Rotating Black Hole Universe and Anti-gravity

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Abstract

On the basis of a black-hole model of the static Universe, a black-hole model of the rotating Universe was proposed. At the same mass, the rotating Universe has (relative to static) a larger radius, lower density, energy density and thickness of the anti-gravity halo.

Keywords: Black Hole Universe, anti-gravity, Schwarzschild radius

01. Introduction

In the dissertation [1] I proposed a static black-hole model of the Universe. Our Universe can be treated as a gigantic homogeneous black hole with an anti-gravity halo. Our Galaxy, together with the solar system and the Earth, which in the cosmological scale can be considered only as a point, should be located near the center of the Black Hole Universe.

Individual "components" of the Universe rotate in planes passing through the center of mass of the Universe with respect to axes perpendicular to these planes and also passing through the center of mass of the Universe with angular velocities of identical values.

In the next part of this work, we will show what corrections the universe spin assumption makes to this model.

02. The rotating (spinning) "exotic" black hole

The rotating (spinning) "exotic" black hole is a homogeneous ball with mass (M) and radius (R) smaller than the Schwarzschild radius (r_S), but not less than half the Schwarzschild radius:

$$\boxed{0.5r_S \le R < r_S = \frac{2GM}{c^2}, \quad R = kr_S, \quad 0.5 \le k < 1},$$

where (c) is maximum value of signal propagation speed, (G) – gravitational constant.

03. Energy density in the area of the rotating (spinning) "exotic" black hole

According to General Relativity, the spacetime metric is determined by the spatial density distribution of all energies (including energy equivalent to mass) [2].

For the rotating (spinning) "egzotic" homogeneous ball, densities of the resting energy (ε_0), kinetic energy (ε_k) and total energy (ε) are respectively:

$$\boxed{\varepsilon_0 = 0.5\rho c^2},$$

$$\boxed{\varepsilon_k = \alpha \cdot \rho c^2 \frac{v^2}{c^2 - v^2}},$$

$$\boxed{\varepsilon = \varepsilon_0 + \varepsilon_k = 0.5\rho c^2 + \alpha \cdot \rho c^2 \frac{v^2}{c^2 - v^2}},$$

where (v) is the value of the velocity perpendicular to the radius vector at a distance (R) from the Universe mass center, (α) – dimensionless factor.

We will generally assume that

$$\boxed{0.5\rho c^2 \le \varepsilon < \rho c^2, \quad \varepsilon = k\rho c^2, \quad 0.5 \le k < 1, \quad k = 0.5 + \alpha \cdot \frac{v^2}{c^2 - v^2}, \quad 0 \le v^2 < \frac{0.5}{\alpha + 0.5} \cdot c^2}.$$

In the case where k = 0.7, the contribution to energy density from the mass is about 71.28%, and from the kinetic energy of the spinning (rotating) mass – about 28.57%.

04. Spacetime metric under and above the event horizon

Spacetime metric under and above the event horizon, when the source of the gravitational field is a rotating (spinning) black hole, can be described by equations [1]:

$$\boxed{R_{\alpha\alpha} = -\kappa k\rho c^2 g_{\alpha\alpha}, \quad R_{\mu\nu} = 0, \quad (\alpha, \mu, \nu = 1,2,3,4; \quad \mu \ne \nu), \quad \kappa = \frac{8\pi G}{c^4}, \quad 0.5 \le k < 1}$$

NOTE

All mixed components of Ricci tensor are identically equal to zero. Set of remaining equations can be reduced to only two independent ones.

$$\boxed{\begin{aligned} R_{11} &= -\kappa k\rho c^2 g_{11} \\ R_{22} &= -\kappa k\rho c^2 g_{22} \end{aligned}} \quad \Rightarrow \quad \boxed{\begin{aligned} &\frac{\partial g_{44}}{\partial r} + \frac{r}{2}\frac{\partial^2 g_{44}}{\partial r^2} = -\kappa k\rho c^2 r \\ &-1 + g_{44} + r\frac{\partial g_{44}}{\partial r} = -\kappa k\rho c^2 r^2 \end{aligned}}$$

Spacetime described by above equations, in which every component of Ricci tensor is proportional to adequate component of metric tensor is an Einstein's space [5].

