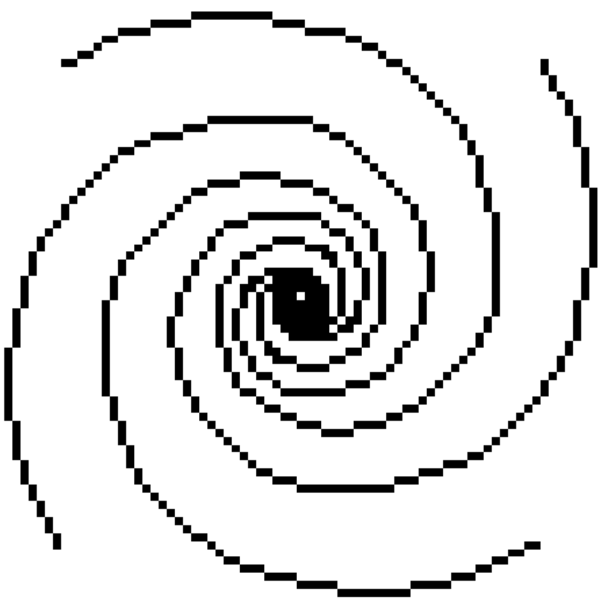
The Spiral Universe



john.erich.ebner@gmail.com
http://blackholeformulas.com

Abstract

We solve the riddle of the spiral shape and flat rotation curves of galaxies, prevalence of dark matter in galaxy dynamics and the source, uniformity and Planck satellite anomaly of the cosmic microwave background.
Wiki calls these "unsolved problems of physics."

They are shown to be a consequence of this model of the dynamic universe. The age, radius, mass, expansion rate, G and density of the universe also come from this model and are unambiguously shown to apply to a black hole and are in the range or magnitude of mainstream values frequently quoted.

This paper postulates that light will orbit any great enough mass. The mass which light orbits is a black hole. We know that gravity deflects light from numerous cases of gravitational lensing so it is not too big a step to see that a deflection of light with one mass could become an orbit of light with a much greater mass.

This simple classical model, of energy and light in orbit, shows the black hole, galaxy and the Cosmos in dynamic equilibrium.

There are no infinities, singularities or free parameters which might be adjusted to reflect a point of view. "The positive evidence in favor of the theory depends upon 'parsimony': an economy of assumptions. A good theory is one that needs to postulate little to explain a lot." [1]

Key Words

Spiral universe, orbiting light or energy, black holes, expanding and rotating universe, gravity, dark matter, cosmic microwave background, unsolved problems in physics, black hole universe, black hole formulas

Cover

The logarithmic spiral of a spiral galaxy.

Authors Note

This document was written with Latex
http://latex-project.org/ftp.html and TexStudio
http://texstudio.sourceforge.net/, both of which are excellent, open-source and free. The PDF pages it produces can be read in two page view and printed two pages at a time in landscape to save paper or two sided to make a book. Your papers can become pamphlets, easily read and edited.

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1 Hubble

Edwin Hubble [2] determined from the linear doppler redshift of galaxies that they are receding at a rate proportional to distance. It is called doppler because of the familiar frequency shift of sound with the velocity of the sound source. Here the frequency shift is in the light toward the red with increasing velocity of recession. The velocity of recession at a certain radial distance r, divided by that distance is a constant. In our examples:

1.1 Hubble's constant: $H_0 = 2.281E\neg18\frac{1}{s}$

$$H_0 = 70.4\frac{km}{s \cdot Mpc}\frac{1000m}{km}\frac{Mpc}{3.086E22m} =$$

Kilometers per second per million parsecs, in smaller units this is:

$$H_0 = \frac{velocity}{distance} = \frac{m}{s}\ per\ meter = 2.281E\neg18\frac{1}{s} \tag{1.1}$$

Meters per second per meter equals one over seconds.

Velocity only changes when a force is applied. Distance always increases in an expanding Cosmos so:
$H_0 = \frac{1}{age} = \frac{velocity}{distance}$ decreases as the Cosmos expands and ages.

Using these smaller more familiar units may lead you to wonder if the expansion is also local. Does the Hubble expansion extend to the galaxy, to the solar system and to atoms? How do you measure expansion if you expand at the same rate? If the local expansion exists, was it missed because the size of the expansion is so small? Hubble's constant has units of 1/seconds which is frequency, angular velocity or 1/age. See the March 2020 isue of Scientific American.

1.2 Cosmic age: $\frac{1}{H_0} = age = 13.9\ billion\ years$

The reciprocal of Hubble's constant is:

$$\frac{1}{H_0} = 4.383E17 \cdot s = 13.9\ billion\ years = age \tag{1.2}$$

We will use 13.9 billion years, from the WMAP satellite, as the age of the Cosmos, in our examples.

1.3 Cosmic radial velocity: $v_r = r \cdot H_0 = c$

Hubble's constant can be written:

$$H_0 = \frac{1}{age} = \frac{c}{c \cdot age} = \frac{c}{13.9\ billion\ light\ years} \tag{1.3}$$

This implies that our dynamic home unit Cosmos, which is a subset of the Universe, is expanding at the speed of light at its current perimeter:

Hubble decreases with age, the radius r, increases with age but the radial velocity of expansion v_r, is constant at c, with distance divided by age at the perimeter of the Cosmos.

$$v_r = \frac{radial\ distance}{travel\ time} = r \cdot H_0 = \frac{r}{age} = \frac{c \cdot age}{age} = c \tag{1.4}$$

$LIGO$ gave us another source of $velocity/distance = H_0$ with the merger of two neutron stars which were then located with telescopes.

1.4 Cosmic radius: $r = \frac{c}{H_0} = 13.9\ billion\ light\ years$

The current radius of the Cosmos:

$$r = \frac{c}{H_0} = c \cdot age = 13.9\ billion\ light\ years = 1.314E26 \cdot m \tag{1.5}$$

This paper does not require space-time, the expansion of the vacuum of space or inflation so the radius is the radius.

This is age, radius and radial velocity based on the expansion rate H_0, not an affirmation of a creation event 13.9 billion years ago.

1.5 Hubble's constant may vary

$$140.8 \frac{km}{s \cdot Mpc} = \frac{1}{6.95\ billion\ years} = 2 \cdot H_0$$

$$70.4 \frac{km}{s \cdot Mpc} = \frac{1}{13.9\ billion\ years} = H_0\ per\ WMAP\ satellite$$

We will use this $70.4 \frac{km}{s \cdot Mpc}$ as Hubble's constant in our examples.

$$67.15 \frac{km}{s \cdot Mpc} = \frac{1}{14.56\ billion\ years} = H_0\ per\ Planck\ satellite$$

$$35.2 \frac{km}{s \cdot Mpc} = \frac{1}{27.8\ billion\ years} = \frac{H_0}{2}$$

$$17.6 \frac{km}{s \cdot Mpc} = \frac{1}{55.6\ billion\ years} = \frac{H_0}{4} \tag{1.6}$$

This suggests that at earlier times, Hubble's constant was bigger and the Cosmos was younger. A younger Cosmos expanded faster.

It is likely that some part of the Hubble constant is due to non-doppler redshift [11]. If half of Hubble's constant is due to non-doppler redshift then the doppler portion is $35.2\frac{km}{s \cdot Mpc}$ and the age is 27.8 billion years not 13.9 billion years.

There is an equilibrium, in stars, between the stellar gas pressure caused by gravity and that caused by radiation [8]. However, the hotter star in a binary pair shows more redshift [11] so some part of the red shift is non-doppler and ambiguous.

How does this affect Hubble's constant and distance calculations?

The calculated age, mass and radius of the Cosmos increases with the decrease in the doppler portion of the redshift. Therefore, if all the redshift were non-doppler, the Cosmos would be infinitely old and massive.

2 Virial theorem: $v_t^2 r = GM \cdots or \cdots \frac{GM}{v^2 r} = 1$

is an energy equation in statistical mechanics used with a cosmic count of masses: "for a stable, self-gravitating, spherical distribution of equal mass objects (stars, galaxies), the total kinetic energy of the objects equals half the total gravitational potential energy" [3] or [4]:

$$\frac{m\,v^2}{2} = \frac{G\,m\,M}{2\,r} \cdots\cdots\cdots \text{ the virial theorem } \cdots\cdots\cdots \tag{2.1}$$

Multiply by 2:

$$m\,v^2 = \frac{G\,m\,M}{r} \cdots\cdots \text{energy = gravitational potential energy} \tag{2.2}$$

Multiply by $\frac{1}{r}$:

$$\frac{m\,v_t^2}{r} = \frac{G\,m\,M}{r^2} \cdots \text{ centrifugal force = gravitational force} \tag{2.3}$$

v_t is the tangent orbital velocity. M and m are masses, in orbit with each other, with the radial distance r between them.
G is the gravitational constant.
In orbiting systems, centrifugal force equals gravitational force. Center fleeing centrifugal force equals center seeking centripetal force. If the centrifugal force were stronger the bodies would spiral apart. If the gravitational force were stronger the bodies would spiral together. The average forces must be equal and opposite for the orbits to endure.

Multiply by $\frac{r}{m}$, yielding more variations of the virial theorem:

$$v^2\,r = G\,M \cdots \text{ or } \cdots \frac{v^2}{G} = \frac{M}{r} \cdots \text{ or } \cdots \frac{G\,M}{v^2\,r} = 1 \cdots\cdots\cdots \tag{2.4}$$

$\frac{GM}{v^2 r} = 1$ is just another way of writing Kepler's third law.

3 Vis-Vita equation: $v^2 = GM\left(\frac{2}{r} - \frac{1}{a}\right)$

Greek for "living force".

$$v^2 = GM\left(\frac{2}{r} - \frac{1}{a}\right) \cdots \text{ With a circular orbit } a = r \ \cdots$$

$$v^2 = GM\left(\frac{2}{r} - \frac{1}{r}\right) = \frac{GM}{r} \cdots\cdots \text{ or } \cdots\cdots v^2\ r = G\ M$$

The same as the virial theorem.

4 Kepler's third law: $4\pi^2 r^3 = p^2 GM$

The orbital period of a circular orbit is p:

$$p = \frac{2\pi r}{v_t} \cdots\cdots\cdots \text{therefore} \cdots\cdots\cdots v_t^2 = \frac{4\pi^2 r^2}{p^2}$$

Substitute for v_t^2 in the virial theorem $\frac{GM}{v^2 r} = 1 \cdots or \cdots v_t^2 r = GM$ equation (2.4 page 8) and collect terms:

$$\frac{4\pi^2 r^2}{p^2} \cdot r = GM \cdots\cdots \text{ or } \cdots\cdots 4\pi^2 r^3 = p^2 GM \cdots\cdots\cdots \quad (4.1)$$

The cube of the radius is proportional to the square of the orbital period if GM is constant. This is Kepler's third law. We will usually use it in the centrifugal equals the gravitational force or virial theorem form. This equation and the idea of conservation of energy are both indubitably correct and are central to our arguments. See section ((18.2 page 33): on flat rotation curves in galaxies where GM is **not** constant.

5 Light in orbit makes a Black Hole

Starting from the virial theorem $v_t^2\ r = G\ M$, equation (2.4 page 8):

5.1 Assign the tangent orbital velocity: $v_t = c$

Now the tangent orbital velocity is c and light or $m \cdot c^2$ = energy can orbit at the radius $r = \frac{mass \cdot G}{c^2}$ which encloses a black hole:

$$c^2\ r = G\ M \cdots \text{or} \cdots \frac{c^2}{G} = \frac{M}{r} \cdots \text{or} \cdots \frac{G\ M}{c^2\ r} = 1 \quad (5.1)$$

5.2 Black Hole Definition: $c^2 r = GM$

We know that gravity deflects light from numerous cases of gravitational lensing. It is almost trivial to postulate that a deflection of light with one mass could become an orbit of light with a greater mass.

We are looking at Newtonian gravity, not warped space time, keeping light in orbit and causing gravitational lensing.

$v_t = c$, is the tangent velocity at the perimeter of any black hole including the Cosmos.

They are black holes because their gravity causes the light to orbit. Their light is retained and orbited not emitted.

Some forget, the everyday realm of Newton includes the deflection of light and black holes. John Mitchell in 1783 predicted dark stars, black holes where their escape velocity exceeds the velocity of light.

$\frac{GM}{c^2 r}$ "may be regarded as the dimensionless strength of the gravitational field. Even at the solar surface: $\frac{GM}{c^2 r} = 2E\neg 6$." [5] For a virial theorem = orbiting light = Newtonian black hole:
$\frac{GM}{c^2 r} = 1$ is 500,000 times larger.

5.3 Rest Energy in orbit: $mc^2 = \frac{GmM}{r}$ or $\frac{GM}{c^2 r} = 1$

Multiply black hole equation (5.1): $c^2\, r = G\, M$ by $\frac{m}{r}$:

$$m\, c^2 = \frac{G\, m\, M}{r} \cdots \text{rest energy = gravitational energy} \cdots \qquad (5.2)$$

The orbital velocity $v_t = c$ where light and energy orbit at the specific radius $r = \frac{mass \cdot G}{c^2}$.

Light might follow a circular orbital path, a bent path as in gravitational lensing or a spiral path with a decreasing gravitational force where everything spirals out as the gravitational force decreases with the age of the universe.

6 Variable G: $\frac{G\ M}{c^2\ r} = 1 \cdots or \cdots G = \frac{c^2 \cdot r}{M}$

Black hole equation (5.1):

$$c^2\, r = G\, M \cdots\cdots \text{ This is our black hole definition} \cdots\cdots \qquad (6.1)$$

Here we take c and M to be constants. This leaves us with r and G as variables. If r is a variable radius and increases with $age,$ as it must as the Cosmos expands, since $r = v_r \cdot age$ or $r = c \cdot age$, then G is a variable and must increase with age.

If G varies there must be a ΔG. This can be written: $G = \Delta G \cdot age$. ΔG is the amount that the gravitational constant G increases per second as seen below.

$$G = \frac{c^2 \cdot r}{M} \text{ or } G = \frac{c^2 \cdot v_r \cdot age}{M} \text{ or } \Delta G {\cdot} age = \frac{c^2 \cdot c \cdot age}{M} \text{ or } \Delta G = \frac{c^3}{M}$$

If G and r are both proportional to age then the orbiting and gravitational energy are constant with expansion including cosmic expansion. Energy is conserved.

6.1 The rate of change of gravity: $\Delta G = \dot{G} = G \cdot H_0$

$$\Delta G = \frac{c^3}{M_c} = \frac{\Delta G \cdot age}{age} = \frac{G}{age} = G {\cdot} H_0 = 1.522E\neg 28 \frac{m^3}{kg \cdot s^3} \quad (6.2)$$

ΔG is constant while the mass of the Cosmos M_c, stays constant, in contrast to H_o which is Hubble's variable constant and G which is the variable gravitational constant.

You may have noticed that G has a value of about 1/15 billion.

$$G = 6.673E\neg 11 \frac{m^3}{kg \cdot s^2} \approx \frac{1}{15 \cdot billion} \frac{m^3}{kg \cdot s^2} \quad (6.3)$$

$G = \Delta G \cdot$ age, increases with age, by a small amount every year.

$$\frac{\Delta G}{year} \approx \frac{1}{15 \cdot billion} - \frac{1}{15 \cdot billion + 1} = 4.5E\neg 21 \frac{m^3}{kg \cdot s^3} \quad (6.4)$$

6.2 Per second: $\Delta G = 1.522E\neg 28 \frac{m^3}{kg \cdot s^3}$

$$\Delta G = \dot{G} = \frac{G}{age} = \frac{c^3}{M_c} = 1.522E\neg 28 \frac{m^3}{kg \cdot s^3} \quad (6.5)$$

6.3 Per year: $\Delta G \cdot year = \Delta G \cdot 31.5E6 \cdot s$

$$\Delta G \cdot year = \frac{c^3}{M_c} \frac{31.5E6 \cdot s}{year} = 4.804E\neg 21 \frac{m^3}{kg \cdot s^3} \quad (6.6)$$

6.4 In age: $G = \frac{\Delta G}{H_0} = \Delta G \cdot age = \Delta G \cdot 4.383E17 \cdot s$

$$G = \Delta G \cdot age = \frac{c^3}{M_c} \cdot 4.383E17 \cdot s = 6.6726E\neg 11 \frac{m^3}{kg \cdot s^2} \quad (6.7)$$

How do we detect such a small ongoing increase in the gravitational constant? Do the ancient stars, galaxies and supernova look different?

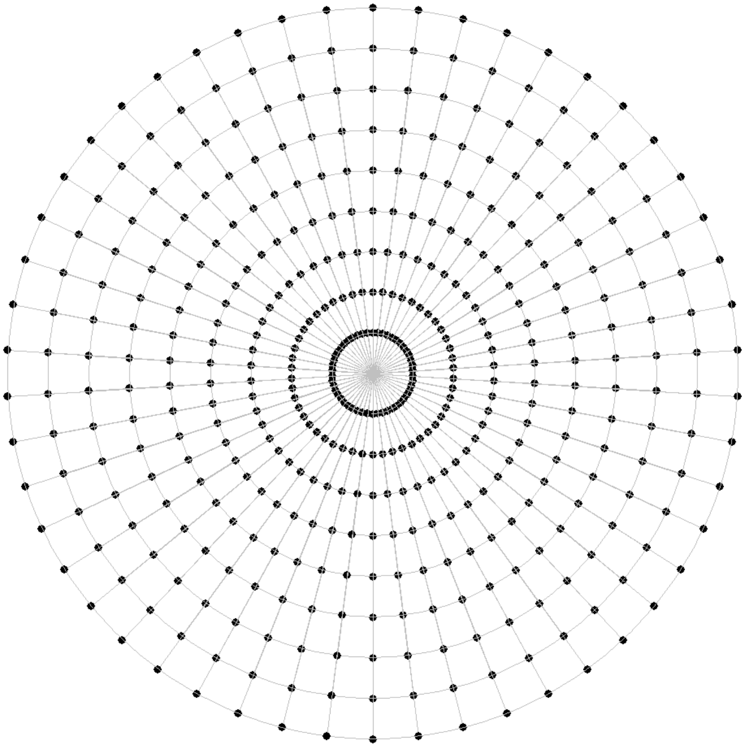


Figure 1: Cosmic radial onion layers with the same mass align.
A fixed mass per shell =
A fixed number of particles per shell =
Crystal like layers. This looks two dimensional like a spider web [7] but these are three dimensional onion layers of spherical shells.
See corrugated galaxy [14]. Also see figure (2).

