TWIN UNIVERSES COSMOLOGY

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(Received 14 July, 1994; accepted 7 February, 1995)

Abstract. Starting from the field equation $\mathbf{S} = \chi(\mathbf{T} - A(\mathbf{T}))$, presented in a former paper, we present a test result, based on numerical simulations, giving a new model applied to the very large structure of the Universe. A theory of inverse gravitational lensing is developed, in which the observed effects could be due mainly to the action of surrounding 'antipodal matter'. This is an alternative to the explanation based on dark matter existence. We then develop a cosmological model. Because of the hypothesis of homogeneity, the metric must be a solution of the equation $\mathbf{S} = 0$, although the total mass of the Universe is non-zero. In order to avoid the trivial solution $R =$ constant $\times\, t$, 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 being the red shift, due to the secular variation of these constants. All the energies are conserved, but not the masses. We find that all of the characteristic lengths (Schwarzschild, Jeans, Compton, Planck) vary like the characteristic length R, from where all the characteristic times vary like the cosmic time t. As the energy of the photon $h\nu$ is conserved over its flight, the decrease of its frequency ν is due to the growth of the Planck constant $h \approx t$. In such conditions the field equations have 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 $s \approx \log t$. 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 re-find, for moderate distances, Hubble's law. A new law: distance = $f(z)$ is derived, very close to the classical one for moderate red shifts.

Introduction

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

$$\mathbf{S} = \chi(\mathbf{T} - A(\mathbf{T})) \tag{1}$$

which follows from the Lagrangian $(R^+ - R^-)$.

The Einstein equation:

$$\mathbf{S} = \chi\mathbf{T} \tag{2}$$

is a local equation, meaning that the local geometry of the universe (tensor $\mathbf{S}$) is determined by the local content of energy-matter (tensor $\mathbf{T}$). In the equation (1) we assumed that the space-time hypersurface had an $S3 \times R1$ 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.

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Astrophysics and Space Science **226:** 273–307, 1995.

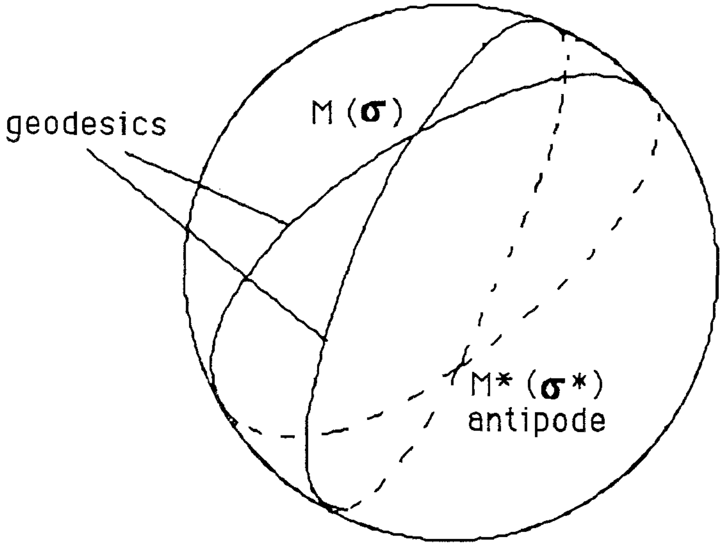

Fig. 1. The coordinate-invariant antipodality relationship.

If σ represents the space coordinates, two geodesics start 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 equation (1).

Consider an $S2$ hollow sphere made of some opaque material. We suppose that, in this medium, heat does not propagate, but causes dilatation. If we deposit thermal energy in some places, the surface will be shaped by dilatation. In such a model, heat represents energy (tensor $\mathbf{T}$). 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 information, from one 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 $\mathbf{T}$), so that the propagation of light along null geodesics is nothing but an hypothesis, well-confirmed by observation and experience. The analogue 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 follows the null-geodesic. Moreover, we assumed that the local geometry $\mathbf{S}$ was determined both by the local energy-matter content $\mathbf{T}$ and by the associated antipodal content $A(\mathbf{T})$. 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

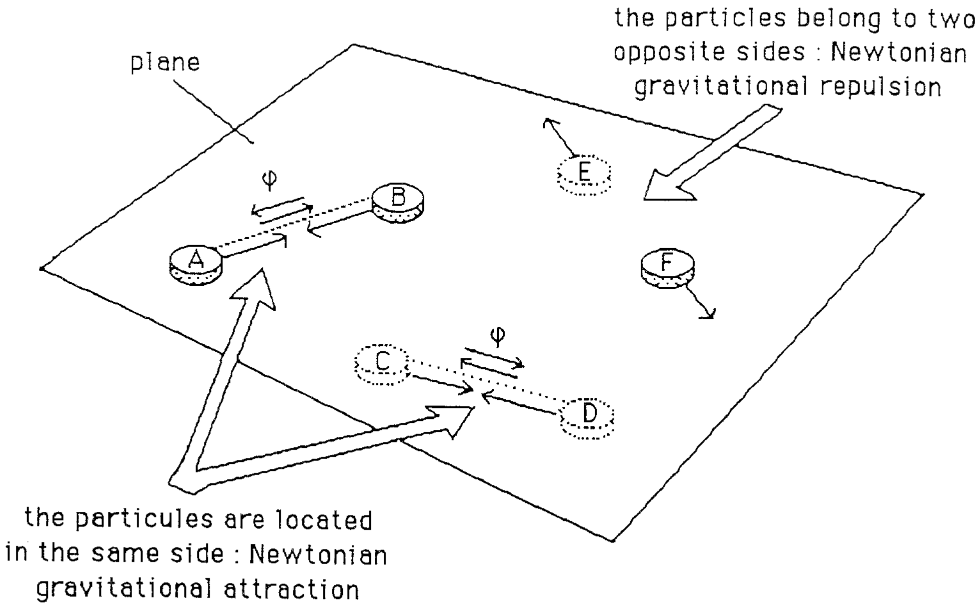

Fig. 2. Two-dimensional image of the system of forces. If the particles are on the same side, they attract each other, according to Newton's law. If they belong to opposite sides they repel each other, according to the repulsive Newton's law. Photons φ can travel from A to B and from C to D and vice-versa,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

in 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 on the same side. They cannot if they are located on different sides. Two masses located on the same side attract each other through Newton's law. Two masses located on opposite sides repel each other, through Newton's law. Particles located on the same side can exchange photons, but not particles located on opposite sides (the plane is opaque). See Figure 2.

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, on large scales, a non-homogeneous 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 *et 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 a given particle 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 64^3 particles, 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?" He concluded immediately: "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 of 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.

1. Large Scale Structure and 'Twin Universe Model'

We assumed in the previous paper [1] that the Universe had an $S3 \times R1$ geometry. Any region of the universe interacts antigravitationally with its associated antipoda 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 mechanisms of the interactions of the two adjacent folds.

Using a boosted HP work-station and a set of 2×5000 interacting points, F. Lansheat confirmed the work of Pierre Midy (reference [1], Figure 8). He then focussed on a smaller region, indicated in Figure 3, in which the density of the matter in the 'adjacent fold' was much higher than in the other fold.