These equations are fulfilled when

$$0 \le r < R, \quad \rho = \mathrm{const} > 0, \quad g_{44} = 1 - \frac{kr_S}{R}\frac{r^2}{R^2}, \quad 0.5 \le k < 1,$$

$$r \ge R, \quad \rho = 0, \quad g_{44} = 1 - \frac{r_S}{r}, \quad r \ne r_S.$$

05. Exterior Schwarzschild metric

Spacetime metric outside mass source ($r \geq R$, $\rho = 0$) is being described by exterior Schwarzschild metric [6]:

$$\boxed{(ds)^2 = \left(1 - \frac{r_S}{r}\right)^{-1}(dr)^2 + r^2(d\theta)^2 + r^2\sin^2\theta\,(d\varphi)^2 + \left(1 - \frac{r_S}{r}\right)(dx^4)^2, \quad x^4 = ict, \quad r \neq r_S = \frac{2GM}{c^2}}.$$

06. Speed of light propagation and exterior Schwarzschild metric

Exterior Schwarzschild metric, for

$$\theta = \text{const}\,, \quad d\theta = 0\,, \quad \varphi = \text{const}\,, \quad d\varphi = 0\,,$$

reduces itself to

$$\boxed{(ds)^2 = \left(1 - \frac{r_S}{r}\right)^{-1}(dr)^2 - \left(1 - \frac{r_S}{r}\right)c^2(dt)^2}.$$

We designate speed (v_{lihgt}) of light propagation from condition

$$(ds)^2 = 0$$

or equivalent

$$\boxed{v^2_{light} = \left(\frac{dr}{dt}\right)^2 = c^2\left(1 - \frac{r_S}{r}\right)^2}.$$

$$\lim_{r \to 0.5 r_S} v_{light} = c\,, \quad \lim_{r \to r_S} v_{light} = 0\,, \quad \lim_{r \to \infty} v_{light} = c\,.$$

Note that

$$\left[0 < \left(\frac{dr}{dt}\right)^2 \leq c^2\right] \Leftrightarrow \left[r \geq \frac{1}{2}r_S, \quad r \neq r_S\right].$$

It means that exterior Schwarzschild metric is correct if and only if

$$\boxed{r \geq \frac{1}{2}r_S, \quad r \neq r_S}.$$

07. Gravitational acceleration of free fall outside mass source

We will designate radial component of gravitational acceleration of free falling test particle by equation of motion [1]:

$$\tilde{a}^r = \tilde{a}^1 = -\tilde{k}\left(\operatorname{sgn} ds^2\right)c^2\left(\Gamma^1_{11}\frac{dr}{ds}\cdot\frac{dr}{ds} + \Gamma^1_{44}\frac{dx^4}{ds}\cdot\frac{dx^4}{ds}\right), \quad r \neq r_S\,, \quad (ds)^2 \neq 0\,.$$

Taking into account, that

$$g_{44}=1-\frac{r_S}{r},\quad r_S=\frac{2GM}{c^2},\quad \widetilde{k}=+1,$$

$$\Gamma^1_{11}=-\frac{1}{2g_{44}}\frac{\partial g_{44}}{\partial r}=-\left(1-\frac{r_S}{r}\right)^{-1}\cdot\frac{GM}{c^2r^2},\quad \Gamma^1_{44}=-\frac{1}{2}g_{44}\frac{\partial g_{44}}{\partial r}=-\left(1-\frac{r_S}{r}\right)\cdot\frac{GM}{c^2r^2},$$

$$1=\left(1-\frac{r_S}{r}\right)^{-1}\left(\frac{dr}{ds}\right)^2+\left(1-\frac{r_S}{r}\right)\left(\frac{dx^4}{ds}\right)^2,$$

we get

$$\boxed{\widetilde{a}^r=\widetilde{a}^1=\widetilde{k}\left(\operatorname{sgn} ds^2\right)\frac{c^2}{2}\frac{\partial g_{44}}{\partial r}=\left(\operatorname{sgn} ds^2\right)\frac{GM}{r^2}}.$$

Physical (true) component of gravitational acceleration of free fall

$$\hat{a}^r\overset{df}{=}\sqrt{-\left(\operatorname{sgn} ds^2\right)g_{rr}}\ \widetilde{a}^r,$$

where

$$g_{rr}=g_{11}=\left(1-\frac{r_S}{r}\right)^{-1},$$

finally can be written in the form:

$$\boxed{\hat{a}^r=\sqrt{-\left(\operatorname{sgn} ds^2\right)g_{rr}}\left(\operatorname{sgn} ds^2\right)\frac{GM}{r^2}}.$$

08. Gravity and anti-gravity

Above equation has interesting physical interpretation. For $r>r_S$ it describes gravity and for $\frac{1}{2}r_S\le r<r_S$ – anti-gravity.

Gravity

$$r>r_S=\frac{2GM}{c^2},\quad g_{rr}=\left(1-\frac{r_S}{r}\right)^{-1}>0,\quad (ds)^2<0,\quad \hat{a}^r=-\frac{GM}{r^2}\cdot\frac{1}{\sqrt{1-\frac{r_S}{r}}}$$

Anti-gravity

$$\frac{1}{2}r_S\le r<r_S=\frac{2GM}{c^2},\quad g_{rr}=\left(1-\frac{r_S}{r}\right)^{-1}<0,\quad (ds)^2>0,\quad \hat{a}^r=+\frac{GM}{r^2}\cdot\frac{1}{\sqrt{\frac{r_S}{r}-1}}$$

09. Main hypothesis

Anti-gravity works in such a way that free test particle located in external gravitational field in certain area gets acceleration directed from the center of that mass source.