7 Cosmic $\frac{mass}{radius}$ $ratio:\quad \frac{m}{r}=\frac{c^2}{G}=1.347E27\frac{kg}{m}$

The mass stays the same but both, the radius $r=\Delta r\cdot age\ or\ r=v_r\cdot age$ and $G=\Delta G\cdot age$ increase with age. The denominator gets bigger. The ratio decreases with time. The volume, which includes a constant mass, expands with the Cosmos. We have expanding black holes, including the Cosmos. We might call these Newtonian black holes.

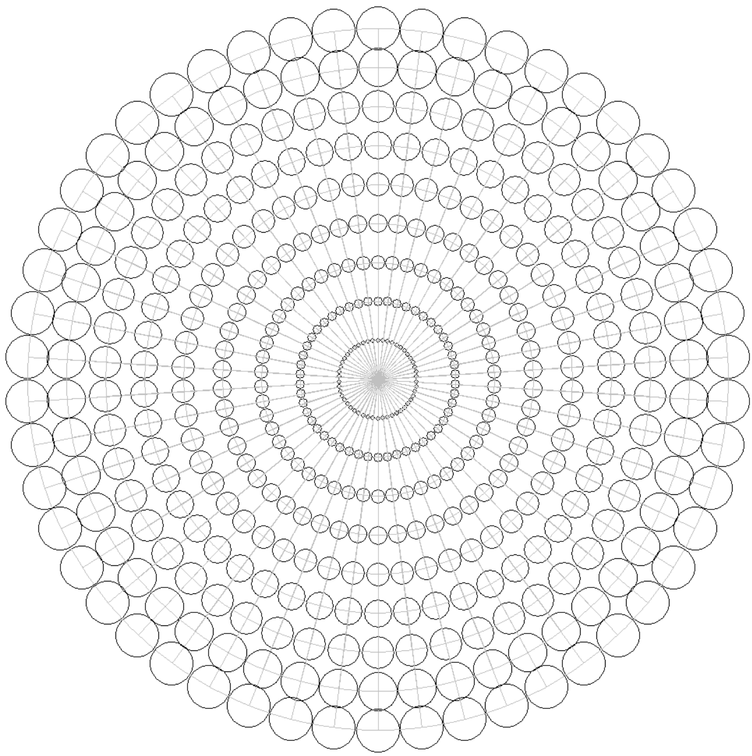


Figure 2: Cosmic radial onion layers with spheres
Can you see how this is like soap bubbles stuck together? The cosmic web follows from the voids between spheres stacked like oranges.

A one solar mass black hole would have a radius of 1476 meters.

A ten solar mass black hole would have a radius of 14760 meters. This is mass = radius times a ratio $(kg = meters \cdot \frac{kg}{meters})$. A solar mass is added every 1476 meters of radius. A fixed mass is added for each meter of radius, that is to say, a fixed number of particles is added for each meter of radius.

This is the combined mass of a stack of concentric spherical shell layers of equal mass or the mass of an onion where each onion layer adds a fixed mass. A fixed mass is a fixed number of attracting particles. Each spherical, meter thick shell layer, adds $1.347E27 \cdot kg$ per meter or per layer. Attracting particles might align in radial and tangent lines from the center, layer to layer, like figures (1 or 2). Cosmic variation in G, v_t and v_r could cause the crystal pattern to clump up. See the corrugated galaxy [14]. Angular momentum might be transferred layer to layer or between the Cosmos and galaxies. Our Cosmos, a cosmic black hole, appears to be a crystal-like sphere.

7.1 Cosmic mass: $M_c = \frac{c^3}{\Delta G} = 1.77E53 \cdot kg$

The speed of light cubed divided by the rate of change of gravity. How surprising is that?

$c^2\, r = G\, M \cdots\cdots$ Our black hole definition from $\cdots\cdots (5.1\, page\, 9)$

Expand with $r = v_r \cdot age,\ \ G = \Delta G \cdot age$ and $v_r = c$:

$$c^2{\cdot}v_r{\cdot}age = \Delta G{\cdot}age{\cdot}M \cdots \text{or} \cdots c^2{\cdot}v_r = \Delta G{\cdot}M \cdots \text{or} \cdots c^3 = \Delta G{\cdot}M \tag{7.1}$$

$6E53 \cdot kg\ \ or\ \ 6E56 \cdot g$ according to Ciufolini and Wheeler [6].

$$M_c \cdot \Delta G = c^3 \cdots \text{or} \cdots \Delta G = \frac{c^3}{M_c} \cdots \text{ or } \cdots G = \frac{c^3}{M_c} \cdot age \tag{7.2}$$

As the $M_c = the\ mass\ of\ the\ Cosmos$ goes up:
$\Delta G,\ G$ and the $gravitational\ forces$ go down, when c^3 is a constant:

$$\underset{M_c}{\uparrow} \cdot \underset{\Delta G}{\downarrow} = c^3 \cdots \text{or} \cdots \underset{M_c}{\downarrow} \cdot \underset{\Delta G}{\uparrow} = c^3$$

If the $mass\ of\ the\ Cosmos = M_c$, has increased over time, through accretion, impacts and merging with other masses, from outside our "stable, self-gravitating, spherical distribution of equal mass objects", our virial dynamic unit Cosmos.
Then, $the\ rate\ of\ change\ of\ gravity = \Delta G$ and the variable $gravitational\ constant = G$, decrease with every increase in mass while increasing with age from their new lower value.
See section (2 page 8) for the virial theorem.

8 Orbital forces decrease with age

How can the gravitational force decrease with age if $G = \Delta G \cdot age$ increases with age?

$$force = \frac{G \cdot m \cdot M_c}{r^2} = \frac{\Delta G \cdot age \cdot m}{c^2 \cdot age^2}\frac{c^3}{\Delta G} = \frac{m \cdot c}{age} \tag{8.1}$$

The gravitational force decreases with age because the age in the numerator is canceled by the age^2 in the r^2 in the denominator.
The orbital centrifugal and gravitational forces are:

$$\frac{m \cdot v_t^2}{r} = \frac{G \cdot m \cdot M_c}{r^2} \cdots\cdots\cdots \text{from equation} \cdots\cdots\cdots (2.3\, page\, 8)$$

At the perimeter of the Cosmos substitute for:
$v_t = c$, $v_r = c \; at \; r = c \cdot age$, $G = \Delta G \cdot age$ and $M = M_c = c^3/\Delta G$.
Collect terms:

$$\frac{m \cdot c^2}{c \cdot age} = \frac{\Delta G \cdot age \cdot m}{(c \cdot age)^2} \frac{c^3}{\Delta G} \cdots\cdots \text{or} \cdots\cdots \frac{m \cdot c}{age} = \frac{m \cdot c}{age} \quad (8.2)$$

The equal and opposite centrifugal and gravitational forces decrease with age. These variable forces were much stronger in the past.

Star formation, accretion and fusion rates would have varied with the stronger forces in the past. The standard candle, Type 1A supernovas, may have been affected.

What does this do to the accelerating universe dark energy theory?

8.1 Gravitational energy is constant with age

It remains equal to the rest energy and stays the same with age as the Cosmos expands. $v_r = c$ at $r = c \cdot age$. From equation (5.2 page 10):

$$\frac{G \cdot m \cdot M_c}{r} = \frac{\Delta G \cdot age \cdot m}{c \cdot age} \frac{c^3}{\Delta G} = \frac{m \cdot c^3}{c} = m \cdot c^2$$

The gravitational energy stays the same, in the Cosmos and smaller black holes because the age cancels. In black holes with a mass smaller than the Cosmos where $v_r < c$ and $M = \frac{M_c \cdot v_r}{c}$:

$$\frac{G \cdot m \cdot M}{r} = \frac{G \cdot m}{r} \cdot \frac{M_c \cdot v_r}{c} = \frac{\Delta G \cdot age \cdot m}{v_r \cdot age} \cdot \frac{c^3}{\Delta G} \cdot \frac{v_r}{c} = m \cdot c^2$$

Light could form a spherical region or shell where light orbits. Any mass or energy inside the shell would contribute to the total mass increasing the radius of the shell. Light could form an empty shell with energy confined to the shell since light has energy and consequently mass. An empty shell of a black hole with only orbiting light or energy does requires some thought. See section (10 page 17) on Geons .

9 Expanding black holes

If $r = v_r \cdot age$ increases with age, as it must in an expanding Cosmos, then $G = \frac{c^3 age}{M_c}$ must also increase with age. Mass and c are constants.

M is the mass of any black hole. M_c is the mass of the Cosmos. v_r is the radial velocity of expansion which varies with mass. Since light orbits black holes, v_t the tangent velocity is always c in black holes. Substitute for r = v_r·age and $G = \Delta G \cdot age = \frac{c^3 age}{M_c}$.

$$r = \frac{M \cdot G}{c^2} \cdots \text{or} \cdots v_r \cdot age = \frac{M \cdot \Delta G \cdot age}{c^2} \cdots \text{or} \cdots v_r = \frac{M \cdot \Delta G}{c^2}$$

The age cancels. Substitute for $\Delta G = \frac{c^3}{M_c}$:

$$v_r = \frac{M}{c^2}\frac{c^3}{M_c} \cdots \text{or} \cdots \frac{v_r}{c} = \frac{M}{M_c} \cdots \text{or} \cdots M = \frac{M_c \cdot v_r}{c} \cdots\cdots \quad (9.1)$$

The radial velocities and masses are ratios. As the $M = mass$ goes up the $v_r = radial\ velocity$ goes up. The radial velocity of expansion is proportional to mass.

9.1 Black hole radial velocity of expansion

$$v_r = mass \cdot \frac{\Delta G}{c^2} = mass \cdot 1.694E\neg 45 \frac{m}{s \cdot kg} \quad (9.2)$$

$$\text{Ten solar masses} = 1.989E31 \cdot kg \cdots \text{so} \cdots v_r = 3.369E\neg 14 \frac{m}{s} \quad (9.3)$$

$$\text{A billion solar masses} = 1.989E39 \cdot kg \cdots \text{so} \cdots v_r = 3.369E\neg 6 \frac{m}{s}$$

$$\text{and } 3.369E\neg 6 \frac{m}{s} \cdot 31,556,926 \frac{s}{year} = 106.3 \frac{m}{year} \quad (9.4)$$

is the expansion rate, which is too small to measure. But:

$$8.898E22 \text{ solar masses = the mass of the Cosmos} = M_c$$

$$\text{and} \cdots 1.77E53 \cdot kg \cdots \text{so} \cdots v_r = 299,792,458 \frac{m}{s} = c \cdots \quad (9.5)$$

Black holes expand in proportion to their mass. The radius of the Cosmos expands at the speed of light c, or 1 light year per year, because it has enough mass for it to expand at c. This proportionally small expansion is one year in the age of the Cosmos or one part in 13.9 billion per year.

9.2 Dark energy

If our Cosmos reached its current mass by merging with other masses, as I suspect, then at earlier times it would have had a smaller radial velocity 'v_r'. Each merging would have increased its mass and radial velocity.

One might say that its radial velocity of expansion v_r, is accelerating, with each cosmic increment in mass, in keeping with the theory of $dark\ energy$.

10 Geons

In 1955, John Archibald Wheeler found an interesting way to treat the concept of body in general relativity which he called Geons [12].

> "An object can, in principle, be constructed out of gravitational radiation or electromagnetic radiation, or a mixture of the two, and may hold itself together by its own gravitational attraction. The gravitational acceleration needed to hold the radiation in a circular orbit of radius r is of the order of $\frac{c^2}{r}$. The acceleration available from the gravitational pull of a concentration of radiant energy of mass M is of the order $\frac{GM}{r^2}$. The two accelerations agree in order of magnitude when$\cdots\cdots$"

$$\frac{c^2}{r} = \frac{G \cdot M}{r^2} \cdots \text{or} \cdots c^2 \cdot r = G \cdot M \text{ from equation } (5.1\ page\ 9)$$

> "$\cdots\cdots$ A collection of radiation held together in this way is called a geon (gravitational electromagnetic entity) and is a purely a classical object. $\cdots\cdots$ Studied from a distance, such an object presents the same kind of gravitational attraction as any other mass. $\cdots\cdots$ A geon made of pure gravitational radiation a gravitational geon $\cdots\cdots$ owes its existence to a localized – but everywhere regular – curvature of spacetime, and to nothing more. In brief, a geon is a collection of electromagnetic or gravitational wave energy, or a mixture of the two, held together by its own gravitational attraction, that describes mass without mass. [13]"

Wheeler gave the name to the "black hole" in 1967. Curious that he did not use the formula he gave to geons in 1955, the year that his friend Einstein died, and apply it to black holes.

11 Orbiting Light Black Hole Formulas

11.1 Mass of a black hole: $M = \frac{c^2 \cdot v_r}{\Delta G}$

$$M = \frac{c^2 \cdot r}{G} = \frac{c^2 \cdot v_r \cdot age}{\Delta G \cdot age} = \frac{c^2 \cdot v_r}{\Delta G} \tag{11.1}$$

11.2 Cosmic mass: $M_c = \frac{c^3}{\Delta G} = 1.77E53 \cdot kg$

$$M_c = \frac{c^2 \cdot r}{G} = \frac{c^2 \cdot c \cdot age}{\Delta G \cdot age} = \frac{c^3}{\Delta G} \tag{11.2}$$

11.3 Radius of a black hole: $r = v_r \cdot age$

$$r = \frac{mass \cdot G}{c^2} = \frac{c^2 \cdot v_r}{\Delta G} \cdot \frac{\Delta G \cdot age}{c^2} = v_r \cdot age \qquad (11.3)$$

11.4 Cosmic radius: $r_c = c \cdot age = 1.314E26 \cdot m$

$$r_c = \frac{M_c \cdot G}{c^2} = \frac{c^3}{\Delta G} \frac{\Delta G \cdot age}{c^2} = c \cdot age \qquad (11.4)$$

11.5 Surface area

$$4\pi \cdot r^2 \cdots or \cdots 4\pi \cdot v_r^2 \cdot age^2 \cdots or \cdots 4\pi \cdot c^2 \cdot age^2 \qquad (11.5)$$

11.6 Density

$$\frac{mass}{volume} = \frac{3 \cdot mass}{4\pi \cdot r^3} = \frac{3 \cdot c^2 \cdot r}{4\pi \cdot r^3 \cdot G} = \frac{3 \cdot c^2}{4\pi \cdot c^2 \cdot age^2 \cdot G} = \frac{3}{4\pi \cdot age^2 \cdot G}$$

$$\frac{3 \cdot c^2}{4\pi \cdot r^2 \cdot G} = \frac{3 \cdot c^6}{4\pi \cdot mass^2 \cdot G^3} \qquad (11.6)$$

Notice the r^2 and $mass^2$ in the denominators. Substitute for:
$G = \Delta G \cdot age$ and $r = c \cdot age$ or $mass = \frac{c^3}{\Delta G}$,
for the cosmic density:

$$\frac{mass}{volume} = \frac{3 \cdot c^2}{4\pi \cdot r^2 \cdot G} = \frac{3 \cdot c^2}{4\pi \cdot c^2 \cdot age^2 \cdot \Delta G \cdot age} \qquad (11.7)$$

11.7 Cosmic density: $\frac{3}{4\pi \cdot \Delta G \cdot age^3} = 1.862\neg 26 \frac{kg}{m^3}$

$$\frac{3}{4\pi \cdot \Delta G \cdot age^3} = 1.862E\neg 26 \frac{kg}{m^3} = 1.862E\neg 29 \frac{g}{cm^3} \qquad (11.8)$$

The lowest density black hole is our Cosmos. The mass of a proton or hydrogen atom is 1.67E-27 kg so the average density of the Cosmos [10] is about 11 protons per cubic meter and is decreasing with the cube of the age of the Cosmos.

This mass density when multiplied by c^2 is the energy density of Einstein's cosmological constant Lambda Λ, cited with dark energy [9] as the source of the expansion of the universe.

This is not unexpected, when the Cosmic mass from equation (11.2) and black hole radial velocity from (9.2) produce the radial velocity c:

$$v_r = Cosmic\,mass \cdot \frac{\Delta G}{c^2} = \frac{c^3}{\Delta G} \cdot \frac{\Delta G}{c^2} = c \qquad (11.9)$$

without the requirement of dark energy in a rotating expanding Cosmos.

11.8 Black hole density, radius and mass

$$Density = \frac{mass}{volume} = \frac{3 \cdot c^2}{4\pi \cdot r^2 \cdot G} = \frac{3 \cdot c^6}{4\pi \cdot mass^2 \cdot G^3} \quad (11.10)$$

Notice the $mass^2$ and r^2 in the denominators. Ten times mass or $r = radius$, equals density divided by 100.

$$r = radius\ of\ a\ black\ hole = v_r \cdot age = \frac{mass \cdot G}{c^2} \quad (11.11)$$

$$\text{Billion solar mass black hole } = 147.46\frac{kg}{m^3} \text{ and } r = 1.477E12 \cdot m$$

$$\text{384 million solar mass black hole } = 1000\frac{kg}{m^3} \text{ and } r = 5.67E11 \cdot m$$

Water is $1000\frac{kg}{m^3}$. Density goes up as mass and radius goes down.

$$\text{100 solar mass black hole } = 1.4746E16\frac{kg}{m^3} \text{ and } r = 147668 \cdot m$$

Tenth the mass or radius equals 100 times the density.

$$\text{10 solar mass black hole } = 1.4746E18\frac{kg}{m^3} \text{ and } r = 14767 \cdot m$$

Tenth the mass or radius equals 100 times the density.

$$\text{1 solar mass black hole } = 1.4746E20\frac{kg}{m^3} \text{ and } r = 1477 \cdot m \quad (11.12)$$

Nuclear density $\approx 1E21\frac{kg}{m^3}$ so:

$$\text{0.384 solar mass black hole } = 1E21\frac{kg}{m^3} \text{ and } r = 567 \cdot m \quad (11.13)$$

Below this, with decreasing radius or mass, the black hole may exceed nuclear density. We only suppose the center 567 meters of radius of any black hole may be above nuclear density.

Protons and electrons may be squashed into charge-free neutrons, reducing the charge and gravity. No charge, no gravity. Some sort of equilibrium between charge and gravity may exists which averts nuclear density. Isolated neutrons decay into protons, electrons and electron antineutrinos.