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

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. In opposition to

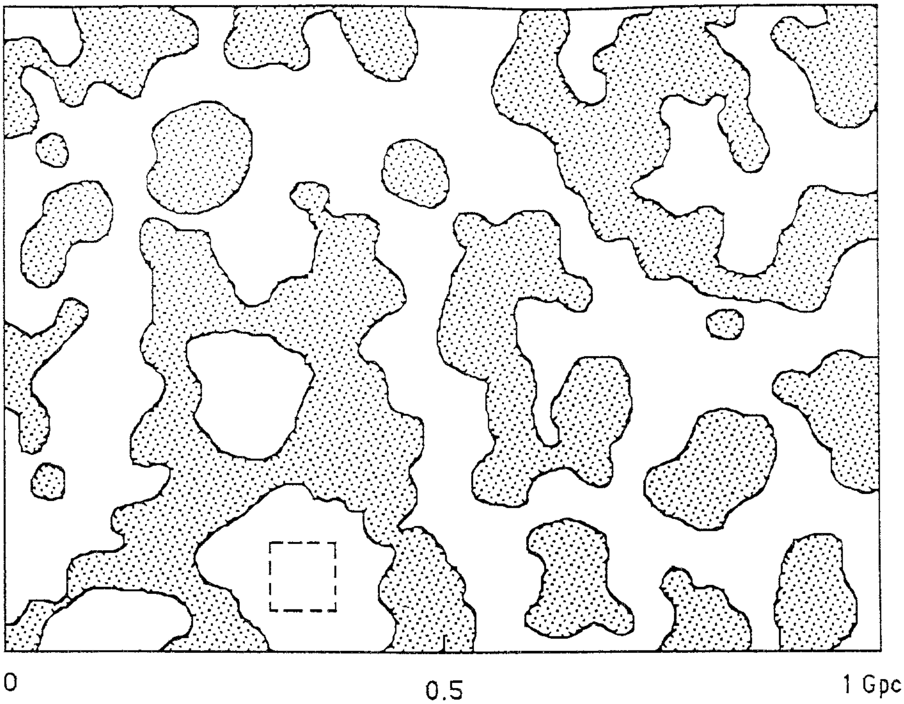

Fig. 3. Dotted square. Focussing on some portion of the very large scale structure in which the density of matter in the first fold (supposedly ours, grey color) is supposed to be smaller than the density of matter in the adjacent fold (white color).

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.

2. $2d$ 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 in 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 artifact due to the border of the field (periodic boundary). This result cannot be compared directly to the empirical law derived from observational data

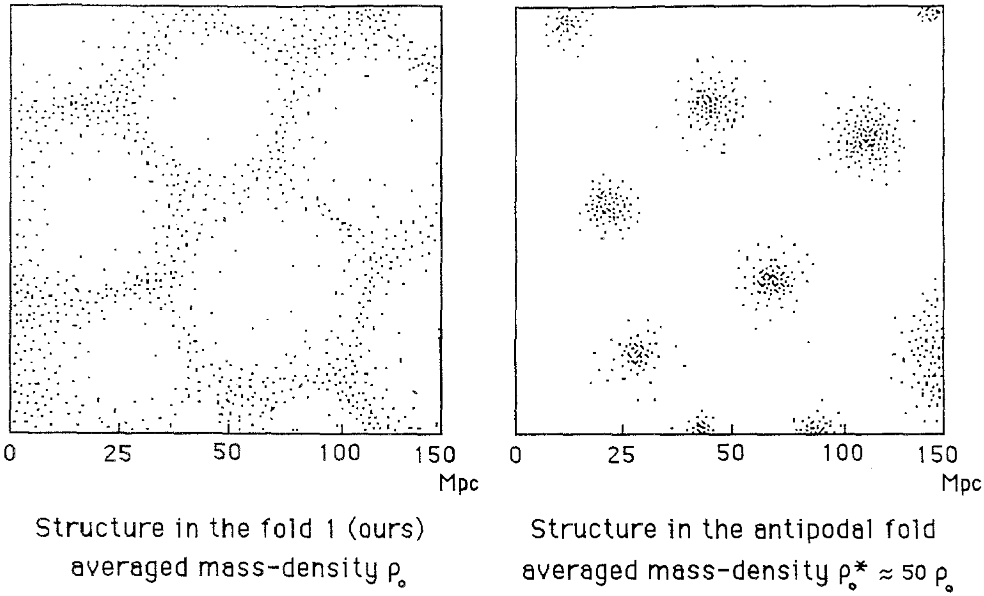

Fig. 4. Results of simulations performed by F. Lansheat, showing the large structure of the Universe, due to the interaction of the two adjacent folds. Mean value of $\rho^* = 50$ times the mean value of ρ (left). Left: cellular structure. Right: cluster structure.

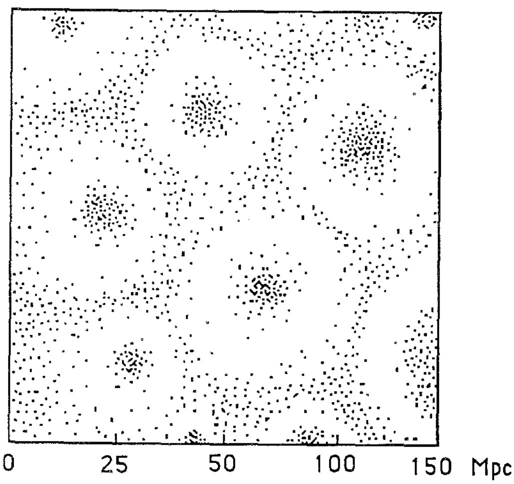

Fig. 5. The same, superimposed.

(slope −1.8); see the surveys of Bahcall (1988) [31], Bahcall and Soneira (1983) [32]. Bahcall and West (1992) [33], and Luo and Schramm (1992) [34]. Three-dimensional simulations have to be performed, with a larger number of points. If possible, a fit with the observational data would provide the ratio of the mass densities of the two universes.

How does one 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 of these processes occur, with their proper characteristic times of formation and evolution. All that we can say is that the suggested very large structure forms in 2 10^9 years.

3. Inverse Gravitational Lensing

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

As a confirmation of this confinement effect, if we remove the antipodal matter from the system, the central object dissipates immediately. Although this figure concentrates on the surrounding 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 distribution, which should be at least ten times larger than ρ.

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:

$$ds^2 = \left(1 - \frac{2m}{r}\right) (dx^\circ)^2 - \frac{dr^2}{1 - \frac{2m}{r}} - r^2(d\theta^2 + \sin^2\theta\, d\varphi) \tag{3}$$

Notice that m is an arbitrary constant of integration. For weak fields and slowly moving bodies we can link the g_{00} term of the metric to the gravitational potential Ψ through:

$$g_{00} \approx 1 + \frac{2\Psi}{c^2} \tag{4}$$

The gravitational potential, due to a mass M is:

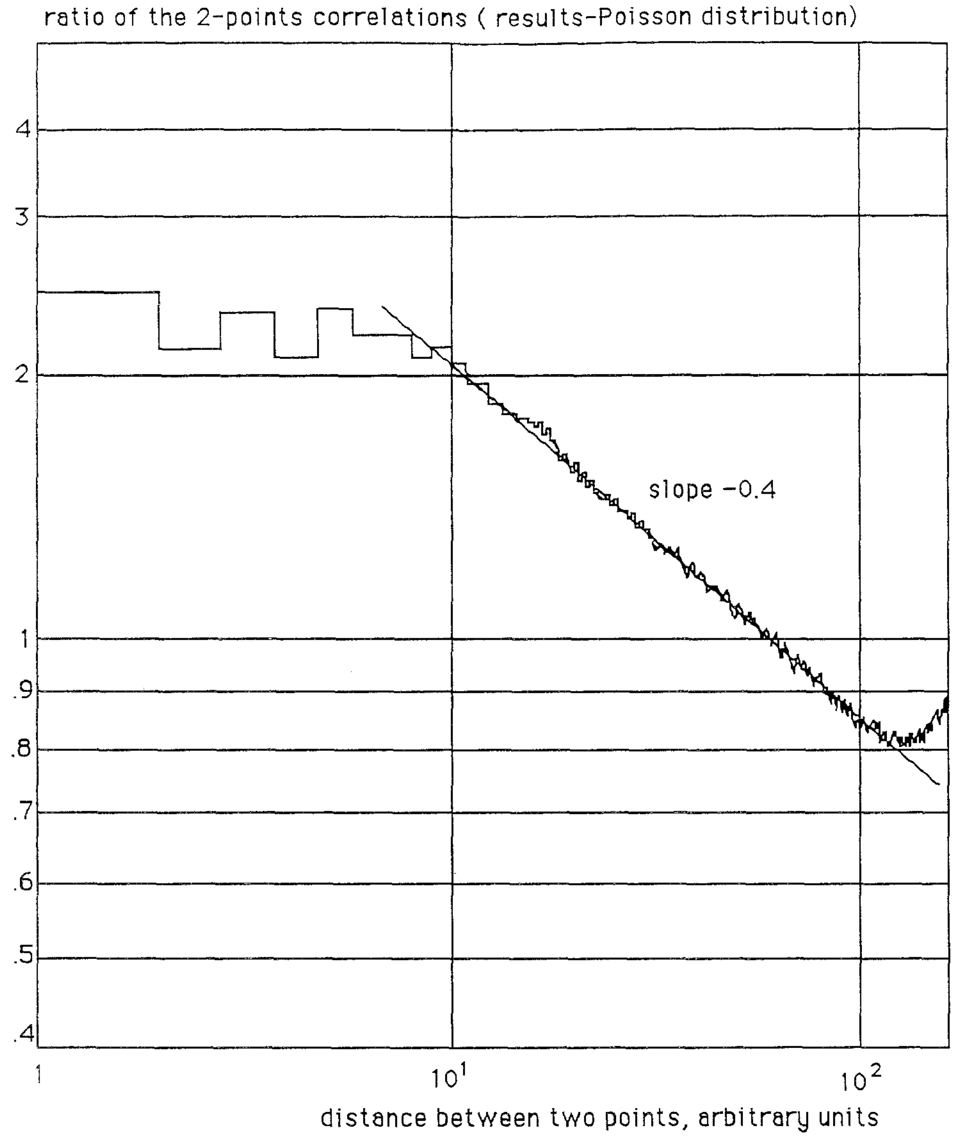

Fig. 6. The slope of the curve of the 2-points correlations ratio (numerical simulation versus Poisson random distribution).

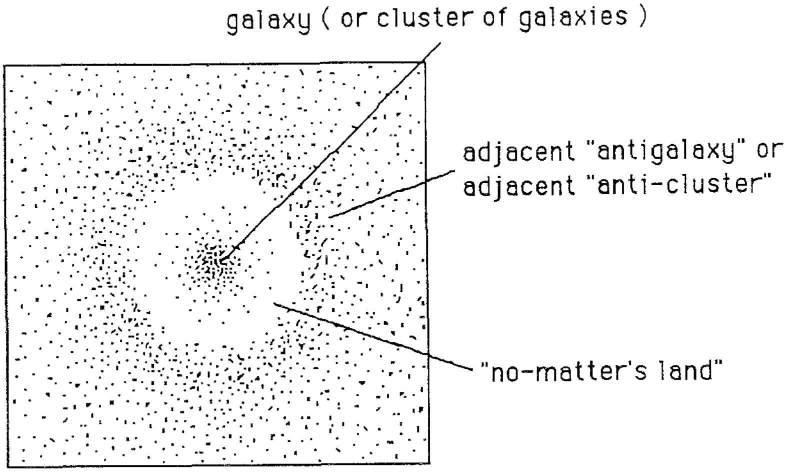

Fig. 7. Concentration of mass confined by the action of the surrounding antipodal matter from $2d$ numerical simulations.

$$\Psi = -\frac{GM}{r} \tag{5}$$

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

$$g_{00} \approx 1 - \frac{2GM}{rc^2} \tag{6}$$

whence:

$$m = \frac{GM}{c^2} \text{ (positive or negative)} \tag{7}$$

If M is positive the characteristic Schwarzschild length is

$$R_s = \frac{2GM}{c^2} \tag{8}$$

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

$$m < 0 \quad M = \frac{mc^2}{G} < 0 \quad R_s = -\frac{2GM}{c^2} > 0 \tag{9}$$

The trajectory, in polar coordinates, corresponds to:

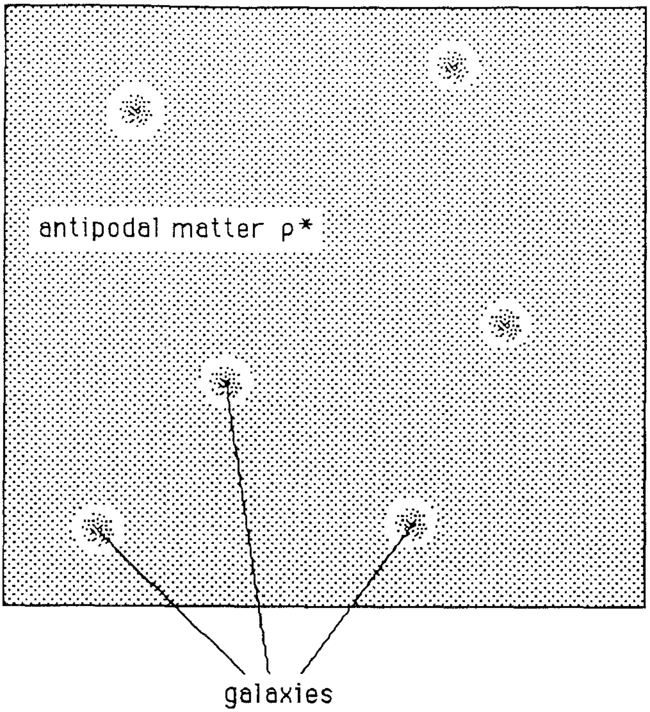

Fig. 8. Galaxies nesting in a wide antipodal matter cloud (the galaxy and the antipodal matter repel each other).

$$\varphi = \varphi_0 + \int_{u_0}^{u} \frac{du}{\sqrt{\frac{c^2 l^2 - 1}{h^2} + \frac{2m}{h^2}u - u^2 + 2mu^3}} \tag{10}$$

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

$$\varphi = \varphi_0 + \int_{u_0}^{u} \frac{du}{\sqrt{\frac{c^2 l^2}{h^2} - u^2 + 2mu^3}} \tag{11}$$

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

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

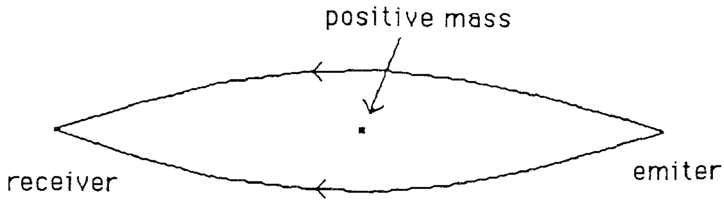

Fig. 9. Classical (positive) gravitational lensing.