In areas, where $g_{\mu\nu} \geq 0$, $(ds)^2 < 0$, $(\mu, \nu = 1,2,3,4)$, graviy occurs.	In areas, where $g_{\mu\nu} \leq 0$, $(ds)^2 > 0$, $(\mu, \nu = 1,2,3,4)$, anti-graviy occurs.

10. Spacetime metric inside mass source

Spacetime metric inside mass source ($0 \leq r < R$, $\rho = \text{const} > 0$) is given by:

$$\boxed{(ds)^2 = g_{11}(dr)^2 + r^2(d\theta)^2 + r^2 \sin^2\theta\,(d\varphi)^2 + g_{44}(dx^4)^2},$$

where

$$x^4 = ict\,, \quad g_{11} = \frac{1}{g_{44}}\,, \quad g_{44} == 1 - \frac{kr_S}{R}\frac{r^2}{R^2}\,, \quad 0.5 \leq k < 1\,, \quad r_S = \frac{2GM}{c^2}\,.$$

11. Speed of light propagation in virtual vacuum tunnel that is inside black hole

Spacetime metric inside black hole, for

$$\theta = \text{const}\,, \quad d\theta = 0\,, \quad \varphi = \text{const}\,, \quad d\varphi = 0\,, \quad R = kr_S\,, \quad 0.5 \leq k < 1\,,$$

reduces itself to the form:

$$(ds)^2 = g_{11}(dr)^2 - g_{44}c^2(dt)^2\,, \quad g_{11} = \frac{1}{g_{44}}\,, \quad g_{44} = 1 - \frac{r^2}{R^2}\,.$$

We will designate speed (v_{light}) of light propagation in virtual vacuum tunnel from condition

$$(ds)^2 = 0$$

or equivalent

$$\boxed{v_{light}^2 = \left(\frac{dr}{dt}\right)^2 = c^2\left(1 - \frac{r^2}{R^2}\right)^2}.$$

$$\lim_{r \to 0} v_{light} = c\,, \quad \lim_{r \to R} v_{light} = 0\,.$$

Notice that

$$R = kr_S\,, \quad 0{,}5 \leq k < 1\,, \quad 0 < v_{light}^2 \leq c^2\,.$$

It means that spacetime metric inside black hole is correct if and only if

$$\boxed{\frac{1}{2}r_S \le R < r_S, \quad r < R}.$$

12. Gravitational acceleration of free fall inside black hole

Radial component of gravitational acceleration of freely falling test particle inside virtual vacuum tunnel, which is located inside black hole, we will get from equation of motion [1]

$$\tilde{a}^r = \tilde{a}^1 = -\tilde{k}\left(\operatorname{sgn} ds^2\right)c^2\left(\Gamma^1_{11}\frac{dr}{ds}\cdot\frac{dr}{ds} + \Gamma^1_{44}\frac{dx^4}{ds}\cdot\frac{dx^4}{ds}\right), \quad 0 \le r < R, \quad (ds)^2 \ne 0.$$

Taking into account, that

$$\tilde{k} = -1, \quad \operatorname{sgn} ds^2 = -1, \quad R = kr_S, \quad 0.5 \le k < 1, \quad r_S = \frac{2GM}{c^2},$$

$$\Gamma^1_{11} = -\frac{1}{2g_{44}}\frac{\partial g_{44}}{\partial r}, \quad \Gamma^1_{44} = -\frac{1}{2}g_{44}\frac{\partial g_{44}}{\partial r}, \quad g_{44} = 1 - \frac{r^2}{R^2}, \quad 1 = g_{44}^{-1}\left(\frac{dr}{ds}\right)^2 + g_{44}\left(\frac{dx^4}{ds}\right)^2,$$

we get

$$\boxed{\tilde{a}^r = \tilde{k}\left(\operatorname{sgn} ds^2\right)\frac{c^2}{2}\frac{\partial g_{44}}{\partial r} = -\tilde{k}\left(\operatorname{sgn} ds^2\right)\frac{c^2}{R^2}r = -\frac{c^2}{R^2}r}.$$

Physical (true) component of gravitational acceleration of free fall

$$\hat{a}^r \stackrel{df}{=} \sqrt{-\left(\operatorname{sgn} ds^2\right)g_{rr}}\ \tilde{a}^r,$$

where

$$g_{rr} = g_{11} = \left(1 - \frac{r^2}{R^2}\right)^{-1},$$

in the end, can be written in the form:

$$\boxed{\hat{a}^r = -\tilde{k}\left(\operatorname{sgn} ds^2\right)\sqrt{-\left(\operatorname{sgn} ds^2\right)g_{rr}}\ \frac{c^2}{R^2}r = -\frac{c^2}{R^2}r\cdot\frac{1}{\sqrt{1 - \frac{r^2}{R^2}}}}.$$

13. Graphic analysis of the full solution

Time-time component of metric tensor and physical (true) component of gravitational acceleration of free fall, in three distance intervals from the center of black hole, are given by below relations.