Gravity seems based on pulsed charge. When orbiting protons and electrons, in opposite atom pairs, or with neutrons stuck to the protons, align momentarily, they create a jerk ,
$(\ + -) \Leftrightarrow (\ + -)$ or $(- + \ ) \Leftrightarrow (- + \ )$, shown as the double arrows. See the animation at [15] or [16], it is hard to describe but easy to see. The jerk is a momentary force between the atoms. The jerk and force are always attractive. Repulsive gravity is not seen. This is just like the opposite poles of bar magnets. The pulses or impulses are so infrequent

$\frac{1}{10E39}$ $seconds$ and of such short duration at such high frequency, that it explains the weakness of gravity compared to un-pulsed Coulomb force. See: Electric gravity: [17]:

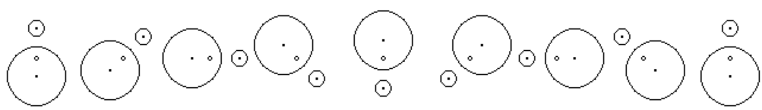
$\frac{v_e}{2\pi \cdot r_e}$ = frequency = 6.58327E15 $\cdot \frac{1}{s}$

$v_e = 15973 \frac{m}{s}$ is the velocity of the electron and $r_e = 3.86E\neg 13 \cdot m$ is the radius of the electron orbit.

$\frac{c}{frequency}$ = wavelength = $45.54E\neg 9 \cdot m.$

This is in the extreme ultraviolet, EUV. Here is a reference to the Solar Dynamics Observatory.

> "EUV wavelengths range between 50 and 5 nano meters, which coincide with the characteristic absorption wavelengths of inner-shell electrons in the atoms that compose matter. As a result, EUV light directed onto a standard mirror or lens at normal incidence is absorbed rather than reflected, making it undetectable. For this reason, EUV light is also absorbed by Earth's atmosphere, which is why telescopes must travel to space to study the light emitted from the Sun."



12 Supernova

x-ray bursters cluster around 1.4 solar masses = $2.8E30 \cdot kg$ [18], and radius [19] of $9600 - 11000 \cdot m$ which yields,

$$x - ray\ burster\ density \approx 5.0E17 \frac{kg}{m^3}\ \ to\ \ 7.6E17 \frac{kg}{m^3} \qquad (12.1)$$

As mass accretes in a binary star system, from a companion star, onto the x-ray burster star, it reaches a point, where the added mass explodes in a fusion explosion called a supernova. This limits the mass of the star which is then ready for more accretion. Apparently, stars do not become black holes by this route of accretion and fusion explosions. The collapse or merger of large stars does provide another route for black hole creation.

Black hole density *decreases* with the increase of mass and radius *not increases*. As black holes get bigger their density decreases. The lowest density black hole is our Cosmos.

13 Merging Soap Bubbles or Black Holes

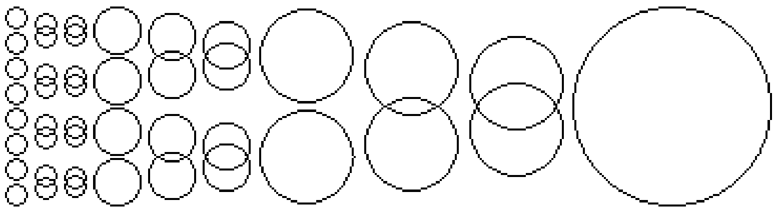


Figure 3: Merging black holes

A short fable about eggland:
In eggland, two eggs touch. Their shells merge much like soap bubbles merge to make a larger soap bubble. Their contents merge. Where there was two eggs, there is now one larger egg with two yokes.

Over time, there is a very big egg with many crowded yokels.

The yokels being unaware of the mechanics of merging make up odd stories about their creation and their importance to the creator.

Looking at figure (3), visualize two soap bubbles or black holes that overlap, their contents merge, thereafter being enclosed by a single larger sphere, of their combined diameters.
Little ones merge to make big ones.

The light and energy that previously orbited around each black hole will, after their travel through space, eventually orbit at this new larger radius.

All these photons orbiting at the same radius have many photon-photon impacts which eventually tends to make the very thin layer of photons uniform.

Not all of these photon-photon [20] or gamma-gamma scatterings are elastic. Many of these impacts emit electromagnetic radiation which reaches us as the cosmic microwave background the CMB, visible in any direction from near the inside surface of the Cosmos where light orbits.

13.1 Spherical caps of merging spheres

See figure (3 page 21). A spherical cap is a part cut off a sphere. When two spheres merge they create a lens shaped merged region. The volume of the lens shaped merged region includes four times the volume of the spherical cap. The volume of a spherical cap is:

$$volume\ of\ a\ spherical\ cap = \frac{1}{3}\pi r^3(3 - fr)fr^2 \tag{13.1}$$

with fr being the fraction of r, that is the height of the cap. The volume of a sphere equal to four spherical caps would be:

$$volume\ of\ four\ spherical\ caps = \frac{4}{3}\pi r^3(3 - fr)fr^2 \qquad (13.2)$$

equals the volume of a sphere when

$$1 = (3 - fr)fr^2\ when\ fr = .6527036 \qquad (13.3)$$

The volume of four spherical caps equals the volume of a sphere of radius r when fr = .6527036.

When the spherical caps of merging black holes of the same size reach .6527036 of their radius, the volume and the mass of the merged portions satisfies the mass/radius formula for a black hole.

$$volume\ of\ the\ sphere = \frac{4}{3}\pi r^3\ when\ (3 - fr)fr^2 = 1 \qquad (13.4)$$

The new velocity distribution in the merged black hole will cause all the orbits to relocate over time but these are small acceleration forces in a low density Cosmos like our own.

Light and energy will eventually occupy an orbit at the new now larger radius of the black hole. The masses within will seek their own new orbits.

The acceleration at the edge of the Cosmos is:

$$\frac{c}{age} = 6.84E\neg 10\frac{m}{s^2} \qquad (13.5)$$

and is fractionally smaller within the Cosmos. This is billions of times smaller than the acceleration of gravity at the Earths surface of $9.8\frac{m}{s^2}$.

Far from being a dramatic event, the merging of low density black holes would be hardly detectable from an acceleration standpoint. A black hole approaching ours would be invisible until the merging. Its contents would then become visible in our Cosmos.

14 Deriving inertial forces

These are polar coordinates. The velocity and accelerations are expressed in terms of perpendicular radial and transverse components.

$$r = \hat{u}_r\ r \qquad (14.1)$$

$$v = \frac{dr}{dt} = \hat{u}_r\frac{dr}{dt} + \frac{d\hat{u}_r}{dt}r$$

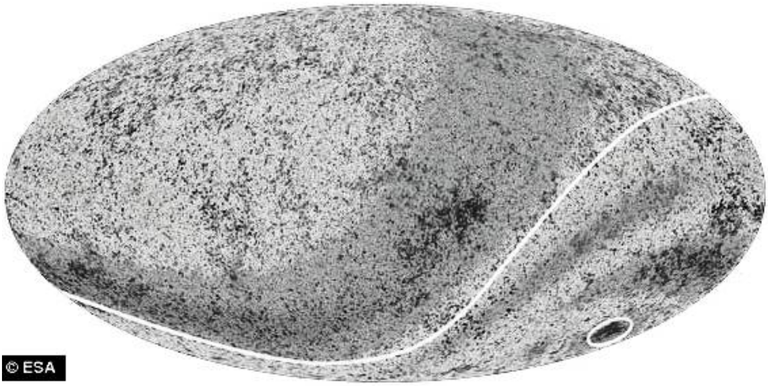


Figure 4: CMB, Cosmic Microwave Background, asymmetry per ESA

$d\hat{u}_r/dt = \hat{u}_\theta \cdot \omega \quad and \quad d\hat{u}_\theta/dt = \neg\hat{u}_r \cdot \omega\ (negative\ angle)$[22]

$$v = \frac{dr}{dt} = \hat{u}_r\, v + \hat{u}_\theta\, \omega\, r \tag{14.2}$$

Velocity v, has two components: A radial component $v_r = \frac{dr}{dt}$, $\perp$ a theta angular or tangent component at right angles $v_\theta = \omega \cdot r$.

$$a = \frac{dv}{dt} = \hat{u}_r \frac{dv}{dt} + \frac{d\hat{u}_r}{dt} v + \hat{u}_\theta \left(\omega \frac{dr}{dt} + r \frac{d\omega}{dt}\right) + \left(\frac{d\hat{u}_\theta}{dt}\right)(\omega\, r)$$

$$a = \frac{dv}{dt} = \hat{u}_r\, a + \hat{u}_\theta\, \omega\, v + \hat{u}_\theta\, \omega\, v + \hat{u}_\theta\, r\, \alpha - \hat{u}_r\, \omega\, \omega\, r$$

$$a = \frac{dv}{dt} = \hat{u}_r(a - \omega^2 r) + \hat{u}_\theta(2\, \omega\, v + r\, \alpha) \tag{14.3}$$

Acceleration has four components. The resultant accelerations are:
Radial: $\hat{u}_r(a - \omega^2 r)$ gravitational and centrifugal.
Theta: $\hat{u}_\theta(2\, \omega\, v + r\, \alpha)$ Coriolis and angular.
The gravitational and centrifugal forces have opposite signs as expected since the forces are equal and opposite.
$\hat{u}_r$ = unit vector pointing in the radial direction $\perp$
$\hat{u}_\theta$ = unit vector pointing in the theta direction
v_r= velocity in the radial direction $\hat{u}_r(v) = v_r$
v_θ = velocity in the theta direction $\hat{u}_\theta(v) = v_\theta$
a_r = acceleration in the radial direction $\hat{u}_r(a) = a_r$

a_θ = acceleration in the theta direction $\hat{u}_\theta(a) = a_\theta$
ω_r= omega angular velocity in the radial direction $\hat{u}_r(\omega) = \omega_r$
ω_θ = omega angular velocity in the theta direction $\hat{u}_\theta(\omega) = \omega_\theta$
α_r = alpha angular acceleration in the radial direction $\hat{u}_r(\alpha) = \alpha_r$
α_θ = alpha angular acceleration in the theta direction $\hat{u}_\theta(\alpha) = \alpha_\theta$
$\omega \times (\omega \times r) = \omega^2 r$ = centrifugal acceleration vector
$2\ \omega \times v$ = coriolis acceleration vector
$r \times \alpha$ = angular acceleration vector

15 The Cosmos rotates and expands

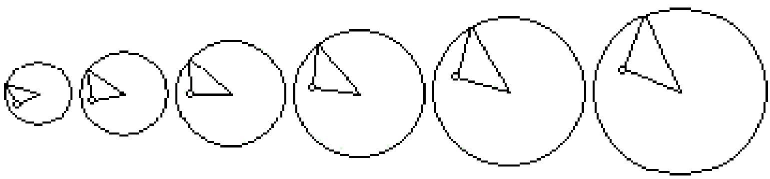


Figure 5: Cosmic balloons

The Cosmos is rotating and blowing up like a balloon but very slowly in relation to its size. See the animation at [33]. The cosmic density is billions of times less than the density of a blown up ballon.

Like a spinning ice skater slows her spin by extending her arms, the spinning universe slows in its rotation while expanding.

The Cosmos is rotating and expanding which produces the spiral galaxy on the cover. See the animation at [34].

At the perimeter of the Cosmos: Light orbits with a
$tangent\ velocity = v_t = c$ and a $radial\ velocity = v_r = c$.
As the Cosmos increases in size, light orbits farther out:
$radius = r = c{\cdot}age$ where $age = the\ age\ of\ the\ Cosmos$. The period increases so the rotation slows down.

This is a Hubble expanding Cosmos. Galaxies are receding at a rate proportional to distance. The further away the faster the recession. Every location within this Cosmos has a constant tangent and radial velocity which are proportional to its radius within the Cosmos, $fr \cdot c \cdot age$ on figure (6 page 25). Since the velocity is constant, the acceleration is zero

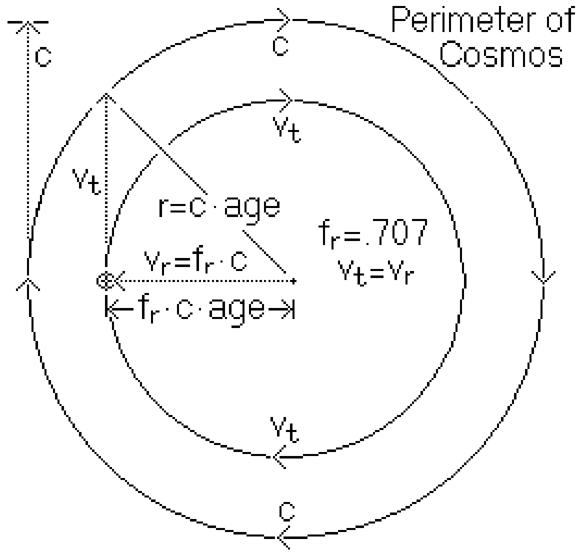


Figure 6: Blow up of triangles

The length of the hypotenuse from the center to the largest circle is the velocity of light times the age of the Cosmos, at that particular time: $radius = r = c \cdot age$.

The perimeter expands and has a radial and tangent velocity of the speed of light: $v_r = v_t = c$.

The base of the triangle expands and rotates at its fixed fraction of the Cosmos. This fraction fr, is the cosine of the triangle which varies from zero to one.

The circled point at the right angle of the triangle is where we might be located. It stays at the same constant fraction of the radius of the Cosmos as the circled point spirals outward.

and no force and no power is required for it to continue on its spiraling out journey. A location spirals out as the forces decrease and the Cosmos expands and slows in its rotation.

In section (1 page 6) we asked; "Does the Hubble expansion extend to the galaxy, to the solar system and to atoms?" The answer depends on the source of the Hubble expansion. We now see that the Hubble expansion of the Cosmos is caused by its dynamic equilibrium. The Cosmos slows in its rotation while it expands. Torque and rotational energy are conserved. Its has a slowing angular acceleration:
$\frac{-1}{age^2} = -5.205E - 36\frac{1}{s^2}$ as it expands. So Hubble expansion does extend to atoms.

The totality of everything is called the Universe. The part of the Universe which we can hope to understand is here called the Cosmos, a subset of either the Universe or the Multi-verse. Some might call the Cosmos the visible Universe. It is certainly home. The Cosmos, galaxy

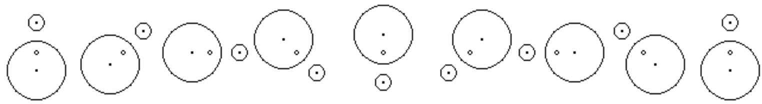


Figure 7: Binary rotations

and solar system all expand and rotate with respect to each other, in dynamic equilibrium.

Looking at figure (7 page 26). If the background universe has features which are close enough, and these features are not black holes, then they may be visible through the intense orbiting energy and light around the Cosmos. Seeing through this orbital energy seems possible since stars are visible near the sun during an eclipse as starlight perpendicular to the huge energy flow from the sun. We might be seeing such features in the Hubble telescope deep field photographs. It would not be remarkable if the background universe looks the same as it does within our dynamic unit Cosmos.

15.1 Cosmic angle of rotation: $\theta = ln(age)$

$$\omega = omega = angular\ velocity = \frac{d}{dt} angle\ of\ rotation = \frac{tangent\ velocity}{radius} = \frac{v_t}{r} = \frac{c}{c \cdot age} = \frac{1}{age} \tag{15.1}$$

is equal to this second equation

$$\frac{d}{dt} ln(age) = \frac{1}{age} \tag{15.2}$$

so that

$$\int \frac{d}{dt} angle\ of\ rotation = \int \frac{d}{dt} \ln(age) \tag{15.3}$$

Integrating on both sides, per Sylvanous P. Thompson [21], the sum of the little bits of the angle of rotation equals the sum of the little bits of the natural logarithm of the age of the Cosmos.

$$\theta = angle\ of\ rotation = \ln(age) \tag{15.4}$$

The rate of change of the angle of rotation theta θ is the angular velocity omega ω.

$$\frac{d}{dt} angle\ of\ rotation = \frac{d}{dt}\ln(age) \tag{15.5}$$

$$\omega = angular\ velocity = \frac{1}{age} \tag{15.6}$$

The rate of change, of the angular velocity omega ω, is the angular acceleration alpha α, the rate of the slowing of the rotation of the Cosmos as it expands.

$$\alpha = \frac{d}{dt} angular\ velocity = \frac{d}{dt}\omega = \frac{d}{dt}\frac{1}{age} \tag{15.7}$$

$$\alpha = angular\ acceleration = \frac{\neg 1}{age^2} = \neg 5.205\neg 36\frac{1}{s^2} \tag{15.8}$$

This is the second derivative of the $angle\ of\ rotation\ \theta$, which is equal to the second derivative of the $ln(age)$.

This very small rate that the Cosmos is decelerating in its rotation is necessary for the equilibrium between rotation and expansion of the Cosmos. It satisfies the rules of dynamics.

The Cosmos rotated faster when it was smaller and younger. This difference in rotation might be detected but the angular acceleration is profoundly slow at $\frac{\neg 1}{age^2} = \neg 5.205E\neg 36\frac{1}{s^2}$.

We are rotating with the Cosmos. Everything has the same slowing universal angular velocity, $\omega = H_0 = \frac{1}{age} = 2.281E\neg 18\frac{1}{s}$, as a component of their local angular velocity.

15.2 Cosmic radius: $c \cdot age = c \cdot e^{\theta}$

$$\theta = 40.62\ radians = ln(4.383E17) \tag{15.9}$$

The base of the natural logarithms is e, e for Euler, 'Oiler'.

$$e^{\theta} = e^{angle\ of\ rotation} = e^{40.62} = 4.383E17\ seconds = age \tag{15.10}$$

$$ln(age) = ln(e^{\theta}) = \theta$$

Each time the Cosmos doubles in age or size the angle of rotation of the Cosmos theta θ, increases by the natural logarithm of 2.

$$\ln(2) = .693\ radians = 39.7\ degrees \tag{15.11}$$

We are currently at 40.62 radians so:

$$\frac{40.62}{2\pi} = 6.465\ revolutions \tag{15.12}$$

might have been made by the orbiting light and energy in the age of the Cosmos. This revolution started when the Cosmos was only:

$$e^{40.62-2\pi} = 8.17E14 \cdot s = 25.89\ million\ years\ old \tag{15.13}$$

We are currently at:

$$e^{40.62} = 4.383E17 \cdot s = age = 13.9\ billion\ years\ old \tag{15.14}$$

The next revolution, of the Cosmos, will last until the age is:

$$e^{40.62+2\pi} = 2.336E20 \cdot s = 7401\ billion\ years\ old \tag{15.15}$$

The slowly stirring Cosmos is slowing down.