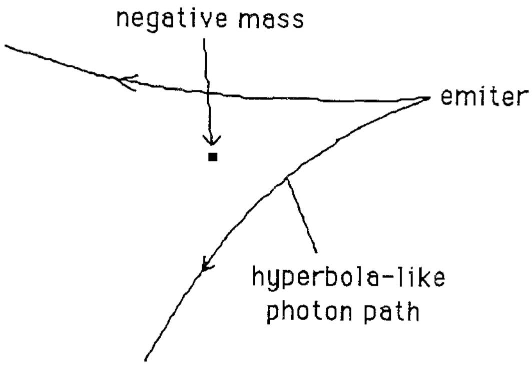

Fig. 10. Negative lensing effect due to a 'negative' mass.

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:

Notice that these hyperbolic paths are familiar to specialists of plasma physics ($e - e$ or $p - p$ scatterings).

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

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

Qualitatively this is equivalent to the effect due to a homogeneous sphere of positive mass. See Figure 13.

Classically one uses the gravitational lensing to evaluate the so-called invisible mass contained in a galaxy. People used 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 invisible mass in a

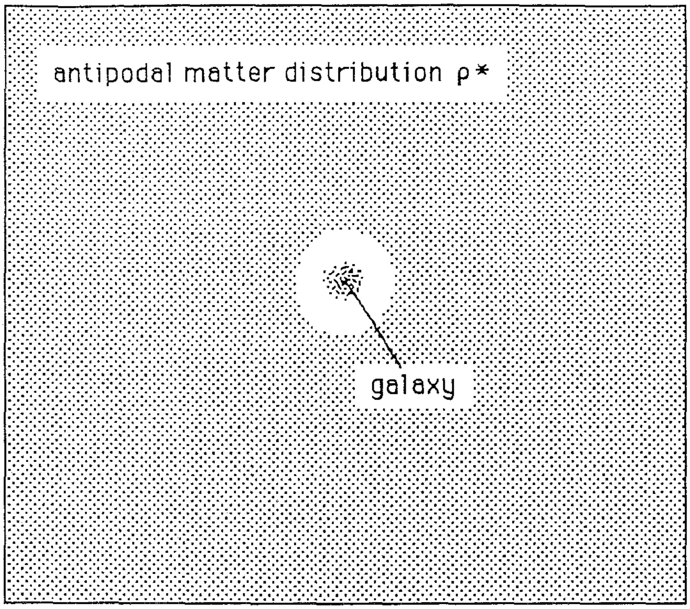

Fig. 11. A galaxy nesting in an homogeneous cloud of antipodal matter.

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.

In our galaxy the mass necessary to prevent the explosion by centrifugal force is about 10 times higher than 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 quite general in the region of the universe we live in. All the neigbour galaxies could then be surrounded by dense halos of antipodal matter, and the observed gravitational lensing should be due mostly to the antipodal material rather 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.

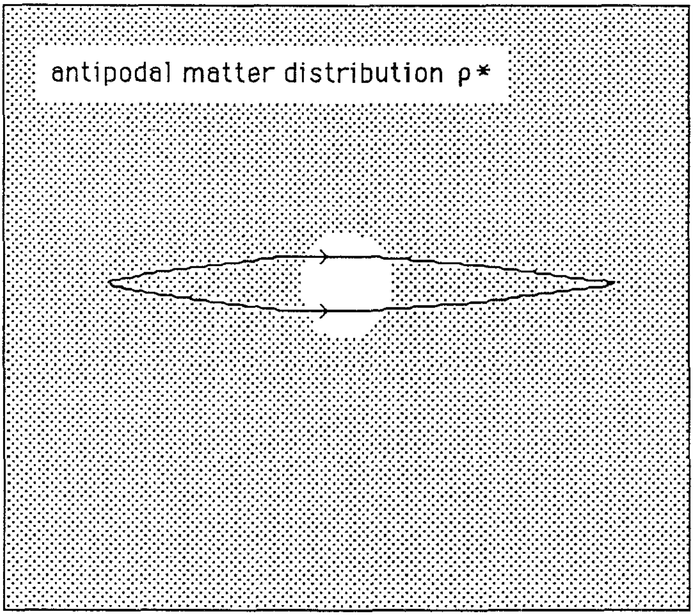

Fig. 12. Induced positive gravitational lensing effect.

4. 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:

$$g_{\mu\nu} = g_{\mu\nu}^{(L)} + \varepsilon\gamma_{\mu\nu} \tag{12}$$

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

$$\left(\frac{ds}{dx^\circ}\right)^2 \cong (1 + \varepsilon\gamma_{\infty}) \tag{13}$$

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

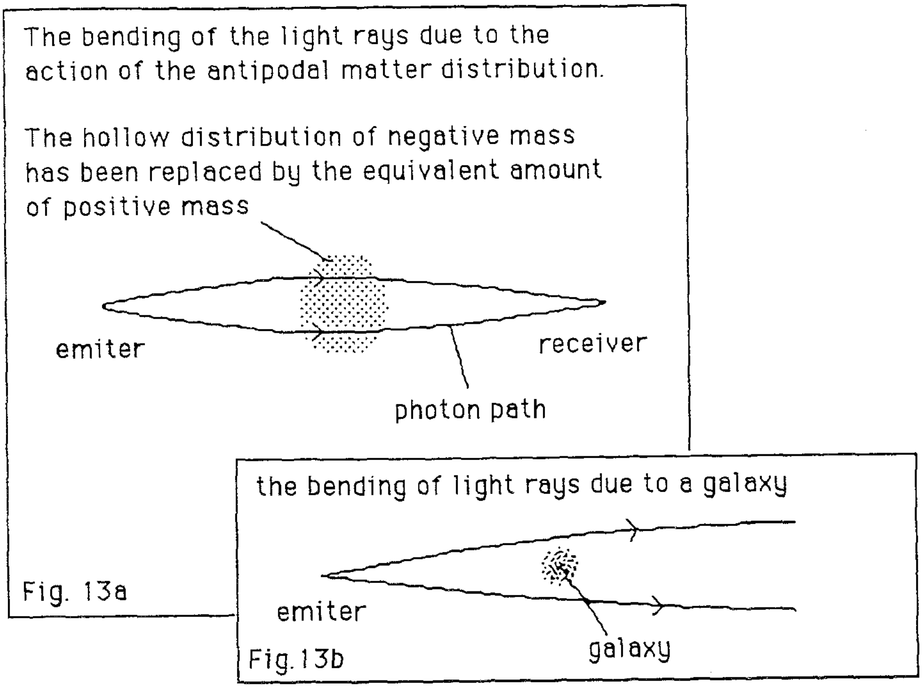

Fig. 13. 13a: Positive gravitational lensing effect due to the distribution of antipodal matter (acting like a negative mass). We have replaced the hollow by an equivalent amount of positive mass. Compared positive lensing due to a galaxy (Fig. 13b).

$$\frac{d^2x^\alpha}{ds^2} + \begin{pmatrix} & \alpha & \\ \eta & & \tau \end{pmatrix} \frac{dx^\eta}{ds}\,\frac{dx^\tau}{ds} = 0 \tag{14}$$

And then we get

$$\frac{d^2x^\alpha}{ds^2} + \begin{Bmatrix} & \alpha & \\ \circ & & \circ \end{Bmatrix} \left(\frac{dx^\circ}{ds}\right)^2 = 0 \tag{15}$$

Beyond the steady state conditions, one uses to write:

$$dx^\circ = c\,dt \tag{16}$$

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

$$\begin{Bmatrix} & \alpha & \\ 0 & & 0 \end{Bmatrix} = \tfrac{1}{2}\varepsilon\,\gamma_{00|\alpha} \tag{17}$$