GRAVITY

$$0 \le r < R = kr_S, \quad g_{44} = \left(1 - \frac{r^2}{R^2}\right) > 0, \quad \hat{a}^r = -\frac{c^2}{R^2} r \cdot \frac{1}{\sqrt{1 - \frac{r^2}{R^2}}}$$

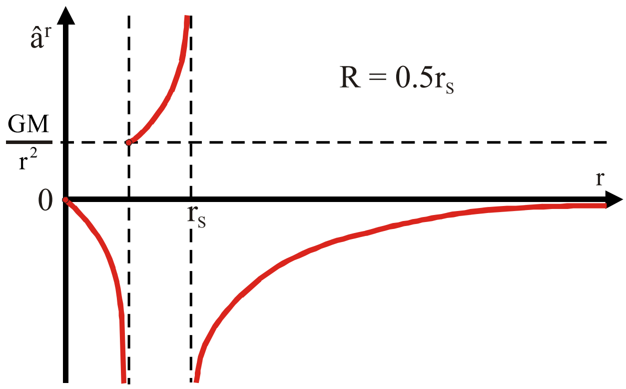
ANTI-GRAVITY

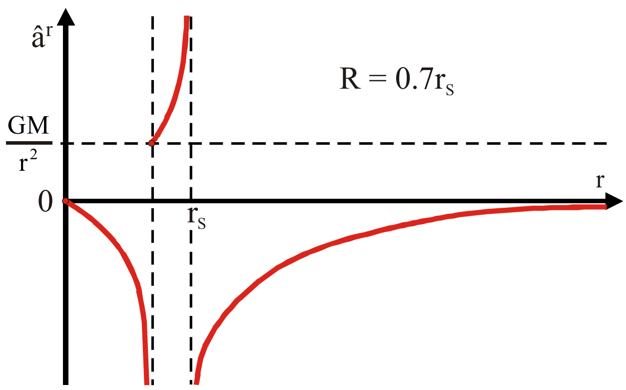
$$k\, r_S = R \le r < r_S, \quad g_{44} = \left(1 - \frac{r_S}{r}\right) < 0, \quad \hat{a}^r = +\frac{GM}{r^2} \cdot \frac{1}{\sqrt{\frac{r_S}{r} - 1}}$$

GRAVITY

$$r > r_S, \quad g_{44} = \left(1 - \frac{r_S}{r}\right) > 0, \quad \hat{a}^r = -\frac{GM}{r^2} \cdot \frac{1}{\sqrt{1 - \frac{r_S}{r}}}$$

Below we present charts of dependence of radial component ($\hat{a}^r$) of physical (true) gravitational acceleration of free fall on the distance (r) from the center of black hole with anti-gravity halo.





From the charts we can see that:

$0 \le r < R = k \cdot r_S \quad \Rightarrow$ gravity

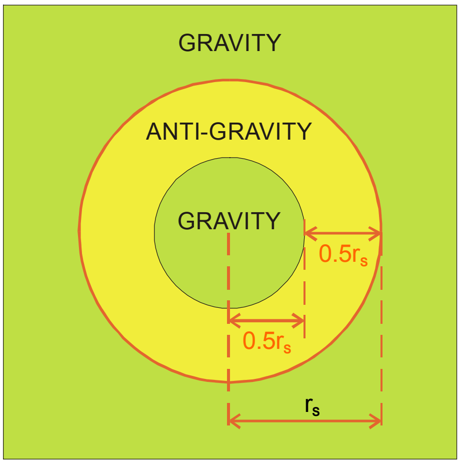
$r = R = k \cdot r_S \quad \Rightarrow$ transition from gravity to anti-gravity

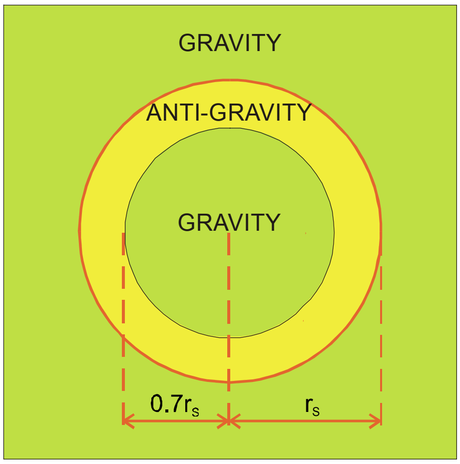
$k \cdot r_S = R < r < r_S \quad \Rightarrow$ anti-gravity

$r = r_S \quad \Rightarrow$ transition from anti-gravity to gravity

$r > r_S \quad \Rightarrow$ gravity

Anti-gravity halo thickness is not greater than half the Schwarzschild radius. Gravity and anti-gravity has layer-like nature.





In the above drawings we illustrated two cases corresponding to different values of energy density in the black hole area:

A.