15.3 Cosmic inertial accelerations

To calculate the path of a particle, from inside a rotating Cosmos, we need the vector sum of three accelerations: the centrifugal, Coriolis and angular. These are components of the so called fictitious forces which are more properly called forces due to inertia. They are certainly not fictitious if you take the Machian view [23] that inertia is the acceleration dependent gravitational force exerted by the rest of the universe.

When you push on a car to get it rolling inertia pushes back. It is the mass of the universe which pushes back. This is Mach's principle. Inertia is explained as a Weber force in the articles and books by A. K. T. Assis [26].

15.4 Cosmic centrifugal acceleration: $\frac{c}{age}$

An angular velocity associated with a radial force.
The centrifugal and gravitational forces are equal.
$\frac{m \cdot v_t^2}{r}$ is the radial centrifugal force.
$\omega \times (\omega \times r) = \frac{v_t}{r} \frac{v_t\ r}{r} = \frac{v_t^2}{r}$ is the tiny acceleration felt by light or energy in orbit at the perimeter of the Cosmos.

$$\omega \times (\omega \times r) = \frac{v_t^2}{r} = \frac{v_t^2}{v_r \cdot age} = \frac{c^2}{c \cdot age} = \frac{c}{age} = 6.84\neg 10 \frac{m}{s^2} \tag{15.16}$$

15.5 Cosmic coriolis acceleration: $\frac{2 \cdot c}{age}$

Inertia will cause a radial outward directed mass, on a rotating platform, to lag behind in a direction opposite to the rotation. This is the reaction. The action which is the Coriolis acceleration is in the direction of the rotation. A person in an accelerating car is pushed back against the seat. This is a reaction to the acceleration. The acceleration is in the direction of the velocity. The reaction is in the direction opposite the velocity.

$$Coriolis\ acceleration = 2 \cdot \omega \cdot v_r = 2 \cdot angular\ velocity \cdot v_r =$$

$$2 \cdot \omega \cdot v_r = \frac{2 \cdot v_t}{r} \cdot v_r = \frac{2 \cdot v_t}{v_r \cdot age} \cdot v_r = \frac{2 \cdot v_t}{age} = \frac{2 \cdot c}{age} \qquad (15.17)$$

15.6 Cosmic angular deceleration: $\frac{\neg c}{age}$

We can calculate the tangent deceleration using the torque formula.

$$torque = force \cdot radius = mass \cdot acceleration \cdot r$$

$$torque = moment\ of\ inertia \cdot angular\ acceleration$$

$$mass \cdot acceleration \cdot r = mass \cdot r^2 \cdot angular\ acceleration$$

$$acceleration = r \cdot \alpha = r \cdot angular\ acceleration = tangent\ deceleration$$

$$acceleration = r \cdot \alpha = v_r \cdot age \cdot \frac{\neg 1}{age^2} = \frac{\neg v_r}{age} = \frac{\neg c}{age} \qquad (15.18)$$

The direction of the deceleration is opposite the rotation. This is a negative tangent force.

15.7 Cosmic Expansion: $\sqrt{2} \cdot \frac{c}{age} = 9.67E\neg 10 \frac{m}{s^2}$

Now that we have calculated the inertial accelerations, we can look at the way the Cosmos expands. We have the:

$$\text{centrifugal acceleration} = \frac{c}{age} \qquad (15.19)$$

directed radially out. We have the:

$$\text{Coriolis angular acceleration} = \frac{2 \cdot c}{age} \qquad (15.20)$$

in the direction of rotation. We have the angular acceleration opposite the direction of rotation.

$$\text{angular deceleration} = \frac{\neg c}{age} \qquad (15.21)$$

The resultant of these accelerations is 45 degrees between the direction of rotation and the outward directed radius. It has a value of:

$$\sqrt{2} \cdot \frac{c}{age} = 9.67E\neg 10 \frac{m}{s^2} \qquad (15.22)$$

A particle moving in this way traces out a logarithmic spiral.
We have seen that the:

$$angle\ of\ rotation = \ln(age) \cdots\cdots \text{or} \cdots\cdots \theta = \ln(age) \quad (15.23)$$

This can be written as:

$$age = e^{angle\ of\ rotation} \cdots\cdots\cdots \text{or} \cdots\cdots\cdots age = e^{\theta} \quad (15.24)$$

Now:

$$r = c \cdot age \quad (15.25)$$

can be written as:

$$r = c \cdot e^{angle\ of\ rotation} \cdots\cdots\cdots \text{or} \cdots\cdots\cdots r = c \cdot e^{\theta} \quad (15.26)$$

This is the equation of a logarithmic spiral. It is no coincidence that many galaxies have a spiral shape. Their spiral is expected in an expanding rotating Cosmos.

16 Logarithmic Spiral

Indeed, it is not that space expands but that the distance between orbiting masses increases as they spiral out and apart from each other in figure (8) as the Cosmos expands and slows in its rotation.

The tangent velocity of the stars orbiting in galaxies, stays the same as the galaxies expand and the orbital periods increase conserving energy per the flat rotation curves of galaxies [27]. Any velocity change would require force and energy which are absent.

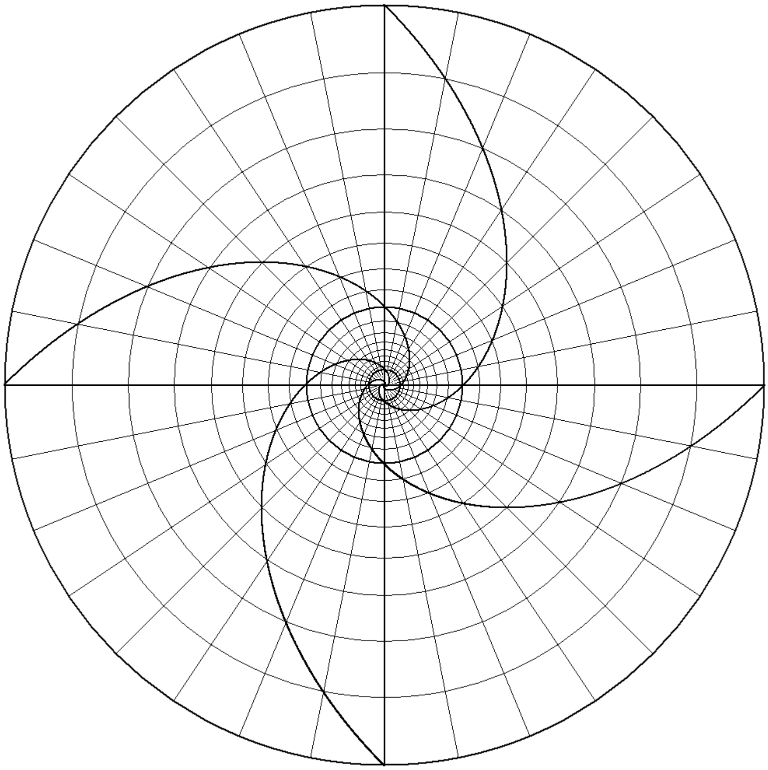


Figure 8: Logarithmic spirals
The angle of rotation $\theta = ln(age)$. $r = radius = c \cdot age = c \cdot e^{\theta}$.
The bold circles are at: $e^{\pi} = 23.14,\ e^{\pi \cdot 1.5} = 111.31\, and\, e^{\pi \cdot 2} = 535.49$.
The ln(23.14) = π. The angle of advance of the arms is 45 degrees. The tangent velocity equals the radial velocity, $v_t = v_r$, in galaxies with flat rotation curves and the Cosmos.

17 Moment of inertia of the Cosmos: $mass \cdot r^2$

$$\text{moment of inertia of a ring} = mass \cdot r^2 \tag{17.1}$$

$$\text{moment of inertia of a spherical shell } = \frac{2}{3} mass \cdot r^2 \tag{17.2}$$

$$\text{moment of inertia of a cylinder } = \frac{1}{2} mass \cdot r^2 \tag{17.3}$$

$$\text{moment of inertia of a solid sphere } = \frac{2}{5} mass \cdot r^2 \tag{17.4}$$

We are not too far off when we call the Cosmic:

$$\text{moment of inertia} \ = mass \cdot r^2 = mass \cdot c^2 \cdot age^2 \tag{17.5}$$

The moment of inertia increases with the square of the radius or age. It is between 0.4 and 1 times $mass \cdot r^2$.

17.1 Torque of the Cosmos is conserved: $\neg M_c \cdot c^2$

$$torque = moment\ of\ inertia \cdot angular\ acceleration$$

$$torque = Mass \cdot r^2 \cdot angular\ acceleration$$

$$torque = Mass \cdot v_r^2 \cdot age^2 \cdot angular\ acceleration \tag{17.6}$$

The moment of inertia increases with the square of r or age. But:

$$\frac{v_r}{c} = \frac{M}{M_c} \cdots\cdots\cdots \text{and} \cdots\cdots\cdots v_t r^2 = \frac{c^2 \cdot M^2}{M_c^2} \tag{17.7}$$

Using equation (17.6), substitute v_r^2 from (17.7) in the following:

$$torque = M \cdot \frac{c^2 \cdot M^2}{M_c^2} \cdot age^2 \cdot angular\ acceleration$$

$$torque = \frac{c^2 \cdot M^3}{M_c^2} \cdot age^2 \cdot angular\ acceleration \tag{17.8}$$

If the mass of the black hole is $M = M_c$, the mass of the Cosmos then:

$$Cosmic\, torque = M_c \cdot c^2 \cdot age^2 \cdot \frac{\neg 1}{age^2} = \neg M_c \cdot c^2 \tag{17.9}$$

$$\text{Energy is conserved} = \neg M_c \cdot c^2 = \frac{kg \cdot m^2}{s^2} \tag{17.10}$$

We see that the age^2, in the square of the radius, in the moment of inertia, is canceled by the angular acceleration $\neg 1/age^2$. The rotational energy or torque stays constant. We will see the same thing in the torque of a spinning galaxy.

The radius of the Cosmos spirals out while the rotation of the Cosmos slows down, and with it all the black holes and galaxies, without a change in energy or use of power, always in dynamic equilibrium. Orbits spiral out as the gravitational force decreases with the age of the Cosmos.

17.2 Angular momentum is conserved: $m \cdot v_t \cdot r$

$$m \cdot v_t \cdot r \text{ is conserved = power} = \frac{kg \cdot m^2}{s} \tag{17.11}$$

$$m \cdot \underset{v_t}{\downarrow} \cdot \underset{r}{\uparrow} \ldots\ldots \text{ or } \ldots\ldots m \cdot \underset{v_t}{\uparrow} \cdot \underset{r}{\downarrow}$$

When the radius changes the velocity changes, if the mass is constant.

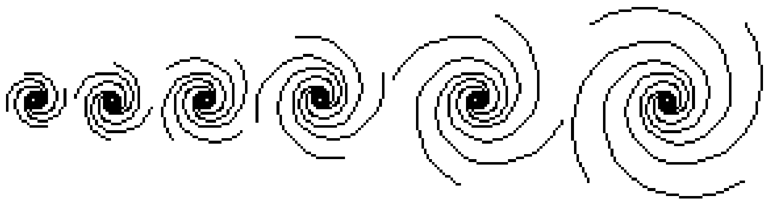


Figure 9: Galactic rotation and expansion

18 Milky Way and galactic matters

Dark matter can be explained by matter present farther out from the galaxy than is seen in the optical spectrum. Most of the galaxy is very low density, cold and dark. This density is too low for the creation of stars or to detect with light. There are occasional orbiting atomic hydrogen clouds in this dark region. The dark matter may be detected in the ultra violet with the James Webb telescope.

Our galaxy, the Milky Way, extends beyond its visible radius, with a $1/r^2$ decreasing density, to a point at which the galaxy is the same density as the Cosmos, at a hundred times its visible radius.

18.1 Visible radius of the galaxy: $R_v = 9.257E20\, m$

$R_v = 30\, kpc \;=\; 97849\, light\ years$ [35] or [36].
Google calls this 105,585 light years..
Wiki calls this 75,000-100,000 light years.

18.2 Flat rotation curve of galaxy: $v_t = 210,000 \frac{m}{s}$

Using the virial theorem $v_t^2\ r = G\ M\ \ or\ \ \frac{v_t^2\ r}{G\ M} = 1$, from equation (2.4 page 8). We have a tangent orbital velocity $v_t = 210,000 \frac{m}{s}$ [32]

at the visible radius R_v, of the Milky Way galaxy. A similar vt, is also measured farther outward, in some dust clouds, with radio telescopes.

As r the radius within a galaxy increases, v_t the tangent velocity of stars, at that radius within the galaxy should decrease with GM taken as a constant, in keeping with Kepler.

However, GM is **not** a constant. G and r are both variable and increasing. What is seen is that the tangent velocity v_t, is largely flat, that is, the velocity stays the same with increasing radius once outside the galactic core. This is called a rotation curve [36] or a flat rotation curve [27] as illuminated by Vera Rubin [30],[31] and by Seth Shostak with radio telescopes [28],[29].

These flat rotation curves have been used as evidence that there is a $halo$ of dark matter in galaxies. What is seldom described is the structure of the $halo$:

A fixed mass is added for each meter increase in the radius of the galaxy R_g. This is like the mass of a stack of concentric spherical shell layers of equal mass or like the mass of an onion where each onion layer adds a fixed mass and an increasing volume . A fixed mass is a fixed number of attracting particles. Each spherical, meter thick shell layer, adds $6.609E20 \cdot kg$ per layer. Attracting particles might align in radial lines from the center, layer to layer.

Angular momentum can be transferred layer to layer or between the Cosmos and galaxies. See figure (1 page 12). The visible extent of a galaxy would be tiny in the center of the figure.

Black holes have a similar pattern but a different velocity over ΔG. Mass = $\frac{c^3}{\Delta G}$ for the Cosmic black hole and $\frac{v_t^3}{\Delta G}$ for a galaxy.

18.3 Galactic: $\frac{mass}{radius} ratio = \frac{m}{r} = \frac{v_t^2}{G} = 6.609E20\frac{kg}{m}$

$$\frac{m}{r} = \frac{v_t^2}{G} \text{ or } \frac{mass}{radius} ratio = \frac{(210,000\frac{m}{s})^2}{6.673E\neg 11\frac{m^3}{kg \cdot s^2}} = 6.609E20\frac{kg}{m} \quad (18.1)$$

The mass of the Earth is added every 9036 meters.
The $\frac{m}{r}$ of a black hole is 1.35E27 $\frac{kg}{m}$, from equation (7 page 12) , over two million times larger than the $\frac{m}{r}$ of the Milky Way galaxy.

18.4 Visible matter: M_v at $R_v = 6.118E41 \cdot kg$

The mass contained within this orbit using the virial theorem $\frac{v_t^2 R}{GM} = 1$ or $\frac{M_v}{R_v} = \frac{v_t^2}{G}$ where M_v is the visible matter:

$$M_v = visible\ matter = \frac{v_t^2 \cdot R_v}{G} = \frac{(210000\frac{m}{s})^2 \cdot 9.257E20 \cdot m}{6.673E\neg 11\frac{m^3}{kg \cdot s^2}} =$$

$$M_v = 6.118E41 \cdot kg \quad or \quad 307.6\, billion\ solar\ masses \tag{18.2}$$

Solar mass = 1.9884E30 kg.

18.5 Galactic density at visible radius R_v : $1.841E\neg 22 \frac{kg}{m^3}$

$$mass = M_v = R_v \frac{v_t^2}{G} \cdots \frac{1}{volume} = \frac{3}{4\pi R_v^3} \cdots R_v = 9.257E20 \cdot m$$

Galactic density at the visible radius of the galaxy:

$$\frac{mass}{volume} = \frac{3 \cdot \frac{v_t^2}{G}}{4\pi R_v^2} = \frac{3 \cdot 6.609E20 \frac{kg}{m}}{4\pi (9.257E20 \cdot m)^2} = 1.841E\neg 22 \frac{kg}{m^3}$$

$$R_v = 9.257E20 \cdot m \qquad \text{density} = 1.841E\neg 25 \frac{g}{cm^3} \tag{18.3}$$

I suspect that this very low density of matter or dark matter, would usually be hard to detect, for example with radio telescopes and 21 cm radiation [38], but it is obviously still probably low density matter, not some mysterious stuff.

Radio telescopes can detect the atomic hydrogen at 21 cm, if it is dense enough along their line of sight. Cold molecular hydrogen [39] which is more stable and probably much more common is unfortunately invisible at radio wavelengths. It may be detected in the future as the unseen dark matter.

R_v times 100 equals density divided by $100^2 = 10,000$.

The density at R_g:

$$R_g = 9.94E22 \cdot m \cdots\cdots \text{density} = 1.597E - 26 \frac{kg}{m^3} \cdots\cdots \tag{18.4}$$

The density of the galaxy at R_g is about the density of the Cosmos.

18.6 Galactic density decreases at $\frac{1}{R^2}$

The galaxy has a constant m/r ratio where R is the galactic radius.

$$mass = \frac{m}{r} R \cdots\cdots \text{and} \cdots\cdots \frac{1}{volume} = \frac{3}{4\pi\ R^3}$$

$$\text{galactic density} = \frac{mass}{volume} = \frac{m}{r} \frac{3 \cdot R}{4\pi\ R^3} = \frac{m}{r} \frac{3}{4\pi\ R^2} \tag{18.5}$$

The galactic density decreases as $1/R^2$. I postulate that the upper limit for the radius of the galaxy would be the radius at which the galactic density at that radius R, equals the average density of the Cosmos.

18.7 Galactic density = Cosmic density: $v_t \cdot age = R_g$

$$\frac{m}{r}\frac{3}{4\pi\ R_g^2} = \frac{3\ M_c}{4\pi\ c^3 age^3}$$

but m/r = v_t^2/G from equation (2.4 page 8) so:

$$\frac{v_t^2}{G}\frac{1}{R_g^2} = \frac{M_c}{c^3 age^3}$$

$$\frac{v_t^2}{R_g^2} = \frac{M_c \cdot G}{c^3 age^3}$$

$M_c = c^3/\Delta G \quad and \quad G = \Delta G \cdot age :$

$$\frac{v_t^2}{R_g^2} = \frac{c^3}{\Delta G}\frac{\Delta G \cdot age}{c^3 age^3}$$

$$v_t^2 \cdot age^2 = R_g^2$$

$$v_t \cdot age = R_g \tag{18.6}$$

18.8 Galactic radius: $R_g = 9.204E22 \cdot m$

$$R_g = v_t \cdot age = 210,000\frac{m}{s} \cdot 4.383E17 \cdot s = 9.204E22 \cdot m$$

$$\frac{v_t^2}{G} = \frac{M_g}{R_g} \cdots \text{ or} \cdots \frac{v_t^2}{G} = \frac{R_g \cdot \frac{m}{r}}{R_g} \cdots \text{ or} \cdots \frac{v_t^2}{G} = \frac{m}{r} \cdots\cdots \tag{18.7}$$

The tangent velocity v_t, will stay flat or constant if the mass/radius ratio $\frac{m}{r}$, is maintained within the galaxy.