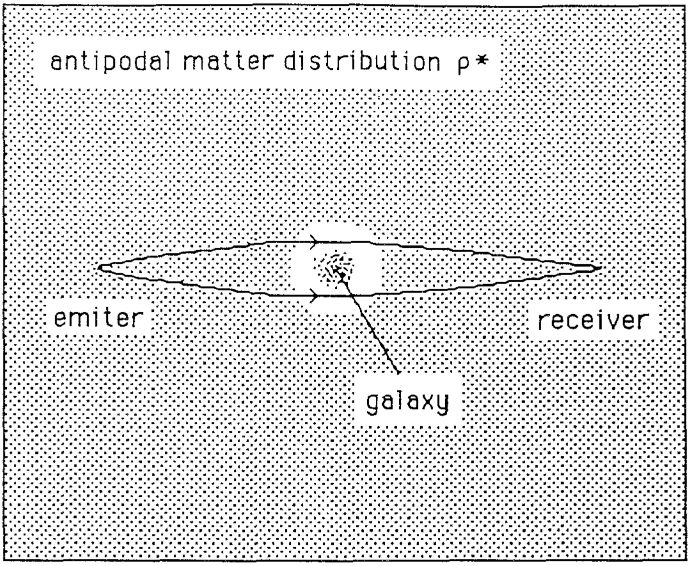

Fig. 14. Combination of the two positive gravitational lensing effect due to the galaxy and to the surrounding antipodal matter.

The geodesic equation becomes:

$$\frac{d^2x^\alpha}{dt^2} = -\frac{c^2}{2}\,\varepsilon\,\gamma_{00}|\alpha \tag{18}$$

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

$$\Psi = \frac{c^2}{2}\,\varepsilon\,\gamma_{00} \text{ or } g_{00} \cong 1 + \frac{2\Psi}{c^2} \tag{19}$$

If we consider a medium with low density ρ_0 and low velocity, the matter energy tensor reduces to:

$$\mathbf{T} = \begin{vmatrix} \rho_0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{vmatrix} \tag{20}$$

whose trace is ρ_0. Then the second member of the field equation becomes:

$$\chi(T_{\mu\nu} - \tfrac{1}{2}g_{\mu\nu}T) = \frac{\chi\rho_0}{2}\,\delta_{\mu\nu} \tag{21}$$

Still in steady hypothesis condition, we get:

$$\varepsilon \sum_{i=1}^{3} \gamma_{00|i|i} = -\chi\rho_0 \tag{22}$$

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

$$\chi = -\frac{8\pi G}{c^2} \tag{23}$$

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 $\partial\mathrm{T} = 0$, which provides conservation equations of physics. But let us point out that the constancy of χ does not require separately 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:

$$\frac{G}{c^2} \approx \text{constant} \tag{24}$$

This idea was suggested by this 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. Troitskii [11].

5. The Robertson-Walker Metric

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

$$ds^2 = (dx^\circ)^2 - e^{g(x^\circ)} \frac{1}{\left(1 + \frac{k}{4}\frac{r^2}{r_\circ^2}\right)^2} (dr^2 + r^2\, d\theta^2 + r^2\ \sin^2\theta\, d\varphi^2) \tag{25}$$

If the Universe is assumed to be homogeneous, then $\mathbf{T} = A(\mathbf{T})$ and the spatially homogeneous cosmological solution comes from:

$$\mathbf{S} = \chi(\mathbf{T} - A(\mathbf{T})) = 0 \tag{26}$$

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

$$\left(\frac{dR}{dx^\circ}\right)^2 + k = 0 \tag{27}$$

$$\frac{2}{R}\frac{d^2R}{dx^{\circ 2}} + \frac{k}{R^2} - \frac{1}{R^2}\left(\frac{dR}{dx^\circ}\right)^2 = 0 \tag{28}$$

From (27) and (28) we get

$$k = -1 \text{ (negative curvature)} \quad \text{and } R = x^{\circ} \tag{29}$$

x° is a 'chronological marker'. Notice that one has 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.

6. A Model with 'Variable Constants'

The hypothesis of the constancy of the so-called constants of physics was first challenged by Milne [15]; then by other 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] (developed ideas mainly based on the variation of G). Time-dependent G has also considered by Brans and Dicke [22]; and 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 approaches focused on the variation of a certain number of 'constants', not of all the constants, in a combined fashion, are developed in the present paper. H. Reeves [27] studied the impact of the separate variations of the constants, one after the 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 tried 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 for laws that let the equations of physics be invariant, so that these variations cannot be evidenced in local lab experiments. These equations follow.

The Schrödinger equation:

$$-\frac{h^2}{2m}\,\Delta\Psi + U\Psi = i\,\frac{h}{2\pi}\,\frac{\partial\Psi}{\partial t} \tag{30}$$

The Boltzmann equation:

$$\frac{\partial f}{\partial t} + \mathbf{v}\cdot\frac{\partial f}{\partial \mathbf{r}} - \frac{\partial \phi}{\partial \mathbf{r}}\,\frac{\partial f}{\partial \mathbf{v}} = \int (f' f'_1 - f f_1)\, g\, a\, da\, d\omega\, d^3\mathbf{v} \tag{31}$$

where f is the distribution function of the velocity $\mathbf{v}$, $\mathbf{r} = (x, y, z)$, t the time, (g, a, ω) the classic impact parameters of a binary collision.

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

$$\Delta\phi = 4\pi G(\rho - \rho^*) \tag{32}$$

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

The (new) field equation

$$\mathbf{S} = \chi(\mathbf{T} - \mathbf{T}^*) \tag{33}$$

where:

$$\chi = -\frac{8\pi G}{c^2} \tag{34}$$

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

The Maxwell equations are:

$$\nabla \times \mathbf{B} = \frac{1}{c^2}\,\frac{\partial \mathbf{E}}{\partial t} \tag{35}$$

$$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t} \tag{36}$$

$$\nabla \cdot \mathbf{B} = 0 \tag{37}$$

$$\nabla \cdot \mathbf{E} + \frac{\rho_e}{\varepsilon_0} = 0 \tag{38}$$

$\mathbf{E}$ and $\mathbf{B}$ 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 an example, the Poisson equation, for gravitation (32), comes from the field equation (33), see [1].

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

The Schrödinger equation (30), with:

$$\mathbf{r} = R\xi \quad \nabla = \frac{1}{R}\,\delta \quad t = T\tau \tag{39}$$

$$U = \frac{h^2}{2mR^2}\,u \tag{40}$$

becomes:

$$-\frac{h^2}{2mR^2}\,(\delta^2\Psi + u\Psi) = i\,\frac{h}{2\pi T}\,\frac{\partial \Psi}{\partial \tau} \tag{41}$$

The Boltzmann equation (31), with:

$$\mathbf{v} = c\zeta \quad \mathbf{r} = R\xi \quad g = c\gamma \quad a = R\alpha \tag{42}$$

$$f = \frac{n}{\langle V\rangle^3}\,e^{\frac{-v^2}{\langle V\rangle^2}} \tag{43}$$

$$f = \frac{1}{R^3 c^3}\,\eta \tag{44}$$

$$f = \frac{1}{R^3 c^3}\,\eta \quad n = \frac{1}{R^3}\,\varpi \quad \phi = \frac{GM}{R}\,\varphi \tag{45}$$

becomes:

$$\frac{1}{T}\frac{\partial \eta}{\partial \tau} + \frac{c}{R}\frac{\partial \eta}{\partial \xi} - \frac{Gm}{R^2 c}\frac{\partial \phi}{\partial \xi}\cdot\frac{\partial \eta}{\partial \zeta} = \frac{c}{R}\int (\eta'\eta'_1 - \eta\eta_1)\,\gamma\alpha\,d\alpha\,d\omega\,d^3\zeta \tag{46}$$