The energy density $\varepsilon = \varepsilon_0 = 0.5\rho c^2$ describes a static black hole with the radius of 0.5 r_S with an anti-gravity halo having the thickness of 0.5 r_S .

B.

The energy density $\varepsilon = \varepsilon_0 + \varepsilon_k = 0.7\rho c^2$ describes a rotating (spinning) black hole with the radius of 0.7 r_S with an anti-gravity halo having the thickness of 0.3 r_S .

NOTE

For $\varepsilon = \varepsilon_0 = \rho c^2$, k = 1 it is impossible to black hole formation, and thus the appearance of anti-gravity.

14. Radius of the rotating (spinning) Black Hole Universe

To determine a radius of the rotating (spinning) Black Hole Universe we will use the dependence of redshift (z^*) of light reaching the Earth from distant galaxies on their distance (r) from the Earth [1].

$$\boxed{z^* \equiv \frac{E_{lab}}{E_{out}} - 1},$$

where

$$E_{lab} = \sqrt{g_{44}^{lab}}\, E_{max}\,, \quad E_{out} = \sqrt{g_{44}^{out}}\, E_{max}\,,$$

E_{lab} – photon energy emitted from a source that is in laboratory,

E_{out} – photon energy emitted from a source that is outside laboratory,

E_{max} – photon energy emitted from a source in the absence of gravitational field,

g_{44}^{lab} – component of metric tensor in laboratory in a place of photon detection,

g_{44}^{out} – component of metric tensor outside of laboratory in a place of photon emission.

Therefore

$$\boxed{z^{*}=\frac{\sqrt{g_{44}^{lab}}}{\sqrt{g_{44}^{out}}}-1}.$$

By assuming,

$$g_{44}^{lab}\approx 1-1.4\cdot 10^{-9},\quad g_{44}^{out}=1-\frac{r^{2}}{R^{2}},$$

we finally have

$$\boxed{z^{*}\approx\frac{\sqrt{1-1.4\cdot 10^{-9}}}{\sqrt{1-\frac{r^{2}}{R^{2}}}}-1}.$$

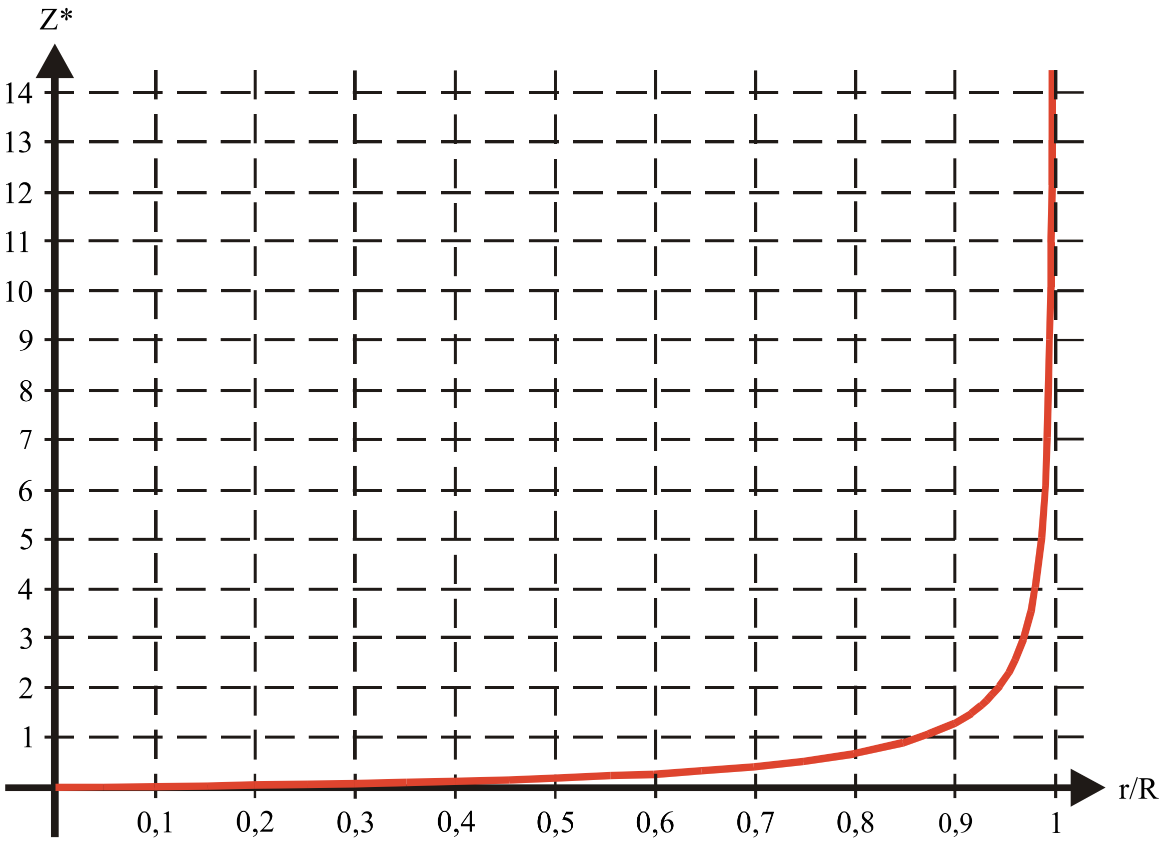


Diagram that shows dependence of redshift (z*) versus the distance (r) of the source from the center of Our Universe. [Attension: (z*) has negative values for ratio (r/R) approximate less than $3.74\cdot 10^{-5}$.]