18.9 Galactic mass: $M_g = 6.08E43 \cdot kg$

$$M_g = R_g \cdot \frac{m}{r} \cdots\cdots \text{ or } \cdots\cdots \frac{M_g}{R_g} = \frac{m}{r}$$

$\frac{m}{r}$ is the mass added by every meter of radius of the galaxy.

$$M_g = R_g \cdot \frac{m}{r} = v_t \cdot age\frac{v_t^2}{G} = \frac{v_t^3 \cdot age}{\Delta G \cdot age} = \frac{v_t^3}{\Delta G} \tag{18.8}$$

Substitute for $G = \frac{c^3 \cdot age}{M_c}$ and r = $v_t \cdot age$ in the following:

$$\frac{v_t^2}{G} = \frac{M_g}{r} \cdots \text{or} \cdots \frac{v_t^2 \cdot M_c}{c^3 \cdot age} = \frac{M_g}{v_t \cdot age} \cdots \text{ or ratios } \cdots \frac{v_t^3}{c^3} = \frac{M_g}{M_c}$$

This is the ratios of velocities cubed to galactic and cosmic mass.

$$\frac{v_t^2}{G} = \frac{M_g}{r} \cdots \text{or} \cdots \frac{v_t^2}{\Delta G \cdot age} = \frac{M_g}{v_t \cdot age} \cdots \text{ or } \cdots v_t^3 = M_g \cdot \Delta G$$

(18.9)

Galactic mass is the ratio of tangent velocity cubed and ΔG :

$$M_g = mass\ of\ galaxy = \frac{v_t^3}{\Delta G} = 6.08E43 \cdot kg \tag{18.10}$$

Compare equation (**??** page **??**) where the mass of the Cosmos,
$M_c = \frac{c^3}{\Delta G} \cdots\cdots and \cdots\cdots 2.9E9 \cdot M_g = M_c$.

18.10 Galactic density $atR_g : 1.86E\neg 26 \frac{kg}{m^3}$

$$mass = M_g = 6.08E43 \cdot kg \cdots \text{and} \cdots \frac{1}{volume} = \frac{3}{4\pi R_g^3}$$

$$\text{Galactic density: } \frac{mass}{volume} = \frac{3 \cdot M_g}{4\pi R_g^3} =$$

$$\frac{3 \cdot 6.08E43 \cdot kg}{4\pi(9.20E22 \cdot m)^3} = 1.86E\neg 26 \frac{kg}{m^3} = 1.86E\neg 29 \frac{g}{cm^3} \tag{18.11}$$

This is the average density of the Cosmos.

18.11 Galactic rotational period

$$Rotational\ period = \frac{2\pi \cdot R}{v_t} = \frac{2\pi \cdot v_t \cdot age}{v_t} = 2\pi \cdot age \tag{18.12}$$

The radius and rotational period of the galaxies increase with R. They are proportional to the age of the Cosmos at their largest extent. Rotational energy is conserved. At earlier times the rotational periods were less and the rotation faster. Distant galaxies are viewed at earlier times so they appear to be smaller and rotating faster.

18.12 Hubble expansion in the galaxy: $v_r = v_t$

Galactic expansion is seen in figure (9 page 33). The tangent velocity v_t, which is seen in the flat rotation curves of galaxies, times the age of the Cosmos equals the radius R_g, of the galaxy. This suggest that there is a Hubble expansion occurring within the galaxy.
$R_u = c \cdot age$.

$$R_g = v_t \cdot age = 210,000 \frac{m}{s} \cdot 4.38E17 \cdot s = 9.204E22 \cdot m = 2.983 \cdot Mpc$$

$$R_g = galactic\, radius = 9.73 \cdot million \cdot light\ years \tag{18.13}$$

Only the inner 98,000 light years is visible, being dense enough for star formation. The galaxy is as low in density as the Cosmos at the perimeter of the galaxy.

$$Hubble's\ constant = \frac{1}{age} = Ho = 70.4\ km/s \cdot Mpc$$

$$v_r = \frac{R_g}{age} = R_g \cdot H_0 = 2.983 \cdot Mpc \cdot 70.4 \frac{km}{s \cdot Mpc} = 210,000 \frac{m}{s} \cdots\cdots so \cdots\cdots v_r = v_t \quad (18.14)$$

The radial velocity v_r, equals the tangent v_t, at the perimeter of the galaxy.

When the tangent velocity of something v_t, equals its radial velocity v_r, it spirals out at a constant angle of 45 degrees. This is the same spiral for the galaxy and for the Cosmos.

18.13 Dark matter halo: $M_g - M_v$

$$M_g = galactic\, mass = \frac{m}{r} \cdot R_g$$

$$M_g = 6.61E20 \frac{kg}{m} \cdot 9.94E22 \cdot m = 6.57E43 \cdot kg \quad (18.15)$$

Dark matter = total matter - visible matter:

$$Dark \cdot matter = 6.57E43 \cdot kg - 6.61E41 \cdot kg = 6.50E43 \cdot kg \quad (18.16)$$

The 98/1 ratio of dark matter/visible matter:

$$\frac{6.50E43 \cdot kg}{6.61E41 \cdot kg} = \frac{dark\ matter}{visible\ matter} ratio = \frac{98}{1} \quad (18.17)$$

18.14 Torque of the spinning galaxy: $\neg mass \cdot v_r^2$

Here mass is the mass of the galaxy. r is the radius of the galaxy. v_r is the radial velocity of expansion at the perimeter of the galaxy or $v_r = v_t$ the characteristic tangent velocity of the flat rotation curve of the galaxy.

$$torque = moment\ of\ inertia \cdot angular\ acceleration$$

$$torque = mass \cdot r^2 \cdot angular\ acceleration$$

$$Galactic\, torque = mass \cdot v_r^2 \cdot age^2 \cdot \frac{\neg 1}{age^2} = \neg mass \cdot v_r^2 \quad (18.18)$$

We see that the square of the radius in the moment of inertia for the galaxy $v_r^2 \cdot age^2$, increases at the same rate the angular acceleration of the galaxy $1/age^2$, decreases so that the age^2 in each cancels and the energy stays constant. The radius of the galaxy increases while the rotation of the galaxy slows down without a change in energy or use of power. Orbits spiral out as the gravitational force decreases with the age of the Cosmos.

19 General relativity shrinks not expands

In general relativity orbits shrink. The orbital, apsidal precession, the line from aphelion to perihelion rotates. The perihelion, closest to the sun, shift angle sigma σ, expressed in radians per revolution, is approximately given by:

$$\sigma = \frac{24\pi^3 L^2}{T^2 c^2 (1 - e^2)} \qquad \text{Rotation of the orbital apsidal line} \qquad (19.1)$$

where L is the semi-major axis, T is the orbital period, c is the speed of light, and e is the orbital eccentricity [45].

L = 5.79E10 m T = 7605000 s e = 0.206
Mercury sigma = 501.2E-9 radians/revolution
sigma*arcsec/radians*100 = 10.338 actually 43 arcsec/century
This is $\frac{43}{3600}$ of a degree, in a century, due to Uncle Albert.
A hardly perceptible amount, in more than a lifetime.

L = 1.082E11 m T = 19414080 s e = 0.007
Venus sigma = 257.2E-9 radians/revolution
sigma*arcsec/radians*100 = 5.305 actually 8.62 arcsec/century

L = 1.496E11 m T = 31558464 s e = 0.017
Earth sigma = 186.1E-9 radians/revolution
sigma*arcsec/radians*100 = 3.839 actually 3.838 arcsec/century
The Earth looses 200 watts a year, see equation (19.4), as its orbit shrinks 3.54E-13 m in a year, see equation (19.2) from [46].
Again, an imperceptible amount.

L = 3.844E8 m T = 88992.5 s e = 0.0549
Moon sigma = 154.9E-9 radians/revolution
sigma*arcsec/radians*100 = 3.196 arcsec/century

L = 2.279E11 m T = 59356800 s e = 0.093
Mars sigma = 123.1E-9 radians/revolution
sigma*arcsec/radians*100 = 2.540 actually 1.351 arcsec/century

The rate of orbital decay or shrink of the orbit, due to gravitational radiation can be approximated [46]. Here $m1$ is the mass of the sun and $m2$ is the mass of the Earth.

$$\frac{dr}{dt} = \neg \frac{64}{5} \frac{G^3}{c^5} \frac{(m_1 m_2)(m_1 + m_2)}{r^3} = \neg 1.12E - 20 \frac{m}{s} \qquad (19.2)$$

where r is the separation between the bodies, t time, G the gravitational constant, c the speed of light, and m1 and m2 the masses of the bodies.

This leads to an expected time to coalesce or spiral into the sun of: [46]

$$t = \frac{5}{256}\frac{c^5}{G^3}\frac{r^4}{(m_1 m_2)(m_1 + m_2)} = 3.32E30\ s. \tag{19.3}$$

This is 1.05E23 years, ten thousand, billion, billion years.

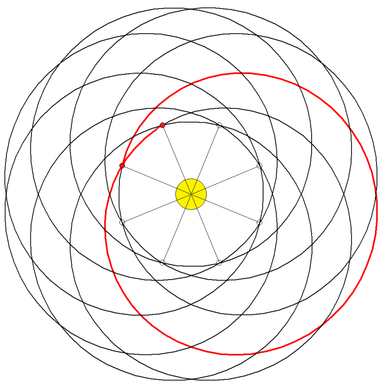


Figure 10: Perihelion precession

The perihelion is the reference point in an orbit when something is closest to the sun. The angles at the spokes are the amount that the perihelion shifts each orbit. A single orbit, around the sun, is shown in red where it begins at one perihelion and rotates clockwise ending at the start of the next perihelion. One loop of the orbit is 360 degrees plus the perihelion shift.

The average rate of energy loss per orbit is [47]:

$$\left\langle \frac{dP}{dt} \right\rangle = \frac{-32G^4(ms^2 \cdot me^2)(ms + me)}{5c^5 \cdot au^5(1-e^2)^{3.5}} \cdot (1 + \frac{73}{24}e^2 + \frac{37}{96}e^4) \tag{19.4}$$

This is 196.4 watts per orbit for the Earth Sun system.

The average rate of angular momentum luminosity loss per orbit [47]:

$$\left\langle \frac{dL}{dt} \right\rangle = \frac{-32G^{3.5}(ms^2 \cdot me^2)\sqrt{(ms+me)}}{5c^5 \cdot au^{3.5}(1-e^2)^2} \cdot (1+\frac{7}{8}e^2) \quad (19.5)$$

The average rate of semi major axis a loss per orbit is [47]:

$$\left\langle \frac{da}{dt} \right\rangle = \frac{-64G^3(ms \cdot me)(ms+me)}{5c^5 \cdot a^5(1-e^2)^{3.5}} \cdot (1+\frac{73}{24}e^2+\frac{37}{96}e^4) \quad (19.6)$$

The average rate of eccentricity e loss per orbit is [47]:

$$\left\langle \frac{de}{dt} \right\rangle = \frac{-304G^3 \cdot e \cdot (ms \cdot me)(ms+me)}{15c^5 \cdot a^4(1-e^2)^{2.5}} \cdot (1+\frac{121}{304}e^2) \quad (19.7)$$

With General Relativity orbits are seen to spiral in, which is the loss of orbital energy, like the precession of quasars by gravitational waves [46] and [48] and like the rosettes of Arnold Sommerfeld [52] and the precession of Mercury [44].

The 1993 Nobel prize for “Gravity investigated with binary pulsars” by R.A. Hulse and J.H. Taylor, described the orbital energy in binary pulsars decreased by the radiation of gravitational waves [48].

20 Hubble expansion in the Solar System

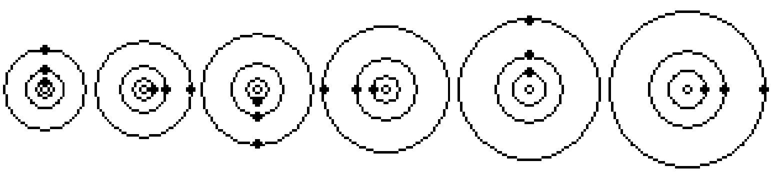


Figure 11: Solar system expansion

If the Hubble expansion extends to the solar system as shown in figure (11), then all the planets share the same very small expansion rate [40] of their orbit.

An expanding ring slows in its rotation. We calculate a change in angular velocity which is due to a radial Hubble velocity. This effect may be detected by atomic clocks or by large ring laser gyroscopes [43] which detect absolute rotations.

The length of the orbit, when divided by 2π radians per revolution equals the meters per radian or

$$meters\ per\ radian = \frac{2\pi rd}{2\pi \cdot radians} = \frac{rd}{radians} = \frac{length}{angle} \quad (20.1)$$

rd is the radial distance from the sun to any planet. $v_r = rd/age$, the radial velocity, the Hubble expansion velocity in meters per second.

$$\frac{v_r}{meters\ per\ radian} = \frac{\frac{rd}{age}}{\frac{rd}{radians}} = \frac{radians}{age} = \frac{angle}{time} \quad (20.2)$$

We see that the rd's cancel so that this rate of precession is universally true for the entire solar system and is not tied to any radius. This is Hubble as a rotation rate.

$$\frac{radians}{13.89\ billion\ years} = 7.199E\neg 11 \frac{radians}{year} \cdot \frac{1,296,000 \cdot arcs}{2\pi \cdot radians} =$$

$$\frac{angle}{time} = 1.485E\neg 5 \frac{arcs}{year} = \text{ Hubble precession} \quad (20.3)$$

This is a very small angle to measure for the Hubble expansion.

$$\frac{31,556,926 \frac{seconds}{year}}{1,296,000 \frac{arcs}{year}} = 24.349 \ \frac{seconds}{arcs} \cdots \text{For the Earth} \quad (20.4)$$

20.1 Hubble expansion and the Earth

This is the amount added yearly to the orbital period by the Hubble expansion from equation (20.3 page 42):

$$1.485E\neg 5 \frac{arcs}{year} \cdot 24.35 \frac{seconds}{arcs} = 3.616E\neg 5 \frac{seconds}{year} \quad (20.5)$$

This is one leap second being added to our orbit in our solar system every 27,655 years.

The entire solar system is slowing in its rotation while it expands, like a dynamic unit, like the galaxy and like the Cosmos. It is a consequence of the slowing rotation of the Cosmos and is tied by dynamics to the expansion of the Cosmos.

The Earth orbits the sun at a $radial\ distance = rd_{earth} = 149E9\ m$. The radial velocity of expansion v_r, between the Earth and sun is proportional to 1/age.

$$v_r = rd_{earth} \cdot H_0 \cdots\cdots\cdots \text{ or } \cdots\cdots\cdots v_r = \frac{rd_{earth}}{age}$$

$$v_r = rd_{earth} \cdot H_0 = 149E9 \cdot m \cdot 2.11E\neg 18 \frac{1}{s} =$$

$$v_r = 3.16E\neg 7 \frac{m}{s} \cdot \frac{31.5E6\ s}{year} = 9.97 \frac{m}{year} \tag{20.6}$$

v_r is too small to measure for the Earth.
General relativity yields a negligible negative v_r = $\neg 1.12E - 20\frac{m}{s}$.
Hubble expansion is 2.81E13 times bigger than the GR contraction.

20.2 Hubble expansion and the Moon

The moon orbits the Earth much closer at a $radial\ distance = rd_{moon} = 380E6 \cdot m$ but the Apollo missions to the moon left behind corner reflectors so that the round trip of laser pulses could be timed and the receding velocity of the moon measured.

$$v_r = rd_{moon} \cdot H_0 = 380E6 \cdot m \cdot 2.11E\neg 18 \frac{1}{s} =$$

$$v_r = 8.02E\neg 10 \frac{m}{s} \cdot \frac{31.5E6\ s}{year} \cdot \frac{1000\ mm}{m} = 25.3 \frac{mm}{year} \tag{20.7}$$

v_r is the radial velocity between the Earth and moon binary pair.
The moons measured radial velocity is 38 mm/year and is usually attributed to tidal drag and not the expansion of the universe. I postulate, 25 mm is due to a Hubble expansion and 13 mm is due to tidal drag.

20.3 Planetary Spirals

To calculate the path of expansion of a planets orbit we need the vector sum of three accelerations. We have the radial:

$$\text{centrifugal acceleration } = v_r \cdot angular\ velocity = \frac{v_r}{age} \tag{20.8}$$

And, we have the angular:

$$\text{coriolis acceleration } = \frac{2 \cdot v_r}{age} \tag{20.9}$$

in the direction of rotation.
Finally, we have the angular acceleration due to slowing rotation:

$$\text{angular deceleration } = \frac{\neg v_r}{age} \tag{20.10}$$

in the direction opposite of rotation.

We have a radial acceleration of $\frac{v_r}{age}$ and an angular acceleration of $\frac{v_r}{age}$. The resultant of these accelerations, is 45 degrees between the direction of rotation and the outward directed radius. It has a value of:

$$\sqrt{2} \cdot \frac{v_r}{age} \tag{20.11}$$

A particle moving in this way traces out a logarithmic spiral.

$$torque = moment\ of\ inertia \cdot angular\ acceleration$$

$$torque = mass \cdot r^2 \cdot angular\ acceleration$$
$$torque = mass \cdot v_r^2 \cdot age^2 \cdot angular\ acceleration$$

$$torque = mass \cdot v_r^2 \cdot age^2 \cdot \frac{\neg 1}{age^2} = \neg mass \cdot v_r^2 \tag{20.12}$$

Here mass is the mass of a planet. r is the radial distance from the sun. $v_r = r/age$ is the radial velocity. We see that the square of the radius in the moment of inertia for the planet, $v_r^2 \cdot age^2$, increases at the same rate the angular acceleration of the planet, $\neg 1/age^2$, decreases so that the age^2 in each cancels and the energy stays constant.

Expansion and rotation rates are linked. The distance from the sun to the planets increase and the orbital periods of the planets lengthen without a change in velocity, energy or the use of power.