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

$$\phi = \frac{Gm}{R}\,\varphi \quad n = \frac{1}{R^3}\,\varpi \quad n^* = \frac{1}{R^3}\,\varpi^* \tag{47}$$

$$\frac{Gm}{R^3}\,\delta^2\varphi = 4\pi\,\frac{Gm}{R^3}\,(\varpi - \varpi^*) \tag{48}$$

becomes:

$$\delta^2\varphi = 4\pi(\varpi - \varpi^*) \tag{49}$$

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

$$\nabla = R\delta \quad t = T\tau \quad \mathbf{B} = B^*\beta \quad E = E^*\varepsilon \quad \rho_e = \frac{e}{\varepsilon_0 R^3}\,\varpi_e \tag{50}$$

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

$$\frac{B^*}{R}\,\delta\times\beta = \frac{E^*}{c^2 T}\frac{\partial \varepsilon}{\partial \tau} \tag{51}$$

$$\frac{E^*}{R}\,\delta\times\varepsilon = -\frac{B^*}{T}\frac{\partial \beta}{\partial \tau} \tag{52}$$

$$\delta\cdot\beta = 0 \tag{53}$$

$$\frac{E^*}{R}\,\delta\cdot\varepsilon + \frac{e}{\varepsilon_0 R^3}\,\varpi_e = 0 \tag{54}$$

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

$$h,\ m,\ c,\ G \tag{55}$$

The invariance of the Schrödinger equation is ensured if:

$$\frac{hT}{mR^2} = Cte \tag{56}$$

The Boltzmann equation is invariant if:

$$\frac{1}{T} \approx \frac{c}{R} \approx \frac{Gm}{R^2 c} \tag{57}$$

The Poisson equation for gravitation poses no particular problem and just becomes

$$\delta^2 \varphi = 4\pi(\varpi - \varpi^*) \tag{58}$$

From the Maxwell equations we get:

$$R \approx cT \tag{59}$$

$$\frac{E^*}{R} = \frac{e}{\varepsilon_0 R^3} \tag{60}$$

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

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

$$G \approx c^2 \tag{61}$$

If not, the equation is no longer divergenceless.

If the quantities:

$$h,\ m,\ c,\ G,\ R,\ T \tag{62}$$

obey these relations, *it will not be possible to have evidence of their variations in any in-lab experiment.*

So what?

From (57) we get immediately:

$$\frac{Gm}{c^2} \approx R \tag{63}$$

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

$$R_s \approx R \tag{64}$$

Examine now the Jeans' length:

$$L_j = \frac{\langle V \rangle}{\sqrt{4\pi G \rho m}} \tag{65}$$

where:

$$\langle V \rangle = c \langle \zeta \rangle$$

$$L_j = \frac{c R^{3/2}}{\sqrt{Gm}} \frac{\langle \zeta \rangle}{\sqrt{4\pi\varpi}} \tag{66}$$

$$\frac{Gm}{c^2} \approx R \quad \frac{c}{\sqrt{Gm}} \approx \frac{1}{\sqrt{R}} \quad L_j = R\,\frac{\langle\zeta\rangle}{\sqrt{4\pi\varpi}} \tag{67}$$
$$L_j \approx R$$

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

$$\frac{hT}{mR^2} = \frac{h}{mR^2}\,\frac{R}{c} = Cte \tag{68}$$
$$\frac{h}{mc} \approx R$$

The Compton Length varies like R:

$$R_c \approx R \tag{69}$$

The Planck length is:

$$L_p = \sqrt{\frac{hG}{c^3}} = \sqrt{\frac{h}{c}\,\frac{G}{c^2}} \tag{70}$$
$$L_p \approx R$$

The Planck time is:

$$t_p = \sqrt{\frac{hG}{c^5}} = \frac{R}{c} \approx T \tag{71}$$

The Jeans time is:

$$t_J = \frac{1}{\sqrt{4\pi G\rho}} \approx T \tag{72}$$

Combining (61) and (63) we get:

$$m \approx R \tag{73}$$

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:

$$\rho = nm = \frac{\varpi}{R^3}\,m \quad \rho \approx \frac{1}{R^2} \tag{74}$$

This is the same law for the contribution ρ_r of the radiation to the density ρ. The conservation of the radiative energy gives:

$$p_r R^3 = \text{constant} \tag{75}$$

Then:

$$p_r = \frac{\rho_r c^2}{3} \rightarrow \rho_r \approx \frac{1}{R^2} \tag{76}$$

7. The Variation of the Constants of Physics in the Framework of an Hypothesis of Generalized Conservation of the Energies

In the standard model of the Universe the mass is conserved, but not the energy. The energy-matter is composed both by massive particles and by photons. Each owns a mass-density, respectively: ρ_m and ρ_r. Today:

$$\rho_m \gg \rho_r \tag{77}$$

The pressure is a density of energy. Today we have:

$$p_m \ll p_r \tag{78}$$

In the standard model we impose the conservation of the mass mc^2, not the conservation of the energy of the cosmic background photons $h\nu$, which varies like $1/R$. Let us consider the opposite hypothesis and conserve the energy, but not the mass. Then:

$$mc^2 = Cte \tag{79}$$

whence:

$$c \approx \frac{1}{\sqrt{R}} \tag{80}$$

We get a model where the velocity of the light is no longer considered an absolute constant. *But, as we insist above, this cannot be evidenced in a laboratory*, for the 'constants' involved in the considered phenomena, according to our hypothesis, follow this process too.

In addition:

$$G \approx \frac{1}{R} \tag{81}$$

$$h\nu \approx \frac{h}{T} = Cte \quad h \approx T \tag{82}$$

Anyone of the considered parameters: G, c, m, R, h, T can be chosen as an evolution parameter. If we take T as an evolution parameter (V.S. Troistkii [28] considered c as an evolution parameter), we get:

$$
\begin{aligned}
&R \approx t^{2/3} \\
&G \approx t^{-2/3} \\
&m \approx t^{2/3} \\
&h \approx t \qquad\qquad (83) \\
&c \approx t^{-1/3} \\
&\rho \approx t^{-4/3} \\
&v \approx t^{-1/3} \\
&L_j \text{ (Jeans)} \approx L_p \text{ (Planck)} \approx L_c \text{ (Compton)} \approx R_s \text{ (Schwarzschil)} \approx R
\end{aligned}
$$

All these lengths vary like $t^{2/3}$.
In addition we have:

$$t_j \text{ (Jeans)} \approx t_p \text{ (Planck)} \approx T \tag{84}$$

And:

$$\frac{mc^2}{\sqrt{1-\frac{v^2}{c^2}}} = Cte \quad h\nu = Cte \tag{85}$$

We get a model in which all the characteristic lengths vary like R and all the characteristic times vary like T.

For an example, if we consider a two-bodies system, orbiting around their common center of gravity, we find that the radius of the orbit varies like R and the orbitation period varies like T.

Now, what could be the observational consequences of such a model?

This process cannot be evidenced in a lab. The only observable effect is the red shift.