For the case when ($r^{2}<<R^{2}$), redshift (z*) is approximately:

$$\boxed{z^{*}\approx\frac{1}{2}\cdot\frac{r}{R}}.$$

According to Hubble observations [1]:

$$\boxed{z = \frac{H}{c} r}.$$

Considering that

$$z^* = z, \quad R = \frac{1}{2} \cdot r_S,$$

we get

$$\boxed{r_S \approx \frac{c}{H}}.$$

While modeling the Hubble Universe, we treated it as a Black Hole Universe in which

$k = 0.5.$

In the case of the rotating (spinning) Black Hole Universe we have:

$$R = kr_S, \quad \frac{1}{2} \le k < 1,$$

$$\boxed{R \approx \frac{kc}{H}}.$$

15. Density of the rotating (spinning) Black Hole Universe

We will determine density (ρ) of the rotating (spinning) Black Hole Universe using the expressions obtained earlier

$$R = kr_S, \quad R \approx \frac{kc}{H}, \quad \kappa = \frac{8\pi G}{c^4}, \quad \rho_{crit} = \frac{3H^2}{8\pi G} = \frac{3H^2}{\kappa c^4} \text{ [1, 2]},$$

where

$$r_S = \frac{2GM}{c^2}, \quad M = \frac{4}{3}\pi R^3 \rho,$$

(ρ_{crit}) means critical density in Friedman's theory of the Universe [1, 2].

Finally we get:

$$\boxed{\rho = \frac{1}{k} \cdot \frac{3c^2}{8\pi G} \cdot \frac{1}{R^2} = \frac{1}{k} \cdot \frac{3}{c^2 \kappa R^2}},$$

$$\boxed{\rho \approx \frac{1}{k^3} \cdot \frac{3H^2}{8\pi G} = \frac{1}{k^3} \cdot \frac{3H^2}{\kappa c^4}},$$

$$\boxed{\rho \approx \frac{1}{k^3} \cdot \rho_{crit}},$$

$$\rho_{stat} = 8 \cdot \rho_{crit}, \quad k_{stat} = 0.5,$$

where

(ρ_{stat}) is the density of the static Black Hole Universe.

In numerical calculations, you can use the following values:

$H \approx 2.43 \cdot 10^{-18} s^{-1}$ [1],

$c \approx 3 \cdot 10^8 m \cdot s^{-1}$,

$$\kappa = \frac{8\pi G}{c^4} = 2.073 \cdot 10^{-43} s^2 \cdot kg^{-1} \cdot m^{-1},$$

$\rho_{crit} \approx 1.058 \cdot 10^{-26} kg \cdot m^{-3}$ [1],

$\rho_F \approx 4.97 \cdot 10^{-27} kg \cdot m^{-3}$ [1].

16. Angular velocity in the rotating (spinning) Black Hole Universe

The angular velocity (ω) in the rotating (spinning) Black Hole Universe

$$\omega = \frac{v}{R}$$

we estimate using relationships

$0 < v < \sqrt{\frac{0.5}{\alpha + 0.5}} \cdot c$, $\quad R \approx \frac{kc}{H}$, $\quad \frac{1}{2} < k < 1$, $\quad H = 2.43 \cdot 10^{-18} s^{-1}$ [1].

The result is

$$\boxed{\omega < \sqrt{\frac{0.5}{\alpha + 0.5}} \cdot \frac{H}{k} = \sqrt{\frac{0.5}{\alpha + 0.5}} \cdot \frac{c}{R}},$$

$$\sqrt{\frac{0.5}{\alpha + 0.5}} \cdot H < \omega < 2\sqrt{\frac{0.5}{\alpha + 0.5}} \cdot H.$$

In a special case, when

$$k = 0.5 + \alpha \cdot \frac{v^2}{c^2 - v^2} = 0.7\,,$$

we get

$$\alpha = 0.2\,,\quad \frac{v^2}{c^2 - v^2} = 1\,,\quad v^2 = \frac{1}{2}c^2\,,\quad v = \sqrt{\frac{1}{2}}\,c \approx 0.7\,c\,,\quad R \approx \frac{0.7c}{H}\,.$$

This means that

$\boxed{\omega \approx H}$ $(H = 2.43 \cdot 10^{-18} s^{-1}$ [1]).

