity of the sun is highly rarefied, for the antipodal mass is pushed away by the mass. Then then second term of the second member of the equation (1) can be neglected:

(106)

$$\mathbf{S} = \chi (\mathbf{T} - A(\mathbf{T})) \approx \chi \mathbf{T}$$

so that, locally, the Einstein equation would become an approximate form of the equation (1). In such conditions, from the equation (1) we refind the classical local observational features, like the advance of the perihelia, etc.

15.2) About the strong field test from binary pulsars:

A pulsar is supposed to be an object located in our galaxy. If we suppose again that the antipodal matter is very rarefied in the conjugated adjacent fold, the field equation becomes:

(107)

$$\mathbf{S} \approx \chi \mathbf{T}$$

i.e. the Einstein equation. Then the observed effects [30] fit both the equation (1) and (2).

16- The problem of electromagnetism and other features of physics

We propose a new cosmological model. As said before, basicly, this model does not contain the electromagnetic nor strong or weak interaction phenomena and this is the same for the classical model. Only a fully unified field theory could deal with. In such conditions is it licit to try to apply the gauge analysis to the charged particle, i.e. to see how could vary the Bohr radius versus R? This is questionable (whence this question was examined by the author if the formal paper [13], section 9) . Same thing for the strong and weak interactions and their associated characteristic lengths (in order to give a new an complete description of the cosmic evolution, including the nucleosynthesis, on should introduce, in this constant energy model, corresponding time-dependant "constants").

Personnaly I would think that the cosmological model is far to be achieved. For an example the so-called cosmological constant Λ could be added, through (suggestion of J.M. Souriau):

(108)

$$\mathbf{S} = \chi (\mathbf{T} + \Lambda \mathbf{g} - A(\mathbf{T}) - \Lambda A(\mathbf{g}))$$

or

(109)

$$\mathbf{S} = \chi (\mathbf{T} + \Lambda\, \mathbf{g} - \mathbf{T}^* - \Lambda\, \mathbf{g}^*)$$

where **T*** and **g* =** A(**g**) are respactively the stress tensor and the metric tensor associated to the conjugated antipodal region.

This work just suggests that the geometry of the universe could be somewhat different from our standard vision. Perhaps an unified model (gravitation plus electromagnetism) could be built, by introducing complex tensors **S , T** and A**(T)** in the equation (1). On another hand, one can shif from a S3 x R1 geometry towards a twin geometry based on the cover of a projective P4 by a sphere S4. Then it could perhaps be possible to deal with CPT symmetry and then to take account of the matter-antimatter duality (the antipodal matter would behave like antimatter and become the lost "cosmological antimatter", as suggestd by Andréi Sakharov and Novikov in 1967 [36,37] and the authors [38,39 and 402]). But this we confess that is a hard mathematical task.

In a Kaluza model we consider a 5 dimensional manifold. Then the electromagnetism can be introduced, whence nobody knows what this fifth dimension represents exactly. Notice that, locally, the model is equivalent to a Kaluza model with a fifth dimension limited to the values ± 1 .

In this model the statute of the Klein-Gordon equation is the same than in the classical General Relativity.

Conclusion

Starting from the field equation presented in a former paper [1] we have presented new results, based on numerical simulations, performed by F. Lansheat. This provides a possible explation of the spongy very large structure of the Universe and is an alternative to the classical pancakes theory, fot our structures are stable over a period of time comparable to the age of the Universe. Then we developped a theory of inverse gravitational lensing: the observed lensing effects could be mainly due to the effect of surrounding antipodal matter, acting like a distribution of negative mass, than to the action of the galaxy itself. This challenges the dark matter concept. Then, starting from the field equation $\mathbf{S} = \chi (\mathbf{T} - \mathbf{A}(\mathbf{T}))$ we have developped a cosmological model with "variable constants". Because of the hypothesis of homogeneity ($\mathbf{T} = \mathbf{A}(\mathbf{T})$ = constant over space) the metric must be solution of the equation $\mathbf{S} = 0$, although the total mass of this closed universe is non-zero ($\mathbf{T} \neq 0$). In order to avoid the triviality of the classical subsequent solution $\mathbf{R} \approx t$, we have built a solution with "variable constants". We have derived the laws linking the different constants of physics :
G , c , h , m in order to keep the basic equations invariant, so that the variation of these constants is not measurable in the laboratory. The only effect of this process is the red shift, due to the secular variation of these constants.

All the energies are conserved, but not the masses. We have found that all the characteristic lengths (Schwarzschild, Jeans, Compton, Planck) vary like the characteritic length R, whence all the characteristic times vary like the cosmic time t.

As the energy of the photon hν is conserved over its flight, the decrease of its frequency is due to the growth of the Planck constant $h \approx t$

In such conditions the field equations has a single solution, corresponding to a negative curvature and to an evolution law: $R \approx t^{2/3.}$

The model is no longer isentropic and $s \approx \text{Log } t$. The cosmologic horizon varies like R, so that the homogeneity of the Universe is ensured at any time, which challenges the inflation theory. We refind, for moderate distances, the Hubble's law. We find a new law: distance = f(z), very close to the classical one for moderate red shifts.