Hubble precession causes stars and planets to spiral apart. Orbits spiral out as the gravitational force decreases with the age of the Cosmos. Spiral galaxies are the evidence.

21 Earth orbital velocity:

v_r is not tangent velocity v_t.

$$v_t^2 \cdot r_{orbit} = G \cdot M_{sun} \cdots \text{ from the virial theorem} \cdots (2.4\ page\ 8)$$

The earths orbital velocity at:
$r_{orbit} = 1\ AU = 149,597,900,000\ m$ is:

$$\frac{G\ M}{v_t^2\ r} = 1 \cdots\cdots \text{or} \cdots\cdots v_t = \sqrt{\frac{G \cdot M_{sun}}{r_{orbit}}} = 29,785\frac{m}{s} \tag{21.1}$$

21.1 Earth escape velocity:

Kinetic energy equals gravitational potential energy.

$$\frac{m \cdot v^2}{2} = \frac{G \cdot m \cdot M}{r} \tag{21.2}$$

$$v_e^2 \cdot rad_{earth} = 2 \cdot G \cdot M_{earth} \cdots\cdots \text{ escape velocity } \cdots\cdots \tag{21.3}$$

$M_{earth} \; = \; 5.9722E24 \; kg.$
$rad_{earth} \; = \; 6,370,000 \; m.$
The earths escape velocity is:

$$\frac{v_e^2 \; rad_{earth}}{G \; M_{earth}} = 2 \; or \; v_e = \sqrt{\frac{2 \cdot G \cdot M_{earth}}{rad_{earth}}} = 11,185.6 \frac{m}{s} \tag{21.4}$$

21.2 Delta v: Δv

The $11 \frac{km}{s}$ is the escape velocity needed to reach infinity. Using $8 \frac{km}{s}$ as the escape velocity reaches twice the radius of the Earth. This is called delta v, Δv in rocket parlance. The Δv, to reach low Earth orbit is $8 \frac{km}{s}$ [24] which gives a margin for error.

21.3 Moon escape velocity:

$$v_e^2 \cdot rad_{moon} = 2 \cdot G \cdot M_{moon} \cdots\cdots \text{ escape velocity} \cdots\cdots \tag{21.5}$$

$rad_{moon} \; = \; 1,738,000 \; m.$
$M_{moon} \; = \; 7.36E22 \; kg.$
The moons escape velocity to infinity is:

$$\frac{v_e^2 \; rad_{moon}}{G \; M_{moon}} = 2 \; or \; v_e = \sqrt{\frac{2 \cdot G \cdot M_{moon}}{rad_{moon}}} = 2,377.2 \frac{m}{s} \tag{21.6}$$

The Δv, $\frac{v_e^2 \; rad_{moon}}{G \; M_{moon}} = 1$, to reach low Moon orbit is $1.68 \frac{km}{s}$. Four of these $\Delta \; v's$, would reach anyplace on the moon or low Earth orbit and the space station. See Zubrin's,"Moon Direct" [25].

22 Solar blackbody watts from temperature

A flux of radiation has a Kelvin temperature. We see the temperature of the sun as 5778 Kelvin. We can convert this to $\frac{watts}{meter^2}$ for black body radiation with the Stephan and Boltzmann law.

$$K^4 \cdot 5.5698E\neg 8 \frac{W}{m^2} = \frac{W}{m^2} \tag{22.1}$$

$$The\ suns\ temperature\ = 5778\ Kelvin = 62E6\frac{W}{m^2} \qquad (22.2)$$

The sun has a wattage of 62E6 $\frac{watts}{meter^2}$ over the surface area of the sun of $4\pi(695E6 \cdot m)^2$ or a total of 3.77E26 watts. At the radial distance of the Earth, 149E9 m, this is

$$\frac{3.77E26 \cdot watts}{4\pi(149E9 \cdot m)^2} = 1341.8\frac{watts}{m^2} = 394 \cdot K = 249.5 \cdot F \quad (22.3)$$

We can work the CMB in just this way.

Space is quite hot in the sun at 249.5·F. Only the Earth's atmosphere protects us. Treat the atmosphere with respect. Look at what happened to Venus with its runaway greenhouse effect.

23 Cosmic Microwave Background: CMB

On figure (12 page 47), the ellipse is the path of a point that moves, so that the sum of its distance from the two foci is constant.

A whisper at one focus of an elliptical room, is heard at the other focus in the room, because the distance and travel time from focus to focus, is the same for any path of sound reflecting off the walls.

Light acts the same, with the same geometry, with ellipsoidal mirrors. The two foci can be called the origin and the destination.

Light leaves the origin as an expanding sphere and reflects at the ellipsoidal surface as a ring. It is a ring because it is the intersection of a sphere and ellipsoid. This reflection focuses the light onto the destination.

The overall travel time from the origin to reflection, to destination, is always the same for all angles of light departing from the origin.

If we retain the origin and destination and change to a luminous expanding sphere we can eliminate the mirror and reflection while keeping the geometry of the intersection of an expanding sphere and ellipsoid.

The luminous sphere is the shell of Cosmos which emits the CMB, Cosmic Microwave Background. Now the ellipsoid is an abstraction that exists in concept but not in reality. The ellipsoid defines the path of things that are perceptible at our location at a certain time.

We see the light of the CMB, at a uniform temperature in any direction, at a certain instant, when it arrives from a certain direction, after it travels for a fixed amount of time, as shown on figure (12 page 47).

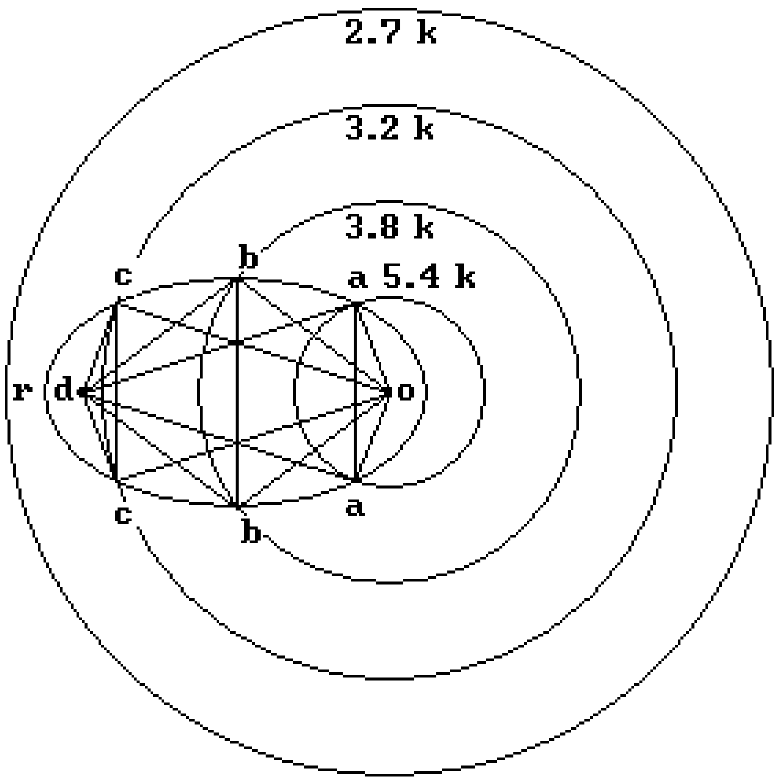


Figure 12: Cosmic cross section

The CMB temperature k, is going down because of the inverse square law of radiation as the Cosmos expands. Compare this with figure (14 page 49). We are located at someplace like d, a focus of the ellipse, in figure (12 page 47) which spirals out as the Cosmos expands. The eccentricity, of the ellipse has an unknown value e. d is on a $concentric\,radius = e \cdot c \cdot age$ and is moving radially and tangentially with a $velocity = e \cdot c$. $\frac{c \cdot age}{2}$ is the semi major axis of the ellipse. See figure (5 page 24). See the animation at [33].

$$r(angle) = \frac{c \cdot age}{2} \cdot \frac{1 - e^2}{1 \pm (cos(angle) \cdot e)} \tag{23.1}$$

23.1 Cosmic Cross Section

figure (12 page 47) and equation (23.1 page 47) show the polar form of the ellipse [53], drawn from the center focus, which is the origin o. The radius of the expanding sphere, which intersects the ellipse is r(angle).

As the angle is varied, the points form an ellipse stretched in the radial direction with $e \cdot c \cdot age$, as the distance between the foci od, on figure (12 page 47). The sum of the distances from the two foci, to a point on the ellipse, is always equal to $c \cdot age$.

The angle and radius when rotated around the center line of the ellipse trace a ring that is the intersection of the sphere and the ellipsoid aa, or bb, or cc, on figure (12 page 47).

This nested series of rings may partially polarize the CMB, Cosmic Microwave Background, along the axis of the origin see figure (13 page 48). Other polarizations seem likely. There is evidence that light traveling through space is polarized in a non-random direction [54].

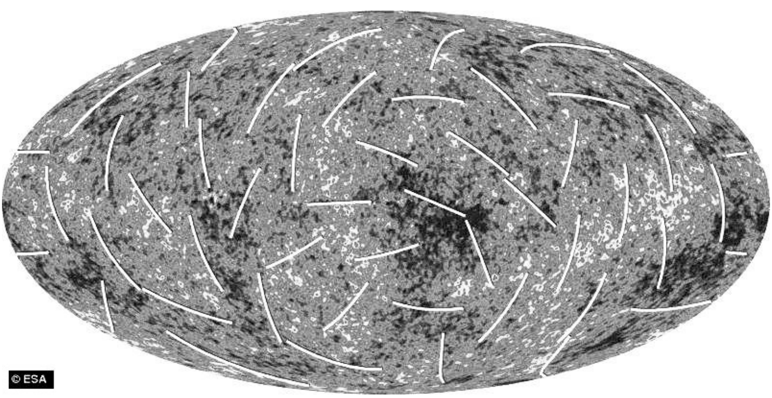


Figure 13: CMB, Cosmic Microwave Background, polarization per ESA

There is also evidence from the Planck satellite [55] that space could be rotating from the asymmetry in the average temperatures of the CMB on opposite hemispheres of the sky as if we are offset from the center and seeing differences in velocity as differences in temperature.

23.2 Uniformity of the CMB

The question of the uniformity of the CMB, Cosmic Microwave Background, is usually answered; that we appear to be at the center of the Big

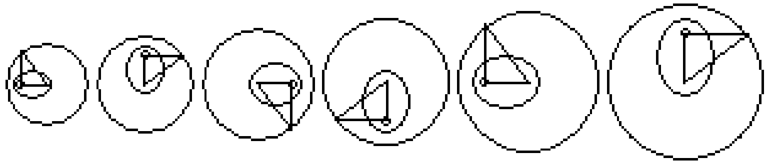


Figure 14: Expanding ellipses

Bang, because the Big Bang explosion happened everywhere. A more quantitative, and less miraculous solution, looks again at figure (12 page 47).

A ray of CMB reaches us after two distinct intervals.

The first interval starts at the center focus, at the origin, at point o, on figure (12 page 47) .

It is with the expanding and cooling spherical shell, before the ray of CMB, which we will be observing, is emitted. Examples on figure (12 page 47) are the lines oa, ob, and oc.

The temperature and $watts/meter^2$, of the expanding sphere, is proportional to the inverse square of the radius.

The second interval, is the travel of the ray of CMB through space, after it leaves the expanding spherical shell. Examples on figure (12 page 47) are the lines ad, bd, and cd. It ends with the reception of the CMB, at the observer at point d.

The temperature and $watts/meters^2$, of the CMB during the second interval, is also proportional to the inverse square of the radius.

The two intervals always add up to $c \cdot age\ meters$ in $age\ seconds$ in any direction the observer looks.

For CMB emitted early in the Cosmos, there is a shorter interval with the expanding sphere, and a much longer path through space interval to reach the observer.

For CMB emitted later, there is a longer spherical expansion interval, before the CMB is emitted, but a shorter path through space interval to the observer.

The expanding spherical shell, the CMB which it emits, and the CMB during its travel through space, all have a temperature proportional to the inverse square of the distance traveled from the origin o.

When the radius of the Cosmos was oa, it emitted CMB from the entire spherical surface. Only that from the ring, on the sphere at aa, will reach d, at the same time as the other rings on the same ellipsoid.

A similar argument can be seen in the rings bb, and cc. All the CMB from the various rings which intersect the ellipse arrive at point d, at the same time and temperature.

$$oa + ad = ob + bd = oc + cd = or = c \cdot age \tag{23.2}$$

The formulas in the next section, show the relationship between radius and temperature.

The CMB had a temperature at point a, of 5.4 K when the Cosmos was one forth its age and size. It arrived at point d, at 2.7 K after expanding for three fourths the age of the Cosmos.

The temperature at point b, was 3.8 K when the Cosmos was one half its age and size. It arrived at point d, at 2.7 K after expanding for half the age of the Cosmos.

The temperature at point c, was 3.2 K when the Cosmos was three fourths its age and size. It arrived at point d, at 2.7 K after expanding for one forth the age of the Cosmos.

The temperature is going down because of the inverse square law of radiation not because of the expansion of the vacuum of space.

23.3 Black body watts from the CMB

A flux of radiation has a Kelvin temperature. We see the temperature of the CMB, Cosmic Microwave Background, as 2.725 Kelvin. We can convert this to $watts/meter^2$ for black body radiation with the Stephan and Boltzmann law.

$$K^4 \cdot 5.5698E\neg 8 \frac{W}{m^2} = \frac{W}{m^2} \tag{23.3}$$

$$2.725^4 \cdot 5.5698E\neg 8 \frac{W}{m^2} = 3.07E\neg 6 \frac{W}{m^2} \tag{23.4}$$

$$CMB \cdot temperature = 2.725 \cdot Kelvin = 3.07E\neg 6 \frac{W}{m^2} \tag{23.5}$$

When one sees something, it is in terms of W/m^2 and the inverse square law. The W/m^2 times the area of the Cosmos = wattage of the CMB, because as we saw in figure (12 page 47), the temperature at point d, where the observer is located, is the same as at point r, the radius of the Cosmos.

$$4\pi \cdot r^2_{Cosmos} \cdot 3.07E\neg 6 \frac{W}{m^2} = 6.67E47 \cdot W = power = \frac{energy}{second} \tag{23.6}$$

The CMB has the luminosity of a 6.67E47 watt light bulb seen from a distance of 13.9 billion light years. This much power output requires 2E21 suns.

This is the same as 6.67E47 watts stretched over the interior surface area of a sphere with a radius of 13.9 billion light years.

The CMB is emitted from the interior of the expanding radiant spherical region herein for simplicity called the shell which is where light orbits at the perimeter of the Cosmos.

The non-elastic impact of some of the photons within this thin spherical shell is the source of the CMB. One might view this as being inside a huge hot spherical shell, watching it emitting heat as it expands and cools with the inverse square of its radius.

The light was accumulated in this shell as the Cosmos gained mass and orbiting light through the merging with other masses or black holes.

The energy emitted in 13.9 billion years by the CMB, if the energy output is constant, is

$$6.67E47 \cdot watts \cdot age = 2.92E65 \cdot Joules \tag{23.7}$$

For comparison, the energy of the Cosmos,

$$M_c \cdot c^2 = 1.59E70 \cdot Joules \tag{23.8}$$

$$\frac{M_c \cdot c^2}{4\pi c^2 age^2 \cdot 3.07E\neg 6 \frac{W}{m^2}} = \frac{1.59E70 \cdot J}{2.92E65 \cdot J} = 54,400 \tag{23.9}$$

If the CMB is the remnant energy from the Big Bang then why is it so feeble?

However, if the CMB is emitted instead through the non-elastic impact of photons at the perimeter of the Cosmos then this small value of energy makes some sense.

The gravitational and centrifugal accelerations on the photon in orbit are c/age. As the Cosmos expands the photons orbit at a larger radius and the orbital accelerations decrease.

The rate of change of the acceleration is $1/age^2$.
$1/r^2_{Cosmos} = 1/c^2 age^2$. The W/m^2 of the CMB is:

$$CMB = \frac{6.67E47 \cdot W}{4\pi r^2_{Cosmos}} = \frac{6.67E47 \cdot W}{4\pi c^2 age^2} = 3.07E\neg 6 \frac{W}{m^2} \tag{23.10}$$

$$\frac{6.67E47 \cdot W}{3.07E\neg 6 \frac{W}{m^2}} = 4\pi r^2_{Cosmos}$$

$$\frac{6.67E47 \cdot W}{4\pi \cdot 3.07E\neg 6 \frac{W}{m^2}} = r^2_{Cosmos}$$

$$\sqrt{\frac{6.67E47 \cdot W}{4\pi \cdot 3.07E\neg 6\frac{W}{m^2}}} = r_{Cosmos} = 1.315E26 \cdot m \quad (23.11)$$

The rate of change of the orbital acceleration is proportional to the W/m^2 of the CMB.

23.4 Shrinking shells of CMB

We can map the power of the CMB onto the smaller spheres and higher temperature when the Cosmos was younger, as long as we keep well clear of infinities.
K_u = CMB temperature
The radius, of the expanding spherical shell of CMB, is proportional to the inverse square of the temperature. The following examples map temperature and radius.
The $K_u = 2.725K$ when the radius of the Cosmos $r_u = 13.9E9$ lyr.

$$\frac{n}{K_u^2} = r_u \cdots\cdots \text{or} \cdots\cdots \frac{n}{r_u} = K_u^2$$

$$n = K_u^2 \cdot r_u = 2.725^2 K^2 \cdot 13.9E9\ lyr = 103.2E9\ K^2 \cdot lyr$$

$$1.315E26 \cdot m = c \cdot age = r_u = \text{ 13.9 billion light years}$$

$$\text{At } r_u: \ \sqrt{\frac{n}{r_u}} = \sqrt{\frac{103.2E9\ K^2 \cdot lyr}{13.9E9\ lyr}} = \sqrt{7.424\ K^2} = 2.725\ K$$

$$\text{At } \frac{3}{4}r_u: \ \sqrt{\frac{4}{3}} \cdot \sqrt{7.424\ K^2} = \sqrt{\frac{4}{3}} \cdot 2.725\ K = 3.15 \cdot K$$

$$\text{At } \frac{1}{2}r_u: \ \sqrt{\frac{2}{1}} \cdot 2.725\ K = 3.85 \cdot K$$

$$\text{At } \frac{1}{4}r_u: \ \sqrt{\frac{4}{1}} \cdot 2.725\ K = 5.45 \cdot K$$

At an age of 1.39 million years, at the freezing point of water of 273 K.

$$\frac{r_u}{(273 \cdot K)^2} = \frac{1.0537E27 \cdot m}{(273 \cdot K)^2} = 1.315E22 \cdot m =$$

$$1.315E22 \cdot m = \frac{r_{Cosmos}}{10000} = 1.39 \text{ million light years} \quad (23.12)$$

23.5 Planck Satellite Asymmetry

The CMB is presumed uniform in the current cosmological standard model. figure (4 page 23) shows the temperature asymmetry in the spherical shell of the CMB. Moving toward the shell produces a blue shift and moving away from the shell produces a red shift. This figure shows the observer is moving with a complex motion. figure (5 page 24) shows both tangent and radial velocity.