17. Comparison of respective parameters of the Black Hole Universe models

Let the parameters k_{spin}, R_{spin}, ρ_{spin}, ε_{spin}, δR_{spin} be a factor in expression for energy density, radius, density, energy density and thickness of the anti-gravity halo of the rotating (spinning) Universe.

Let the parameters k_{stat}, R_{stat}, ρ_{stat}, ε_{stat}, δR_{stat} be a factor in expression for energy density, radius, density, energy density and thickness of the anti-gravity halo of the static Universe.

Let's compare these parameters when a mass of the black hole is fixed and $v^2 = 0.5c^2$, so we have:

$$M = \text{const},\quad c = \text{const},\quad G = \text{const},\quad r_S = \frac{GM}{c^2} = \text{const}\,,\quad k_{spin} = 0.7,\quad k_{stat} = 0.5\,.$$

In both models $R = kr_S$. The rays ratio is therefore:

$$\frac{R_{spin}}{R_{stat}} = \frac{k_{spin} r_S}{k_{stat} r_S} = \frac{k_{spin}}{k_{stat}} = \frac{0.7}{0.5} = 1.4\,.$$

In both models $\rho = M\left(\frac{4}{3}\pi R^3\right)^{-1}$. The densities ratio is therefore given as:

$$\frac{\rho_{stat}}{\rho_{spin}} = \left(\frac{R_{wir}}{R_{spin}}\right)^3 = \left(\frac{k_{wir}}{k_{spin}}\right)^3 = (1.4)^3 = 2.744\,.$$

In both models, the ratio of energy densities is

$$\frac{\varepsilon_{spin}}{\varepsilon_{stat}} = \frac{0.5\rho_{spin} + 0.2\rho_{spin}}{0.5\rho_{stat}} = \frac{k_{spin}}{k_{stat}} \cdot \frac{\rho_{spin}}{\rho_{stat}} = \frac{k_{spin}}{k_{stat}} \cdot \left(\frac{k_{stat}}{k_{spin}}\right)^3 = \left(\frac{k_{stat}}{k_{spin}}\right)^2 = (1.4)^{-2}\,.$$

The thicknesses ratio of anti-gravity halos is given by:

$$\frac{\delta R_{spin}}{\delta R_{stat}} = \frac{0.3 r_S}{0.5 r_S} = 0.6 .$$

In [1], the values of the radius and density of the static Black Hole Universe were calculated assuming that the Hubble constant is $H = 75\,\mathrm{km}\cdot\mathrm{s}^{-1}\cdot\mathrm{Mpc}^{-1}$ [7].

$$\boxed{R_{stat} \approx \frac{c}{2H} \approx 0.6\cdot 10^{26}\,\mathrm{m} \approx 6.31\text{ bilion light years}, \quad r_S \approx \frac{c}{H} \approx 1.2\cdot 10^{26}\,\mathrm{m}},$$

$$\boxed{\rho_{stat} = 8.464\cdot 10^{-26}\,\mathrm{kg}\cdot\mathrm{m}^{-3}}.$$

In a distance from the center of Earth, approximately equal to

$$\boxed{(r_0)_{stat} \approx 2.245\cdot 10^{21}\,\mathrm{m} \approx 2.363\cdot 10^{5}\text{ light years} = 236300\text{ light years}}$$

redshift measured in relative to Our Planet changes sign from negative to positive.

18. Stability of the model

In order for proposed by me model was stable, it must be additionally assumed that the radial component of gravitational acceleration (a^r_{grav}) of the rotating (spinning) Black Hole Universe performs the role of the radial component of centri**petal** acceleration (a^r_{petal}).

Radial component of the gravitational acceleration of free fall [1]

$$\boxed{a^r_{grav} = -\frac{c^2}{R^2} r}$$

and radial component of centri**petal** acceleration

$$\boxed{a^r_{petal} = -\omega^2 r}$$

satisfy the condition

$$\boxed{a^r_{grav} = a^r_{petal}},$$

when

$$\boxed{\omega_{stab} = \frac{c}{R}}.$$

After taking into account that

$$R = k r_S, \quad 0.5 < k < 1 ,$$

we get

$$\boxed{\omega_{stab} = \frac{c}{kr_S}}.$$

Below we will consider possible cases for the fixed (k).

The universe rotates (spins) when

$$0.5 > k < 1.$$

The universe is stable when

$$\boxed{\omega_{stab} = \frac{c}{kr_S}, \quad 0.5 < k < 1}.$$

The rotating (spinning) universe is unstable when

$$\boxed{0 < \omega < \omega_{stab}} \quad \text{and} \quad \boxed{\omega_{stab} < \omega < \frac{c}{r_S}}.$$

The above statement shows that it is possible to extend the presented model of the rotating (spinning) Black Hole Universe, which will allow to describe the vibrations around the equilibrium position $\boxed{\omega_{stab} = \frac{c}{kr_S}}$.

