2. On a Dynamic Equilibrium for the Distribution of the Gravitational Force in Cosmological Space

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Introduction

In Section 1, the Universe is defined as a finite space that contains a finite number of gravitationally bound collections of matter, with no attempt to define any changes over time. In this section, the model of that universe is dynamic, but defined to contain a single collection of matter, defined as point-mass, inside a region undergoing contraction.

The mass is defined to be at the center of a space containing: 1) a region in a state of continual and constant *negative gravitational contraction*, 2) a boundary where the net gravitational force equals zero, and 3) the total energy contained within the zero boundary is hypothesized to equal the total energy outside the boundary, where the space is in a state of continual and constant *positive gravitational expansion* over time.

2.1 Gravitational Acceleration over Cosmological Time

Starting with the inverse square law of force, where the numerator expresses the product of a standard-mass (M), a negligible reference-mass (m), and the Universal Gravitational Constant (G) and thus determines the gravitational force for every distance,

$$f(r) = -\frac{K}{r^2}, \qquad K = GMm \tag{1}$$

assume the existence of a non-zero, positive constant;

$$f(r) = -\frac{K}{r^2} + B, \quad B = \frac{K}{b_0^2}, \tag{2}$$

Here B is a numeral not a function, and b_0 represents the distance from the point-mass where the force is null, and beyond which it is positive. See Section 1.

Divide out the reference-mass (m), and obtain an expression for the acceleration with respect to distance variable, r :

$$a(r) = -\frac{k}{r^2} + \frac{k}{b_0^2}, \qquad k = GM \tag{3}$$

The theory examines the change of this acceleration function, equation (3), as a function of time under the boundary constraints of Section 1, so that in this universe containing a single point-mass, the acceleration vector can be determined at any point in space-time. It is imagined that the single point-mass is at the center of the source of negative gravitation, ie. a collection of particles whose mean distance of separation decreases over time, like a contracting gas cloud.

For reasons to be explained concurrently with the development of the theory, the function $a(r,t)$, takes the following form. See Figure 1:

$$a(r,t) = -\frac{k \cdot t}{r^2} + \frac{k}{b_0^2 \cdot t}, \qquad k = GM \tag{4}$$