8. The Red Shift as an Observational Effect due to the Secular Variation of the Constants of Physics. The Question of the Expansion of the Universe

We will identify the parameter T to the cosmic time t, running the events of the universe. According to our hypothesis, the energy of a travelling photon is conserved, but as

$$h \approx t$$

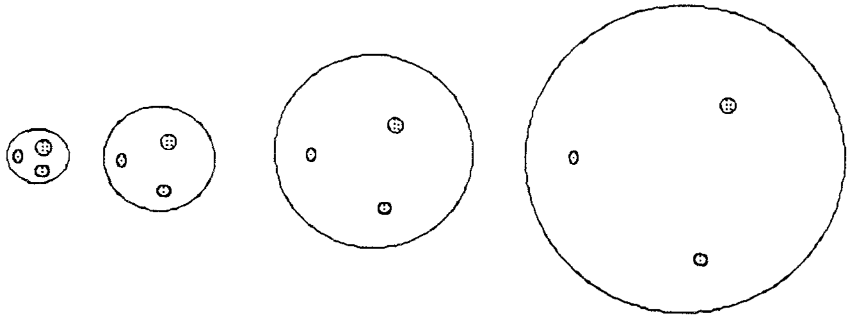

Fig. 15. Standard model: the containment expands, not the contents.

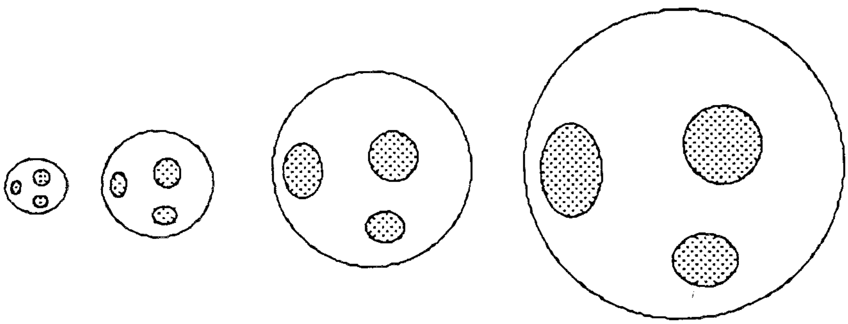

Fig. 16. Present model, both expand (the concept of an expansion looses its significance, for there is no longer a reference scale).

then

$$\nu \approx \frac{1}{t} \tag{86}$$

This idea was first introduced by E.A. Mine [15]. In an astronomical observatory we measure the frequency of the received photon and we find a red shift, that we interpret in terms of the variation of its energy, due to an expansion process. But if we consider that the energy is conserved over its long flight this red shift effect can be reinterpreted in terms of the secular variation of the Planck constant.

We then ask 'is the Universe expanding?' this questions falls, for all the objects of the Universe follow the above process: the massive bodies, the stars, the galaxies, and the Universe itself.

If we consider that the Universe is expanding, it implies that its content (the particles, the galaxies) does not expand in time, in order to have a reference scale.

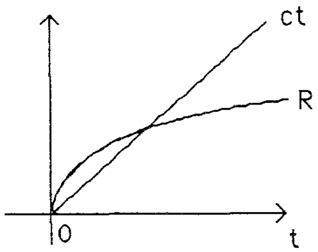

Fig. 17. Comparison of the evolution of the characteristic length of the Universe with the cosmological horizon, in an Eintein-de Sitter model.

If the contents of the Universe undergoes the same process as the Universe itself (a gauge process) the question of the expansion becomes irrelevant.

In the present model, in the laboratory, the instruments vary like any length we want to measure, for both follow the process. The question of the expansion becomes irrelevant and the only observable phenomenon, evidencing the cosmic evolutions is the red shift, which is no longer connected to the Doppler-Fizeau effect, but to the secular variation of h, combined to the hypothesis of the conservation of the photon energy $h\nu$ during its flight.

9. The Problem of the Cosmological Horizon

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

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

$$H = \int_0^t c(\tau)\, d\tau \approx t^{2/3} \approx R \tag{87}$$

If the Universe was homogeneous at the beginning, the collisional process, always present, tends to maintain this homogeneity. If it was not, it tends to smooth it. This constitutes 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.

Fig. 18. Comparison 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.

10. 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:

$$t = \text{constant } (x^\circ)^{3/2} \tag{88}$$

The dimension of the constant is:

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

In the standard definition of the cosmic time from

$$t = \text{constant } x^\circ \quad (x^\circ = ct)$$

the dimension of the constant is

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

11. Entropy as a Better Chronological Marker

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

$$s = \frac{k}{n} \int_{?} f \operatorname{Log} f \, du \, dv \, dw \tag{89}$$

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:

$$s \approx \frac{3}{2} \, k \operatorname{Log} R \approx \operatorname{Log} t \tag{90}$$

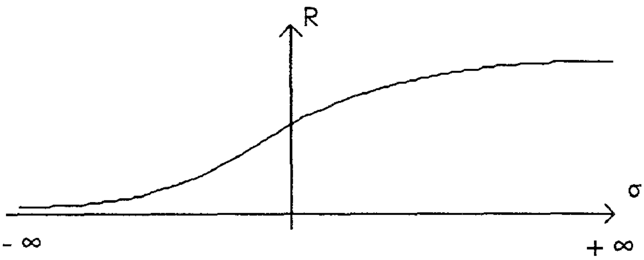

Fig. 19. The evolution of the curvature radius R of the Universe versus the entropy.

If $R(t)$ is an increasing function of t, the cosmic entropy grows like the cosmic time. In lab 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 that such enormous change in time would go with zero entropy variation. In the present model when the time t tends toward zero, s tends toward $-\infty$.

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

$$\sigma = \frac{2}{3}\,\mathrm{Log}\,t \tag{91}$$

we get:

$$dt = 3/2\,t\,d\sigma \tag{92}$$

Let us return to the Robertson Walker metric.

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

We get, with $R = 3/2ct$:

$$dS^2 = R^2\left\{d\sigma^2 - \frac{du^2 + u^2\,d\theta^2 = \sin^2\,\theta\,d\varphi^2}{\left(1 - \frac{u^2}{2}\right)^2}\right\} \tag{93}$$

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

In the classical description (t, σ) the physicist, when t tends to zero, has some difficulty defining any material clock, for the velocities of the particles tend toward c. In a 'variable constant cosmological 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 find that the associate characteristic hypervolume $R^3 c^3$ varies like t.

12. The Red Shift and the Robertson-Walker Metric with a Variable Light Velocity

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

$$E_i \approx R^\gamma \tag{94}$$

Then we find:

$$1 + z = \left(\frac{R_2}{R_1}\right)^\gamma \tag{95}$$

The value $\gamma = 1$ is chosen in order to fit with the classical value.
Then, expanding the function $1/R(t)$ into a series with respect to

$$\varepsilon = \frac{c_2(t - t_2)}{R_2} \tag{96}$$

we get:

$$c_2 z \cong (2 - \gamma)\, \frac{R_2'}{R_2}\, d_2 \tag{97}$$

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

$$t = \frac{2}{3}\, \frac{d_2}{c_2 z} \tag{98}$$

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

$$d_2 = R_2 u = \frac{3}{2}\, c_2 t_2\, \frac{(1 + z)^2 - 1}{(1 + z)^2 + 1} \tag{99}$$

When z tends towards infinity we find the cosmological horizon $3/2c_2t_2$, which is twice as small as the standard value $3c_2t_2$. If we compare the present model to the EdS model, we get, for the distances, the ratio:

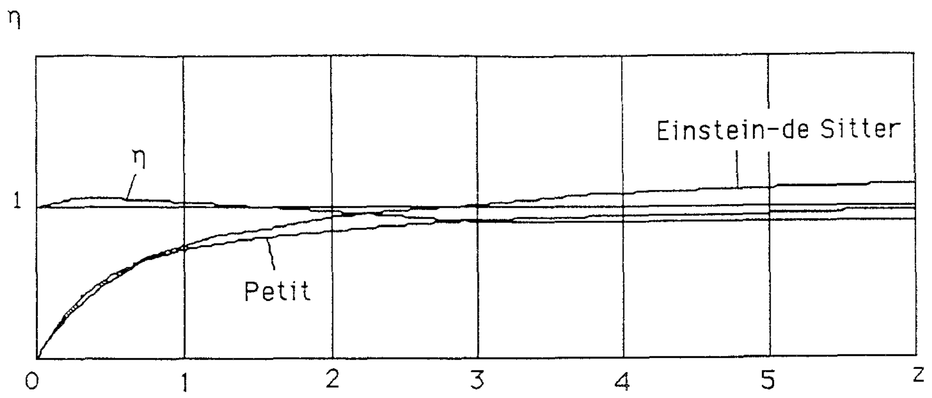

Fig. 20. The distances for the present model and for the Einstein-de Sitter model, and the ratio η of these distances, versus the red shift.

$$\eta = \frac{(1+z)^2 - 1}{(1+z)^2 + 1} \frac{1}{2 - \dfrac{2}{\sqrt{1+z}}} \tag{100}$$

They are similar for weak z values, as shown in 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 toward 0.5 when z tends toward infinity. For $z < 2.5$ the difference between the two distance evaluations is less than 5%.

For 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:

$$\phi = \phi_0 \frac{(1+z)^2}{(1+z) - \sqrt{1+z}} \tag{101}$$

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.

In the present model, the situation is basically different, for the objects are supposed to expand with the Universe. See Figure 22.

The corresponding formula is:

$$\phi = \phi_0 \frac{(1+z)^2 + 1}{(1+z)^2 - 1} \tag{102}$$

When z tends toward infinity, ϕ tends to be constant.

Notice that in our model:

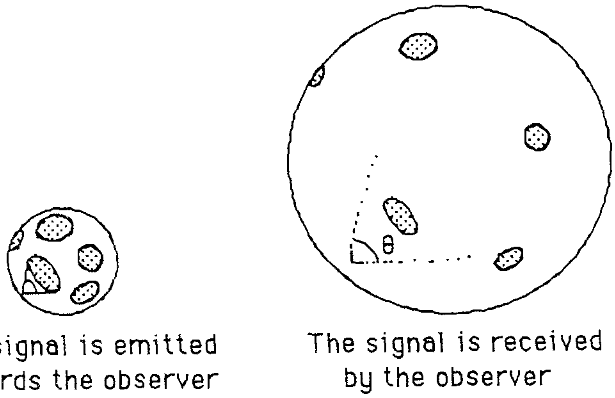

Fig. 21. Why the classical model overestimates the angular size of large red shift objects. The measure, at the reception time, corresponds to a 'fossil' angular size, when the object was closer.

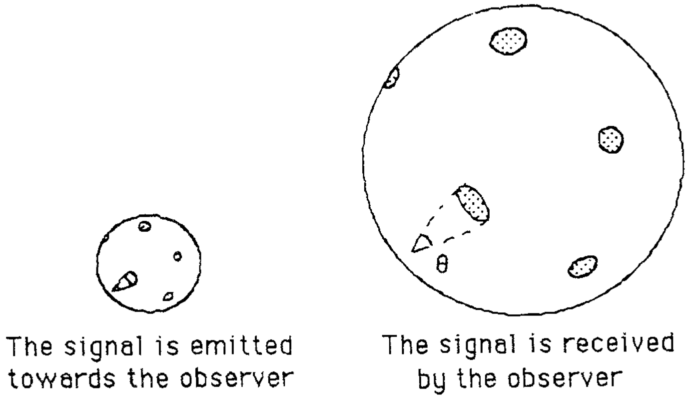

Fig. 22. Present model: The light moves along geodesics. The angular size is unchanged.

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

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 validate the model. See the discussion in reference [14].

13. The Light Emission Problem

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

$$\nu = nQv \tag{103}$$

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

$$n \approx \frac{1}{R^3} \quad Q \approx R^2 \quad V \approx \frac{1}{\sqrt{R}} \tag{104}$$

which gives:

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

Assume now that the characteristic amount of energy E_i, for this energy production reaction would vary like $R(t)$.

The energy emission rate varies like:

$$P \approx \frac{R}{t} \approx c \approx \frac{1}{\sqrt{R}} \tag{105}$$

As such 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 and plot $\mathrm{Log}(P) - 0.5\,\mathrm{Log}\,(1+z)$ when find something quite constant.

14. Some Remarks about other Possible Comparison to Observational Material

14.1. 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 tests and the present model. In effect, 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 the second term of the second member of the equation (1) can be neglected:

$$\mathbf{S} = \chi(\mathbf{T} - A(\mathbf{T})) \approx \chi\mathbf{T} \tag{106}$$

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.

14.2. 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:

$$\mathbf{S} = \chi \mathbf{T} \tag{107}$$

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

15. The Problem of Electromagnetism and other Features of Physics

We propose a new cosmological model. As said before, basically, this model does not contain the electromagnetic nor strong or weak interaction phenomena and this is the same for the classical model. Something 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 (this was examined by the author in the formal paper [13], Section 9). The same thing goes for the strong and weak interactions and their associated characteristic lengths (in order to give a new and complete description of the cosmic evolution, including the nucleosynthesis, one should introduce, in this constant energy model, corresponding time-dependant 'constants').

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

$$\mathbf{S} = \chi(\mathbf{T} + \Lambda \mathrm{g} - A(\mathbf{T}) - \Lambda A(\mathrm{g})) \tag{108}$$

or:

$$\mathbf{S} = \chi(\mathbf{T} + \Lambda \mathrm{g} - \mathbf{T}^* - \Lambda \mathrm{g}^*) \tag{109}$$

where $\mathbf{T}^*$ and $\mathrm{g}^* = A(\mathrm{g})$ are respectively the stress tensor and the metric tensor associated to the conjugated antipodal region.

This work suggests only that the geometry of the universe could be somewhat different from our standard vision. Perhaps a unified model (gravitation plus electromagnetism) could be built, by introducing complex tensors $\mathbf{S}$, $\mathbf{T}$ and $A(\mathbf{T})$ in the equation (1). On another hand, one can shift from a $S3 \times R1$ 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 take account of the matter-antimatter duality (the antipodal matter would behave like antimatter and become the lost 'cosmological antimatter', as suggested by Andréi Sakharov and Novikov in 1967 [36,37] and the authors [38,39 and 40]). But this, we confess, is a hard mathematical task.

In a Kaluza model we consider a 5 dimensional manifold. Then the electromagnetism can be introduced, from what source or origin no-one 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 as in 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 explanation of the spongy, very large structure of the Universe and is an alternative to the classical pancakes theory, for our structures are stable over a period of time comparable to the age of the Universe. Then we developed a theory of inverse gravitational lensing: the observed lensing effects could be due mainly 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 $\mathbf{S} = \chi(\mathbf{T} - A(\mathbf{T}))$ we have developed a cosmological model with 'variable constants'. Because of the hypothesis of homogeneity ($\mathbf{T} = A(\mathbf{T}$ = constant over space) the metric must be a 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 $R \approx t$, 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 characteristic length R, from where all the characteristic times vary like the cosmic time t.

As the energy of the photon $h\nu$ 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 have 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 $s \approx \operatorname{Log} t$. 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, 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 in the first. Obviously, a single test cannot validate such a model.

Acknowledgement

The author thanks Professor Oaxiiboo F. for useful suggestions and critic.

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