23.6 Merging Black Holes

There are groupings of mass in space so great that gravity, in the age of the Cosmos, would be inadequate for their formation from hydrogen gas. These are called large-scale structure [56]. An example is the Sloan great Wall [57]. Their great mass should have been reflected in the observed inhomogeneities in the CMB.

The merging of black holes, does however, explain these structures and the Planck satellite anomaly [55]. The smaller black hole in a merging black hole pair has a higher density. The merged contents are enclosed in a much larger volume.

The merged photons are bunched together. All these photons orbiting at the same radius have many photon-photon impacts which eventually tends to make the very thin layer of photons uniform.

Not all of these photon-photon [20] or gamma-gamma impacts are elastic. Many of these scatterings emit electromagnetic radiation which reaches us as the cosmic microwave background the CMB, visible in any direction.

The merged masses are bunched together. From within our black hole, one sees only the merged contents. The smaller black hole leaves behind a locally higher residual mass density, in the stretched out, merged contents, which is the artifact or footprint of their merging. See figure (15 page 54).

The merging of black holes helps to explain the origin of our cosmic black hole home. Over the eons black holes continued to merge with ours until we reached the mass of millions of billions of solar masses, whose low density and more benign environment, allowed the origin of life and whose great size allowed the merger of black holes without the sterilizing effects of earlier mergers which occurred closer in a smaller denser Cosmos.

If we are living *inside* a black hole Cosmos as suggested, the cosmic microwave background CMB, comes to us from the inside surface of our Cosmos.

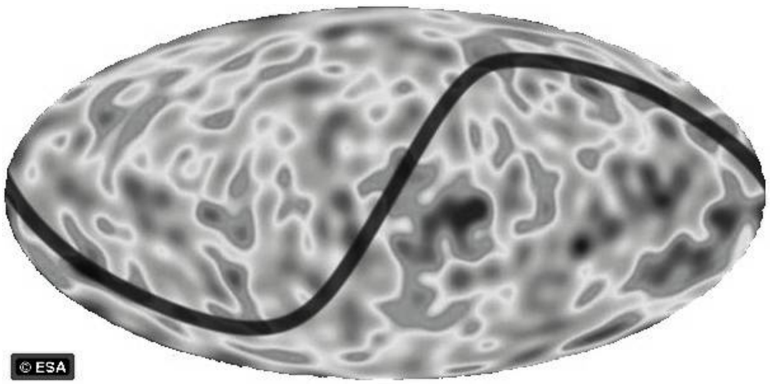


Figure 15: CMB, Cosmic Microwave Background, anomaly per ESA

24 Comparing Black Holes

24.1 $\frac{c^2r}{GM} = 1 \cdots\cdots or \cdots\cdots \frac{c^2r}{GM} = 2$

In the orbiting light black holes we have:
rest energy equals gravitational energy:
$mc^2 = GmM/r$ and if you multiply by $\frac{1}{r}$,
centrifugal force equals gravitational force:
$mc^2/r = GmM/r^2 \cdots\cdots$ or$\cdots\cdots \frac{c^2r}{GM} = 1.$
The original black hole definition goes back centuries to John Mitchell in 1783 and is based on escape velocity from a star exceeding the speed of light.

However, in the Schwarzschild black holes:
We have $escape\ velocity\ = \ c$ or:
$c = \sqrt{2GM/r} \cdots\cdots or \cdots\cdots \frac{c^2r}{GM} = 2$:
or half the rest energy = the kinetic energy = gravitational energy:
$.5mc^2 = GmM/r$ and if you multiply by $\frac{2}{r}$
$mc^2/r = 2GmM/r^2$
centrifugal force equals two times gravitational force so,
light must escape if the escape velocity only equals the speed of light.
$\frac{c^2r}{GM} = 2.$

24.2 Escape Velocity: $\frac{v^2 r}{GM} = 2$

The escape velocity from the earth using: $\frac{v^2 r}{GM} = 2$.
me = 5.972E24 kg
re = 6.37E6 m

$$v = \sqrt{\frac{2 \cdot G \cdot me}{re}} = 11,193\frac{m}{s} \tag{24.1}$$

The idea with escape velocity is that the escaping object is slowing continuously and reaches infinity with zero velocity, zero kinetic energy and zero gravitational energy. If the escape velocity only equals the speed of light then light will escape.

24.3 Kinetic energy equals Gravitational energy

$$\frac{m \cdot v^2}{2} = \frac{G \cdot m \cdot M}{r} \tag{24.2}$$

Here v, is the escape velocity. Substitute v = c:

$$m \cdot c^2 = \frac{2 \cdot G \cdot m \cdot M}{r} \cdots \text{or} \cdots \text{Schwarzschild } r = \frac{2 \cdot G \cdot M}{c^2} \tag{24.3}$$

The rest energy equals twice the gravitational energy. The energy of the escaping light is twice the gravitational energy.
Multiply by 1/r:

$$\frac{m \cdot c^2}{r} = \frac{2 \cdot G \cdot m \cdot M}{r^2} \tag{24.4}$$

The centrifugal force now equals twice the gravitational force. Light can not be restrained to an orbit in the Schwarzschild black hole.
Isolate r:

$$r = \frac{2 \cdot G \cdot M}{v^2} \tag{24.5}$$

If r = infinity in this escape velocity equation then:

$$infinity = \frac{2 \cdot G \cdot M}{v^2} \tag{24.6}$$

which is OK. v is the velocity which can approach zero at infinity. But v can't be c unless c approaches zero at infinity. If r = infinity and v_r = c in the Schwarzschild equation then:

$$infinity = \frac{2 \cdot G \cdot M}{c^2} \tag{24.7}$$

which is false. c can not go to zero at infinity. Rewrite the Schwarzschild equation:

$$\frac{mc^2}{2} = \frac{GmM}{r} \cdots\cdots \text{or} \cdots\cdots mc^2 = \frac{2\,GmM}{r} \tag{24.8}$$

This is kinetic energy equals gravitational energy or the rest energy equals twice the gravitational energy or multiplying by 1/r: the centrifugal force is twice the gravitational force and light can not orbit.:

$$\frac{mc^2}{r} = \frac{2\,GmM}{r^2} \tag{24.9}$$

The Schwarzschild radius is frequently seen in General Relativity as $r = 2M$, by using '$geometric\ units$' such that c and G are one [63]. Obviously, this odd shorthand obscures the possible and necessary variability of G in an expanding and dynamic Cosmos.
See '$Variable\ G$' page (10).
$c^2 r = 2GM$ is **not** equal $r = 2M$.

What happens when you put a variable G in GR?

'$Atomic\ units$' where the mass, radius, charge, energy and Planck's constant within atoms are all one, also obscure reality.

25 Schwarzschild Black Hole Formulas

The Schwarszchild radius is the radius of the '$event\ horizon$'. No event $within$ the event horizon can be seen from $outside$ the event horizon. Its contents are $unobservable$.

25.1 Schwarzschild radius: $r = \frac{2\,G\,M}{c^2}$

$$r = \frac{2\,G\,M}{c^2} \cdots\cdots \text{or} \cdots\cdots c^2\,r = 2\,G\,M \cdots\cdots \text{or} \cdots\cdots$$

$$\frac{c^2\,r}{G\,M} = 2 \cdots\cdots \text{or} \cdots\cdots \frac{M}{r} = \frac{c^2}{2\,G} = 6.73E26\frac{kg}{m} \cdots\cdots \tag{25.1}$$

We have four numbers, G, c, r, and M. We will use:
$r = c \cdot age = 13.9$ billion light years and
$G = \Delta G \cdot age$, canceling the age in r and G. The Schwarzschild radius of the universe = the orbiting light black hole radius. Both expand at c for the age of the universe. See '$Variable\ G$' page (10).

$$r_u = \frac{2 \cdot G \cdot M_u}{c^2} = c \cdot age = 13.9 \text{ billion light years} \tag{25.2}$$

25.2 Schwarzschild mass of the Universe: $M_u = \frac{c^2 r}{2G}$

$$M_u = \frac{c^2 \cdot r}{2 \cdot G} = \frac{c^2 \cdot c \cdot age}{2 \cdot \Delta G \cdot age} = \frac{c^3}{2 \cdot \Delta G} = 9.56E52 \cdot kg \quad (25.3)$$

This Schwarzschild mass is half the value of orbiting light black holes, with $M_c = \frac{c^2 \cdot r}{G} = 1.91E53 \cdot kg$ from equation (**??** page **??**).
The 2 is a characteristic of Schwarzschild black holes and using kinetic energy = gravitational energy.

25.3 Schwarzschild density of the Universe: $\frac{3}{8\pi \cdot G \cdot age^2}$

$$\frac{mass}{volume} = \frac{3 \cdot mass}{4\pi r^3} = \frac{3 \cdot c^2}{8\pi \cdot G \cdot r^2} = \frac{3 \cdot c^6}{32\pi \cdot mass^2 \cdot G^3} =$$

The density decreases with the square of the radius or mass.
$G = \Delta G \cdot age \cdots or \cdots mass = \frac{c^2 \cdot r}{2 \cdot G} \cdots or \cdots r = \frac{2 \cdot G \cdot mass}{c^2}$.

$$\frac{3}{8\pi \cdot G \cdot age^2} = \frac{3}{8\pi \cdot \Delta G \cdot age^3} = 7.97E\neg 27 \frac{kg}{m^3} \quad (25.4)$$

This density is about 5 protons per meter cubed, half the density of the Cosmos we calculated for orbiting light black holes. Schwarzschild black holes are twice as big, half as massive and half as dense as orbiting light black holes. The factor of 2 in $\frac{2 \cdot G \cdot M}{r \cdot c^2}$ is missing from orbiting light black holes $\frac{G \cdot M}{r \cdot c^2}$. This difference may be testable.

25.4 Photon-sphere: $r = \frac{3 \cdot G \cdot M}{c^2} \cdots or \cdots \frac{c^2 \cdot r}{G \cdot M} = 3$

Energy in orbit black holes are not the photon-sphere, outside the event horizon of Schwarzschild black holes [64], where light might orbit at $r = \frac{3\,GM}{c^2}$ [65] with the velocity c. The 3 is a characteristic of the photon-sphere.

$$r = \frac{3 \cdot G \cdot M}{c^2} = \text{`}photon\ sphere' \;\; or : \quad (25.5)$$

$$c^2 \cdot r = 3 \cdot G \cdot M \quad or \quad \frac{c^2 \cdot r}{G \cdot M} = 3 \quad or \quad \frac{M}{r} = \frac{c^2}{3 \cdot G}$$

25.5 Velocity in orbiting light black holes

the velocity of the gas clouds at
$r = \frac{3\,GM}{c^2}$ is less than c and possibly detectable.

$$v^2 = \frac{G \cdot M}{r} \;\; and \;\; r = \frac{3 \cdot G \cdot M}{c^2} \;\; so \;\; v = \sqrt{\frac{c^2}{3}} = .577 \cdot c \quad (25.6)$$

$v = .577 \cdot c$ may be detectable with the measurement of orbital periods of x-ray emitting clouds that orbit some black holes in binary systems of a black hole and star. A radiating mass of gas orbiting a black hole is like a lighthouse beacon sweeping past Earth hundreds of times per second. Even at the Schwarzschild radius $r = \frac{2\,GM}{c^2}$, orbiting light black holes would have $v = .707 \cdot c$ not c.

26 The black hole in M87

We looked at the first images of the glowing, ring-like structure of the supermassive black hole at the center of the galaxy M87. It is around 16 megaparsecs (4.937E23 meters) away and 7.22 billion times the mass of the Sun (1.436E40 kg). The radius of the black area of the hole is said to be about 350 au (52.236E12 m). This is larger than our solar system cite Wiki.

$$c^2 \cdot r = k \cdot G \cdot M \;\; or \;\; k = \frac{c^2 \cdot r}{G \cdot M} = \frac{c^2 \cdot 52.236E12 \cdot m}{G \cdot 1.293E40 \cdot kg} = 5.454$$

$$r = \frac{k \cdot G \cdot M}{c^2} = \frac{5.454 \cdot G \cdot M}{c^2} \tag{26.1}$$

$$r = \frac{2 \cdot G \cdot M}{c^2} \text{ Schwarzschild radius or event horizon} \tag{26.2}$$

The measurements of the black area is about five times the event horizon according to Nature News or $r_{eh} = 5 \cdot \frac{2 \cdot G \cdot M}{c^2} = 10 \cdot \frac{G \cdot M}{c^2}$.
I calculate $r_{shadow} = 5.454 \cdot \frac{G \cdot M}{c^2} \approx 5 \cdot \frac{G \cdot M}{c^2}$.
This is about half the event horizon $r_{eh} = 10 \cdot \frac{G \cdot M}{c^2}$.
This indicates r_{eh} should be $r_{eh} = 5 \cdot \frac{G \cdot M}{c^2}$.

Nature News 10 April 2019, “A black hole event horizon should appear five times larger than it is, because the hole warps the surrounding space and bends the paths of light. The effect, discovered by physicist James Bardeen at the University of Washington in Seattle in 1973, is similar to the way that a spoon looks larger when dipped in a glass of water. Moreover, Bardeen showed that the black hole would cast an even larger ‘*shadow*’.”

26.1 Shadow

“Photons just outside the apparent boundary can orbit the black hole near the circular photon radius several times adding to the observed intensity.

This produces a marked deficit of the observed intensity inside the apparent boundary, which we refer to as the 'shadow' of the black hole."

Heino Falcke in "Viewing the Shadow of the Black Hole at the galactic center", [66] said the 'shadow' is ten times the gravitational radius and the 'gravitational radius' is half the Schwarzschild radius $R_s \equiv 2\frac{GM}{c^2}$ *or* $R_g \equiv \frac{GM}{c^2}$ so the $shadow = 10\frac{GM}{c^2}$.

I found the $r_{shadow} = 5.424\frac{GM}{c^2}$ in equation (26.1 page 58).

This supports $shadow \approx 5\frac{GM}{c^2}$. This favors $\frac{c^2 r}{GM} = 1$ in equation (2.4 page 8) over $\frac{c^2 r}{GM} = 2$ in equation (25.1 page 56).

27 What is reasonable?

At a temperature below 3000 K plasma becomes transparent to light. The radius from section [23.4] becomes:

$$\frac{1.0537E27 \cdot m}{(3000 \cdot K)^2} = 1.18E20 \cdot m = 12,466\ light\ years? \quad (27.1)$$

At an age of 12,466 years? It would fit in the core of a galaxy. This is only the CMB, but this much power would require an absurdly large star. An inside out or hollow star since its radiation comes to us from every direction. We have allowed the ease of doing calculations to project something absurd.

At its present mass, our Cosmos could never have been that small or young.

We can see that these formulas, and others like them, might be used to trace back to a creation event at a point of infinite temperature and density.

This has become dogma, trussed up with patches, which helps obscure the absurdity of physical infinities.

Since smaller black holes merge to make bigger black holes, consider that the Cosmos came about by the merging of black holes, in a multi-verse of black hole universes. Multi-verses separated by space *not* multiple dimensions.

Low density black holes are big, old and expanding fast so they incorporate a lot of space over time.

Big ones present a bigger target for merging. Old ones present a target for merging that has been around for a long time. Space seems well populated with black holes.

It is a small step, for our dynamic unit, our Cosmos, to be just another ordinary low density black hole in a universe full of the same.

A ledger might have beliefs on the left side, and evidence for those beliefs on right side. The dynamics described here are mathematically consistent beliefs, which don't require physical infinities.

The evidence is the values presented by the mass, radius and density of the Cosmos, source and uniformity of the CMB, the spiral shape and the flat rotation curves of galaxies and the prevalence of dark matter.

All the parts slip together seamlessly. The dynamics locks all the parts together. There are no free parameters which might be adjusted to reflect a point of view.

References

[1] parsimony from Richard Dawkins @ *The Ancestors Tale*, 115 (2004)

[2] Edwin Hubble @ http://en.wikipedia.org/wiki/Hubble's_law

[3] Virial theorem @ http://hosting.astro.cornell.edu/academics/courses/astro201/vt.htm

[4] Virial theorem @ http://www.mathpages.com/home/kmath572/kmath572.htm

[5] Strength of the gravitational field, *Gravitation and Spacetime*, 306 (1976)

[6] mass of the Cosmos from Ciufolini and Wheeler, *Gravitation and Inertia*, 5 (1995)

[7] spider webs from Ian Stuart, *Calculating the Cosmos*, 275 (2016)

[8] stars and luminosity from Ian Stuart, *Calculating the Cosmos*, 157 (2016)

[9] lambda Λ from Ian Stuart, *Calculating the Cosmos*, 256 (2016) "Cosmologist attribute the accelerating expansion of the universe to a presumed energy source, which they call 'dark energy'. One possibility is Einstein's cosmological constant Λ. A positive value for Λ, inserted in the equations, creates the observed rate of acceleration. If this is correct, Einstein's biggest blunder wasn't putting the cosmological constant into his field equations, it was taking it out again. To fit observations,its value must be extremely small: about $10E\neg 29$ grams per cubic centimetre when energy is expresed as mass via Einstein's famous equation $E = mc^2$."