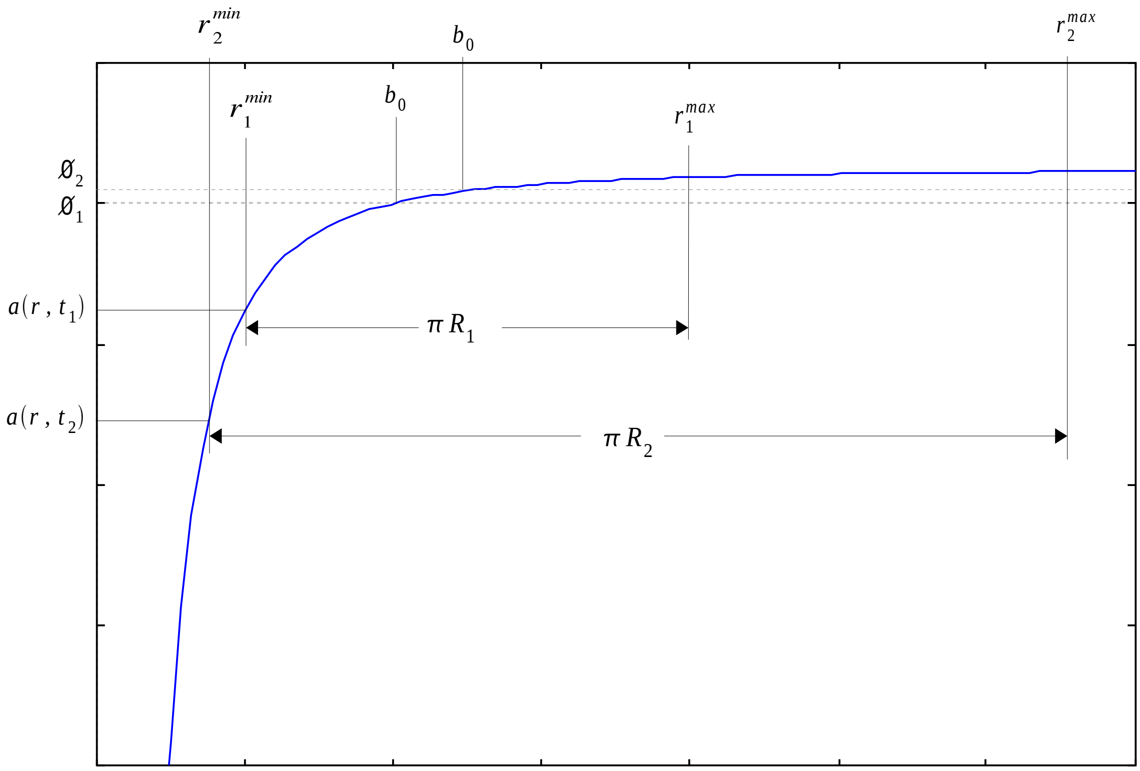

Fig.1 *Values* $a(r,t)$; πR_n *= half the circumference of the Universe*

This function can be represented as a vector product of an acceleration vector and a time vector,

$$\vec{\boldsymbol{T}} = \frac{\mathbb{Q}}{t}\,\boldsymbol{i_1} - \mathbb{R} \cdot t\,\boldsymbol{i_2} \tag{5}$$

$$\vec{\boldsymbol{A}} = -\frac{k}{r^2}\,\boldsymbol{i_1} + \frac{k}{b_0^2}\,\boldsymbol{i_2}, \tag{6}$$

The scalars $\mathbb{Q}$, and $\mathbb{R}$, characterize $\vec{T}$ as unique, expressing the magnitudes of the time components relative to each other and to the components in $\vec{A}$; equation (4) would be rewritten as follows:

$$a(r,t) = -\frac{k \cdot \mathbb{R}\, t}{r^2} + \frac{k \cdot \mathbb{Q}}{b_0^2 \cdot t}, \qquad k = GM \tag{7}$$

The following two vector products, containing the function *a(r,t)* will be used interchangeably:

$$\vec{\boldsymbol{T}} \times \vec{\boldsymbol{A}} = \vec{V} \neq \vec{\boldsymbol{A}} \times \vec{\boldsymbol{T}} \tag{8}$$

$$\vec{\boldsymbol{T}} \times \vec{\boldsymbol{F}} = m\vec{V} \tag{9}$$

Equation (7) can be expressed in matrix notation, with units of velocity:

$$v_k^j = \begin{vmatrix} \frac{\mathbb{Q}}{t} & -\mathbb{R} \cdot t \\ -\frac{1}{r^2} & \frac{1}{b_0^2} \end{vmatrix} \tag{10}$$

Equation (9) can be expressed in matrix notation, with units of momentum:

$$p_k^j = m \begin{vmatrix} \frac{\mathbb{Q}}{t} & -\mathbb{R} \cdot t \\ -\frac{1}{r^2} & \frac{1}{b_0^2} \end{vmatrix} \tag{11}$$

these matrices are conjectured to represent the velocity of the expansion of universe and the momentum of expansion, at all possible times and distances from gravitational sources.

Simplify v_k^j by performing the following operations: divide out k, t and $\mathbb{Q}$:

$$v_k^j = k\,\mathbb{Q} \cdot t \begin{vmatrix} \frac{1}{t^2} & -\frac{\mathbb{R}}{\mathbb{Q}} \\ -\frac{1}{r^2} & \frac{1}{b_0^2} \end{vmatrix} \tag{12}$$

Simplifying inside the brackets, both v_i^2 are scalars;

$$v_k^j = k\mathbb{Q}\cdot t \begin{vmatrix} \frac{1}{t^2} & -a^2 \\ -\frac{1}{r^2} & b^2 \end{vmatrix} ; \quad \frac{1}{b_0^2} = b^2 , \quad \frac{\mathbb{R}}{\mathbb{Q}} = a^2 \tag{13}$$

Interchanging rows with columns; $k \; \mathbb{Q}$ is also a scalar;

$$v_k^j = \Omega \cdot t \begin{vmatrix} \frac{1}{t^2} & -a^2 \\ -\frac{1}{r^2} & b^2 \end{vmatrix} ; \quad k\mathbb{Q} = \Omega \tag{14}$$

Checking the units for consistency;

$$v_k^j = m^3 \cdot sec \begin{vmatrix} sec^{-2} & sec^{-2} \\ m^{-2} & m^{-2} \end{vmatrix} ; \tag{15}$$