19. Final remarks

At the same mass, the rotating (spinning) Universe has (relative to static) a larger radius, lower density, lower energy density and lower thickness of the anti-gravity halo. The distance from the center of the Earth is greater, at which the redshift measured in relative to Our Planet changes sign from negative to positive.

The kinetic energy density of the rotating (spinning) Black Hole Universe (ε_k) should be less than the corresponding resting energy density (ε_0).

$$\boxed{\varepsilon_k < \varepsilon_0, \quad 0 < v^2 < \frac{0.5}{\alpha + 0.5} \cdot c^2}.$$

It was noticed that the Schwarzschild radius of the Black Hole Universe is approximately equal to a quotient of the speed of light and the Hubble's constant.

$$\boxed{r_S \approx \frac{c}{H}}.$$

The rotating (spinning) Black Hole Universe has been shown to be stable for $\boxed{\omega_{stab} = \frac{c}{kr_S}}$. The inclusion of energy transformation processes (including its dissipation) in the proposed model will allow to describe possible vibrations around the equilibrium position $\boxed{\omega_{stab} = \frac{c}{kr_S}}$.

The only observational parameter in the theory presented here is the Hubble constant for which we assumed the value of $H = 75\,\mathrm{km}\cdot\mathrm{s}^{-1}\cdot\mathrm{Mpc}^{-1} \approx 2.43\cdot 10^{-18}\mathrm{s}^{-1}$ [7].

A moment of inertia of the "exotic" ball is a tensor. We will dedicate another paper to it.

The use of the traditional relation for resting energy density $\varepsilon_0 = \rho c^2$ does not describe a black hole, and even more so a phenomenon of anti-gravity.

20. A very brief historical sketch

George Gamow in 1946 [8] first suggested that the universe can rotate: "We can ask ourselves whether it is not possible to assume that all matter in the visible universe is in a state of general rotation around some centre located far beyond the reach of our telescopes?"

Kurt Gödel in 1949 [9] and in 1952 [10] found a solution of the field equations (with cosmological constant (λ) different from zero)

$$\boxed{R_{\mu\nu} - \tfrac{1}{2} g_{\mu\nu} r\overline{R} = -\kappa T_{\mu\nu} + \lambda g_{\mu\nu}},$$

describing a model of the Universe with a constant spatial radius (R), in which matter rotates around an axis passing through the center of mass (the axis of rotation is X^3), the solution was given in a rotating system with matter [2].

$$\boxed{ds^2 = -\left(dx^1\right)^2 + \tfrac{1}{2} e^{2bx^1}\left(dx^2\right)^2 - \left(dx^3\right)^2 + 2e^{bx^1} dx^2 dx^4 + \left(dx^4\right)^2},$$

where

$$ds^2 \geq 0, \quad x^4 = ct, \quad b = \frac{1}{R}, \quad \boxed{R = \frac{1}{c\sqrt{\kappa\rho}}}, \quad \lambda = \frac{1}{2R^2}, \quad T_{\mu\nu} = \rho v_\mu v_\nu,$$

$$v = \left(v^1, v^2, v^3, v^4\right) = (0,0,0,c), \quad v = \left(v_1, v_2, v_3, v_4\right) = \left(0, ce^{bx^1}, 0, c\right).$$

For comparison, in our model:

$$\boxed{R_{spin} = \sqrt{\frac{3}{k}} \cdot \frac{1}{c\sqrt{\kappa\rho}}}.$$

We also write Gödel's metric in cylindrical coordinates

$$x^1 = r\cos\varphi, \quad x^2 = r\sin\varphi, \quad x^3 = x^3, \quad x^4 = x^4.$$

$$
\begin{aligned}
ds^2 = &-\left(\cos^2\varphi - \tfrac{1}{2}e^{2br\cos\varphi}\sin^2\varphi\right)dr^2 - r^2\left(\sin^2\varphi - \tfrac{1}{2}e^{2br\cos\varphi}\cos^2\varphi\right)d\varphi^2 - \left(dx^3\right)^2 + \left(dx^4\right)^2 + \\
&+ 2r\sin\varphi\cos\varphi\left(1 + \tfrac{1}{2}e^{2br\cos\varphi}\right)dr d\varphi + 2e^{br\cos\varphi}\sin\varphi\, dr dx^4 + 2re^{br\cos\varphi}\cos\varphi\, d\varphi dx^4
\end{aligned}
$$

For $\varphi = 0$ and $\varphi = 2\pi$

$$
ds^2 = -dr^2 + \tfrac{1}{2}r^2 e^{2br}\, d\varphi^2 - \left(dx^3\right)^2 + \left(dx^4\right)^2 + 2re^{br}\, d\varphi dx^4 .
$$

After a full rotation of the coordinate system, with fixed (r), the metric remains unchanged.

A detailed review of issues concerning the rotating (spinning) Universe and analysis of known models can be found in [11, 12].

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