[10] density of universe from Ian Stuart,@ *Calculating the Cosmos*, 256 (2016) $10E\neg 29$ grams per cubic centimetre

[11] non-doppler redshift @ 2 http://newtonphysics.on.ca/hubble/index.html

[12] Geons by J. A. Wheeler, *Geons*, Phys. Rev. 97:511-36 (1955)

[13] mass without mass from Ciufolini and Wheeler, *Gravitation and Inertia*, 77-78 (1995)

[14] corrugated galaxy @ ThecorrugatedgalaxyMilkyWaymaybemuchlargerthanprevious
html

[15] Electric Gravity Pulses @ ./ellipsepulses.html

[16] Electric Gravity Pulses @ ./pulse10.gif

[17] Electric Gravity @ ./electricgravitylatex.pdf

[18] neutron star mass @ http://www.lsw.uni-heidelberg.de/users/mcamenzi/NS_Mass.html

[19] x-ray burster radius @ http://www.astro.washington.edu/users/ben/a510/NSTARS.new.html

[20] photon-photon @ http://www.hep.ucl.ac.uk/opal/gammagamma/gg-tutorial.html

[21] sum of the little bits from, Sylvanous P. Thompson, *Calculas Made Simple*, 1 (1910)

[22] $\Delta U_\theta\ points\ - U_r$, Physics by Resnick and Halliday, 1960-1977 page 225

[23] Machian view @ http://www.bun.kyoto-u.ac.jp/\cdotsuchii/mach.pr.html

[24] Δv, $The\ Case\ for\ Space$, by Robert Zubrin, 2019

[25] Δv, $Moon\ Direct$, by Robert Zubrin, 2018 https://www.thenewatlantis.com/publications/moon-direct

[26] $Relational\ Mechanics$, by A. K. T. Assis, 1999 @ Amazon or https://www.ifi.unicamp.br/~assis/papers.htm

[27] Flat rotation curve @ http://www.astro.cornell.edu/academics/courses/astro201/rotation_flat.htm

[28] Seth Shostak @ http://www.astronomy.com/magazine/superstars-of-astronomy-podcasts/2015/08/seth-shostak

[29] Seth Shostak @ http://arxiv:

[30] Vera Rubin @ https://en.wikipedia.org/wiki/VeraRubin

[31] Vera Rubin @ http://arxiv:astro-ph/0010594v3

[32] 210,000 m/s @ http://www.astronomynotes.com/ismnotes/s7.htm

[33] triangular definitions @ http://blackholeformulas.com/files/dctri.10.gif

[34] expanding Cosmos @ http://blackholeformulas.com/files/dcconccirc.10.gif

[35] Galaxy @ http://arxiv.org/abs/0902.3913

[36] rotation curve @ http://www.astro.cornell.edu/academics/courses/astro201/rotation_curves.htm

[37] Ellipse Pulses @ http://blackholeformulas.com/files/ellipsepulses.html

[38] 21 cm radiation @ http://en.wikipedia.org/wiki/Hydrogen_line

[39] molecular hydrogen @ http://www.newtonphysics.on.ca/hydrogen/index.html

[40] precession @ http://en.wikipedia.org/wiki/Precession

[41] On Mach's Principle by A. K. T. Assis, 1989, page 305 @ https://www.ifi.unicamp.br/~assis/papers.htm

[42] Origin of Inertia by Amitabha Ghosh, 2000 page 29

[43] large ring laser gyroscopes @ http://www.wettzell.ifag.de/LKREISEL/G/LaserGyros.html

[44] Precession of Mercury @ https://en.wikipedia.org/wiki/Tests_of_general_relativity

[45] Test of general relativity @ https://en.wikipedia.org/wiki/Test_of_general_relativity

[46] Gravitational Waves @ https://en.wikipedia.org/wiki/Gravitational_wave

[47] Gravitational Waves Lecture @ https://www.physics.usu.edu/Wheeler/GenRel2013/Notes/GravitationalWaves.pdf

[48] Gravitational Wave Nobel Prize @ http://www.nobelprize.org/nobel_prizes/physics/laureates/1993/press.html "Hulses and Taylors discovery in 1974 of the first binary pulsar, called PSR 1913 + 16 (PSR stands for pulsar, and 1913 + 16 specifies the pulsars position in the sky) thus brought about a revolution in the field. We have here two very small astronomical bodies, each with a radius of some ten kilometres but with a mass comparable with that of the sun, and at a short distance from each other, only several times the moons distance from the earth. Here the deviations from Newtons gravitational physics are large. As an example may be mentioned that the periastron shift, the rotation of the elliptical orbit that the pulsar (according to Keplers first law from the beginning of the 17th century) follows in this system, is 4 degrees per year. The corresponding relativistic shift for the most favourable example in our solar system, the above-mentioned perihelion motion of Mercury, is 43 seconds of arc per century (this is less than a tenth of the very much larger contributions to the perihelion motion caused by perturbations from other planets, chiefly Venus and Jupiter). The difference in size between the shifts is partly due to the orbital speed in the binary pulsar, which is almost five times greater than Mercurys, and partly due to the pulsar performing about 250 times more orbits a year than Mercury. The orbiting time of the binary pulsar is less than eight hours, which can be compared with the one month our moon takes to orbit the earth.... The discovery of the first binary pulsar is primarily of great significance for astrophysics and gravitational physics.... It was found that the orbit period is declining: the two astronomical bodies are rotating faster and faster about each other in an increasingly tight orbit. The change is very small. It corresponds to a reduction of the orbit period by about 75 millionths of a second per year (orbit not year), but, through observation over sufficient time, it is nevertheless fully measurable. This change was presumed to occur because the system is emitting energy in the form of gravitational waves in accordance with what Einstein in 1916 predicted should happen to masses moving relatively to each other. According to the latest data, the theoretically calculated value from the relativity theory agrees to within about one half of a percent with the observed value."

[49] Hulse-Taylor @ https://en.wikipedia.org/wiki/Hulse-Taylor_binary.pdf
"The orbit has decayed since the binary system was initially discovered, in precise agreement with the loss of energy due to

gravitational waves described by Albert Einstein's general theory of relativity.[2][10][11][12] The ratio of observed to predicted rate of orbital decay is calculated to be 0.9970.002.[12] The total power of the gravitational waves emitted by this system presently is calculated to be 7.35 1024 watts. For comparison, this is 1.9Solar System radiates only about 5000 watts in gravitational waves, due to the much larger distances and orbit times, particularly between the Sun and Jupiter and the relatively small mass of the planets. With this comparatively large energy loss due to gravitational radiation, the rate of decrease of orbital period is 76.5 microseconds per year, the rate of decrease of semimajor axis is 3.5 meters per year, and the calculated lifetime to final inspiral is 300 million years.[2][12] Characteristics:
Mass of companion: 1.387 M
Total mass of the system: 2.828378(7) M
Orbital period: 7.751938773864 hr
Eccentricity: 0.6171334
Semi-major axis: 1,950,100 km
Periastron separation: 746,600 km
Apastron separation: 3,153,600 km
Orbital velocity of stars at periastron (relative to center of mass): 450 km/s
Orbital velocity of stars at apastron (relative to center of mass): 110 km/s"

[50] Binary-pulsar @ https://en.wikipedia.org/wiki/Binary-pulsar.pdf
"The binary pulsar PSR B1913+16 (or the "Hulse-Taylor binary pulsar") was first discovered in 1974 at Arecibo by Joseph Hooton Taylor, Jr. and Russell Hulse, for which they won the 1993 Nobel Prize in Physics. While Hulse was observing the newly discovered pulsar PSR B1913+16, he noticed that the rate at which it pulsed varied regularly. It was concluded that the pulsar was orbiting another star very closely at a high velocity, and that the pulse period was varying due to the Doppler effect: As the pulsar was moving towards Earth, the pulses would be more frequent; and conversely, as it moved away from Earth fewer would be detected in a given time period. One can think of the pulses like the ticks of a clock; changes in the ticking are indications of changes in the pulsars speed toward and away from Earth. Hulse and Taylor also determined that the stars were approximately equally massive by observing these pulse fluctuations, which led them to believe the other object was also a neutron star. Pulses from this system are now tracked to within 15 s. [1] (Note: Cen X-3 was actually

the first ”binary pulsar” discovered in 1971, followed by Her X-1 in 1972) The study of the PSR B1913+16 binary pulsar also led to the first accurate determination of neutron star masses, using relativistic timing effects.[2] When the two bodies are in close proximity, the gravitational field is stronger, the passage of time is slowed and the time between pulses (or ticks) is lengthened. Then as the pulsar clock travels more slowly through the weakest part of the field it regains time. A special relativistic effect, time dilation, acts around the orbit in a similar fashion. This relativistic time delay is the difference between what one would expect to see if the pulsar were moving at a constant distance and speed around its companion in a circular orbit, and what is actually observed.”

[51] Gravitational wave @ https://en.wikipedia.org/wiki/Gravitational_wave.pdf
“In Einstein’s general theory of relativity, gravity is treated as a phenomenon resulting from the curvature of spacetime. This curvature is caused by the presence of mass. Generally, the more mass that is contained within a given volume of space, the greater the curvature of spacetime will be at the boundary of its volume.[7] As objects with mass move around in spacetime, the curvature changes to reflect the changed locations of those objects. In certain circumstances, accelerating objects generate changes in this curvature, which propagate outwards at the speed of light in a wave-like manner. These propagating phenomena are known as gravitational waves.

As a gravitational wave passes an observer, that observer will find spacetime distorted by the effects of strain. Distances between objects increase and decrease rhythmically as the wave passes, at a frequency equal to that of the wave. The magnitude of this effect decreases in proportion to the inverse distance from the source.[8]:227 Inspiraling binary neutron stars are predicted to be a powerful source of gravitational waves as they coalesce, due to the very large acceleration of their masses as they orbit close to one another. However, due to the astronomical distances to these sources, the effects when measured on Earth are predicted to be very small, having strains of less than 1 part in 1020. Scientists have demonstrated the existence of these waves with ever more sensitive detectors. The most sensitive detector accomplished the task possessing a sensitivity measurement of about one part in 5 1022 (as of 2012) provided by the LIGO and VIRGO observatories.[9] A space based observatory, the Laser Interferometer Space Antenna, is currently under development by ESA.

Gravitational waves can penetrate regions of space that electromagnetic waves cannot. They allow the observation of the merger of black holes and possibly other exotic objects in the distant Universe. Such systems cannot be observed with more traditional means such as optical telescopes or radio telescopes, and so gravitational wave astronomy gives new insights into the working of the Universe. In particular, gravitational waves could be of interest to cosmologists as they offer a possible way of observing the very early Universe. This is not possible with conventional astronomy, since before recombination the Universe was opaque to electromagnetic radiation.[10] Precise measurements of gravitational waves will also allow scientists to test more thoroughly the general theory of relativity. In principle, gravitational waves could exist at any frequency. However, very low frequency waves would be impossible to detect, and there is no credible source for detectable waves of very high frequency as well. Stephen Hawking and Werner Israel list different frequency bands for gravitational waves that could plausibly be detected, ranging from 107 Hz up to 1011 Hz.[11]

History

The possibility of gravitational waves was discussed in 1893 by Oliver Heaviside using the analogy between the inverse-square law in gravitation and electricity.[15] In 1905, Henri Poincar proposed gravitational waves, emanating from a body and propagating at the speed of light, as being required by the Lorentz transformations[16] and suggested that, in analogy to an accelerating electrical charge producing electromagnetic waves, accelerated masses in a relativistic field theory of gravity should produce gravitational waves.[17][18] When Einstein published his general theory of relativity in 1915, he was skeptical of Poincar's idea since the theory implied there were no ”gravitational dipoles”. Nonetheless, he still pursued the idea and based on various approximations came to the conclusion there must, in fact, be three types of gravitational waves (dubbed longitudinal longitudinal, transverselongitudinal, and transversetransverse by Hermann Weyl).[18]

However, the nature of Einstein's approximations led many (including Einstein himself) to doubt the result. In 1922, Arthur Eddington showed that two of Einstein's types of waves were artifacts of the coordinate system he used, and could be made to propagate at any speed by choosing appropriate coordinates, leading Eddington to jest that they ”propagate at the speed of thought”.[19]:72 This also cast doubt on the physicality of the third (transversetransverse) type that Eddington showed always propagate at the speed of light regardless of coordinate system. In 1936, Einstein and Nathan Rosen submitted a paper to Physical Review in which they claimed gravitational waves could not exist in the full general theory of relativity because any such solution of the field equations would have a singularity. The journal sent their manuscript to be reviewed by Howard P. Robertson, who anonymously reported that the singularities in question were simply the harmless coordinate singularities of the employed cylindrical coordinates. Einstein, who was unfamiliar with the concept of peer review, angrily withdrew the manuscript, never to publish in Physical Review again. Nonetheless, his assistant Leopold Infeld, who had been in contact with Robertson, convinced Einstein that the criticism was correct, and the paper was rewritten with the opposite conclusion and published elsewhere.[18][19]:79ff In 1956, Felix Pirani remedied the confusion caused by the use of various coordinate systems by rephrasing the gravitational waves in terms of the manifestly observable Riemann curvature tensor. At the time, Pirani's work was mostly ignored because the community was focused on a different question: whether gravitational waves could transmit energy. This matter was settled by a thought experiment proposed by Richard Feynman during the first "GR" conference at Chapel Hill in 1957. In short, his argument known as the "sticky bead argument" notes that if one takes a rod with beads then the effect of a passing gravitational wave would be to move the beads along the rod; friction would then produce heat, implying that the passing wave had done work. Shortly after, Hermann Bondi, a former gravitational wave skeptic, published a detailed version of the "sticky bead argument".[18] After the Chapel Hill conference, Joseph Weber started designing and building the first gravitational wave detectors now known as Weber bars. In 1969, Weber claimed to have detected the first gravitational waves, and by 1970 he was "detecting" signals regularly from the Galactic Center; however, the frequency of detection soon raised doubts on the validity of his observations as the implied rate of energy loss of the Milky Way would drain our galaxy of energy on a timescale much shorter than its inferred age. These doubts were strengthened when, by the mid-1970s, repeated experiments from other groups building their own Weber bars across the globe failed to find any signals, and by the late 1970s general consensus was that Weber's results were spurious.[18]

In the same period, the first indirect evidence of gravitational waves was discovered. In 1974, Russell Alan Hulse and Joseph Hooton Taylor, Jr. discovered the first binary pulsar, which earned them the 1993 Nobel Prize in Physics.[20] Pulsar timing observations over the next decade showed a gradual decay of the orbital period of the HulseTaylor pulsar that matched the loss of energy and angular momentum in gravitational radiation predicted by general relativity.[21][22][18] This indirect detection of gravitational waves motivated further searches, despite Weber's discredited result. Some groups continued to improve Weber's original concept, while others pursued the detection of gravitational waves using laser interferometers. The idea of using a laser interferometer for this seems to have been floated independently by various people, including M. E. Gertsenshtein and V. I. Pustovoit in 1962,[23] and Vladimir B. Braginski in 1966. The first prototypes were developed in the 1970s by Robert L. Forward and Rainer Weiss.[24][25] In the decades that followed, ever more sensitive instruments were constructed, culminating in the construction of GEO600, LIGO, and Virgo.[18]

After years of producing null results, improved detectors became operational in 2015. On 11 February 2016, the LIGO-Virgo collaborations announced the first observation of gravitational waves,[26][27][28][29] from a signal (dubbed GW150914) detected at 09:50:45 GMT on 14 September 2015 of two black holes with masses of 29 and 36 solar masses merging about 1.3 billion light-years away. During the final fraction of a second of the merger, it released more than 50 times the power of all the stars in the observable universe combined.[30] The signal increased in frequency from 35 to 250 Hz over 10 cycles (5 orbits) as it rose in strength for a period of 0.2 second.[27] The mass of the new merged black hole was 62 solar masses. Energy equivalent to three solar masses was emitted as gravitational waves.[31] The signal was seen by both LIGO detectors in Livingston and Hanford, with a time difference of 7 milliseconds due to the angle between the two detectors and the source. The signal came from the Southern Celestial Hemisphere, in the rough direction of (but much farther away than) the Magellanic Clouds.[29] The confidence level of this being an observation of gravitational waves was 99.99994A year earlier, the BICEP2 claimed that they had detected the imprint of gravitational waves in the cosmic microwave background. However, they were later forced to retract this result.[12][13][32][33] In 2017, the Nobel Prize in Physics was awarded to Rainer Weiss, Kip Thorne and Barry Barish for their role in the detection of gravitational waves.[34][35][36] Binaries

Gravitational waves carry energy away from their sources and, in the case of orbiting bodies, this is associated with an in-spiral or decrease in orbit.[40][41] Imagine for example a simple system of two masses such as the EarthSun system moving slowly compared to the speed of light in circular orbits. Assume that these two masses orbit each other in a circular orbit in the xy plane. To a good approximation, the masses follow simple Keplerian orbits. However, such an orbit represents a changing quadrupole moment. That is, the system will give off gravitational waves.

In theory, the loss of energy through gravitational radiation could eventually drop the Earth into the Sun. However, the total energy of the Earth orbiting the Sun (kinetic energy + gravitational potential energy) is about 1.14 1036 joules of which only 200 watts (joules per second) is lost through gravitational radiation, leading to a decay in the orbit by about 1 1015 meters per day or roughly the diameter of a proton. At this rate, it would take the Earth approximately 1 1013 times more than the current age of the Universe to spiral onto the Sun. This estimate overlooks the decrease in r over time, but the radius varies only slowly for most of the time and plunges at later stages, as

[52] Sommerfeld @ http://astronomy.nmsu.edu/cwc/Teaching/ASTR605/Lectures/atomicphys.pdf

[53] Polar form of ellipse @ https://en.wikipedia.org/wiki/Ellipse#Polar_form_relative_to_focus

[54] polarized in a non-random direction @ https://universe-review.ca/F02-cosmicbg06.htm

[55] Planck satellite @ http://www.esa.int/Our_Activities/Space_Science/Planck/Planck_reveals_an_almost_perfect_Universe

[56] large scale structure @ http://en.wikipedia.org/wiki/Large-scale_structure_of_the_Cosmos

content...

[57] Sloan great wall @ http://en.wikipedia.org/wiki/Sloan_Great_Wall

[58] orbiting systems @ http://blackholeformulas.com/files/gravityrosettesinertialatex.pdf

[59] Gravity, rosettes, inertia @ http://blackholeformulas.com/files/solarwobblelatex.pdf

[60] kinetic energy @ http://www.newtonphysics.on.ca/kinetic/index.html

[61] Chandrasekhar from Pedro G. Ferreira, *The Perfect Theory*, 55-57 (2014)

[62] nuclear density @ http://en.wikipedia.org/wiki/Nuclear_density

[63] r=2M from Jean-Pierre Luminet, *Black Holes*, 120 (1992)

[64] Schwarzschild radius @ https://en.wikipedia.org/wiki/Schwarzschild_radius

[65] Photon-sphere @ https://en.wikipedia.org/wiki/Photon_sphere

[66] Shadow and Gavitational radius @ arXiv:astro-ph/9912263v1 14 Dec 1999

[67] Go to index blackholeformulas.com @ http://blackholeformulas.com/