It is hypothesized that v_k^j is the matrix that describes the change in the distribution of the gravitational forces, both positive and negative, in a universe with a single mass whose energy of contraction equals the energy of the expansion of the surrounding space over time. However, v_k^j only provides the magnitudes of the gravitational force with respect to a particular set of coordinates r that still require an additional transformation for the integral, with respect to r, of equation (4) to be consistent with principles of energy conservation, so that -from r_{min}, where $a(r)$ is greatest, to $r = b_0$, where $a(r)$ equals zero- would be the same for all t. See Figure 1. That is, the value of the total negative gravitational energy of the system should not change and be consistent with principles of energy conservation.

Before providing this metric, we seek the inverse transformation of $\bar{v}_k^j$ which differs from v_k^j only by the linear function of t, $\Omega \cdot t$.

$$\bar{v}_k^j = \begin{vmatrix} \frac{1}{t^2} & -a^2 \\ -\frac{1}{r^2} & b^2 \end{vmatrix} \tag{16}$$

Introducing the basis vectors of $\bar{v}_k^j$:

$$\boldsymbol{p}_1 = \frac{1}{t^2} \boldsymbol{i}_1 - a^2 \boldsymbol{i}_2 \tag{17}$$

$$\boldsymbol{p}_2 = -\frac{1}{r^2} \boldsymbol{i}_1 + b^2 \boldsymbol{i}_2 \tag{18}$$

The magnitude of $\bar{v}_k^j$ is:

$$[\![v]\!] = \left[\frac{(b^2 r^2 - a^2 t^2)}{r^2 t^2} \right] \tag{19}$$

the transpose of $\bar{v}^j_k$; see Appendix B for proof:

$$\bar{V}^j_k = \begin{vmatrix} \dfrac{b^2 r^2 t^2}{(b^2 r^2 - a^2 t^2)} & \dfrac{a^2 r^2 t^2}{(b^2 r^2 - a^2 t^2)} \\ \dfrac{t^2}{(b^2 r^2 - a^2 t^2)} & \dfrac{r^2}{(b^2 r^2 - a^2 t^2)} \end{vmatrix} \tag{20}$$

can be simplified to:

$$\bar{V}^j_k = \frac{r^2 t^2}{(b^2 r^2 - a^2 t^2)^2} \begin{vmatrix} b^2 & a^2 \\ t^2 & r^2 \end{vmatrix} \tag{21}$$

with basis of $\bar{V}^j_k$:

$$\boldsymbol{p}^{\mathbf{1}} = \frac{b^2 r^2 t^2}{(b^2 r^2 - a^2 t^2)} \boldsymbol{i}_{\mathbf{1}} + \frac{t^2}{(b^2 r^2 - a^2 t^2)} \boldsymbol{i}_{\mathbf{2}} \tag{22}$$

$$\boldsymbol{p}^{\mathbf{2}} = \frac{a^2 r^2 t^2}{(b^2 r^2 - a^2 t^2)} \boldsymbol{i}_{\mathbf{1}} + \frac{r^2}{(b^2 r^2 - a^2 t^2)} \boldsymbol{i}_{\mathbf{2}} \tag{23}$$

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The symmetric tensor:

$$h_{jk} = \begin{vmatrix} \dfrac{1+a^4 t^4}{t^4} & \dfrac{-(1+b^2 a^2 r^2 t^2)}{r^2 t^2} \\ \dfrac{-(1+b^2 a^2 r^2 t^2)}{r^2 t^2} & \dfrac{1+b^4 r^4}{r^4} \end{vmatrix} \tag{24}$$

can be simplified to:

$$h_{jk} = \frac{1}{r^4 t^4} \begin{vmatrix} 1+a^4 t^4 & -(1+b^2 a^2 r^2 t^2) \\ -(1+b^2 a^2 r^2 t^2) & 1+b^4 r^4 \end{vmatrix} \tag{25}$$

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the symmetric tensor to equation (12) is then:

$$h_{jk} = \frac{(GM \mathbb{Q})^2}{r^4 t^2} \begin{vmatrix} 1+a^4 t^4 & -(1+b^2 a^2 r^2 t^2) \\ -(1+b^2 a^2 r^2 t^2) & 1+b^4 r^4 \end{vmatrix} \tag{26}$$