An observational test is suggested, based on the values of the angular sizes of distant objects. Comparing the available data to the predictions of our model and to those of the (peculiar) Einstein-de Sitter model, we find a slight advantage for the first. Obviously, a single test cannot valid such a model.

References

[1] Petit J.P.: The missing mass effect. Il Nuovo Cimento B Vol. 109 July 1994, pp. 697-710
[2] Zel'dovich Ya.B., Astrofisica 6. 319 MNRAS 192, 192 (1970)
[3] Doroskhevitch A.G. MNRAS 192,32 (1980)
[4] Klypin A.A & Shandarin S.F. MNRAS, 204, 891 (1983)
[5] Centrella J.M. & Mellot A.L. Nature 305, 196 (1983)
[6] Mellot J.M. & Shandarin S.F. Nature 346, 633 (1990)
[7] Shandarin S.F In Large Scale Structures of the Universe, ed J.Audouze, M.C. Peleton and A.Szalay, 273. Dordrecht: Kulwer (1988)
[8] Kofman L.A , Pogosyan D. , and Shandarin S. MNRAS 242, 200 (1990)
[9] Peebles P.J.E. Principles of Physical Cosmology, Princeton University Press (1993)
[10] R.Adler M.Bazin & M.Schiffer: Introduction to General Retivity. Mac-Graw Hill book company 1975
[11] V.S Troitskii , Astrophysics and Space Science 139 (1987) 389-411
[12] J.P.Petit, Mod. Phys. Lett. A3 (1988) 1527
[13] J.P.Petit, Mod. Phys. Lett. A3 (1988) 1733
[14] J.P.Petit, Mod. Phys. Lett. A4 (1989) 2201
[15] E.A. Milne: Kinematic Relativity Oxford 1948.
[16] P.A. Dirac: 1937, Nature, **139,** 323
[17] P.A. Dirac: 1973 Proc. Roy. Soc. London , **A333**, 403
[18] F.Hoyle & J.V.Narlikar: Cosmological models in conformally invariant gravitational theory. Mon. Notices Roy. Astr. Soc. 1972 155 pp 305-325.
[19] V.Canuto & J.Lodenquai: Dirac cosmology, Ap.J. **211**: 342-356 1977 January 15.
[20] T.C.Van FLlandern: Is the gravitational constant changing? Ap.J, **248**: 813-816
[20] V.Canuto & S.H. Hsieh: The 3 K blackbody radiation, Dirac's large numbers hypothesis, and scale-covariant cosmology. Ap.J., 224 : 302-307, 1978 September 1
[21] A.Julg. Dirac's large numbers hypothesis and continuous creation. Ap.J. **271**: 9-10 1983 August 1
[22] Brans and Dicke [*], Phys. Rev. 124-925 (1961)
[23] Ratra, Astrophys. J. Lett. 391, L1 (1992)
[24] Guth, Phys. Rev. D23, 347 (1981)
[25] Sugiyama and Sato, Astrophys. Jr. 387, 439 (1992)
[26] Yoshii and Sato, Astrophys. J. Lett. 387, L7, (1992)
[27] H. Reeves, Rev. Mod. Phys, 66, 193, (1994),
[28] V.S Troitskii, Astrophysics and Space Science 139 (1987) 389-411
[29] J.M. Souriau, Structure des systèmes dynamiques, Ed. Dunod 1970, France
[30] Taylor, Rev. Mod. Phys. 66, 711 (1994)
[31] Bahcall N.A 1988 Ann. Rev. of Astron. Ap. 26, 631 (19-20)
[32] Bahcall N.A and Soneira R.M. 1992 Ap. J. 392, 419
[33] Bahcall N.A and West M.J. 1992, Ap. J. 392, 419
[34] Luo X. and Schramm D.N. 1992. Science 256, 313
[35] P.D.Barthel & G.K. Miley. Evolution od radio structure in quasars: a new probe of protogalaxies? Nature Vol 333, 26 may 1988.
[36] A.D. Sakharov , ZhETF Pis'ma 5: 32 (1967); JETP Lett. 5.24 (1967) trad. Preprint R2-4267, JINR, Dubna
[37] D.Novikov, ZhETF Pis'ma 3:223 (1966) ; JETP Lett. 3:142 (1966), trad Astr. Zh. 43:911 (1966) Sov. Astr. 10:731 (1967)
[38] J.P.Petit: "Univers énantiomorphes à temps propres opposés", CRAS du 8 mai 1977, t.285 pp. 1217-1221
[39] J.P.Petit: "Univers en interaction avc leur image dans le miroir du temps". CRAS du 6 juin 1977, t. 284, série A, pp. 1413-1416
[40] J.P.Petit, Le Topologicon, Ed. Belin, France, 1983.

***Acknowledgements**:*

This work is supported by the french CNRS and by the A. Dreyer Brevets et Developpement company.