Relativity and Gravity in a Planck-level Black-hole Universe Simulation

Malcolm Macleod
E-mail: maclem@platoscode.com

The Simulation Hypothesis proposes that all of reality is in fact an artificial simulation, analogous to a computer simulation, and as such our reality is an illusion. In this article, virtual particles are mapped within an incrementally (the simulation clock-rate) expanding in Planck units 4-axis hyper-sphere array (the virtual universe). These particles oscillate between an electric wave-state and a Planck mass Planck time point-state, where only the point-state has defined co-ordinates within the hyper-sphere. The velocity of expansion is a constant (the origin of the speed of light) and all particles/objects travel at this velocity within the hyper-sphere, however the electromagnetic spectrum, as the means of information exchange, is restricted to lateral movement across the hyper-sphere, thus the observable universe is relativistic. Probability wave-function orbitals are replaced with physical units of momentum, thus neither an electric force or gravitational force are required, only an exchange of orbital momentum (orbits are maintained by a conservation of momentum 'buoyancy'). Electrons do not 'jump' from 1 orbital to another (transition), rather the electron orbitals are replaced, the electron then confined to the new orbital boundary. Atomic spectra emerges from the geometry of the particles. Gravitational orbits are the sum of point-state to point-state orbitals. At 14 billion years, this simulation will have similar characteristics to our universe CMB.

1 Virtual Universe

The Simulation Hypothesis proposes that all of reality, including the earth and the universe, is in fact an artificial simulation, analogous to a computer simulation [6].

In an article on the virtual electron was shown how the Planck units for mass, space, time and charge can be constructed from a mathematical electron [7]. In this article these virtual particles are mapped within an expanding hypersphere (the virtual universe). The expansion is the simulation clock-rate and so the origin of Planck time, the arrow of time, and of particle motion.

In sections 2-3 the particles are pulled along by this hypersphere expansion. In hypersphere co-ordinates all particles and objects travel at, and only at, the speed of expansion (the origin of the speed of light), however information between them is exchanged by electro-magnetic waves which are restricted to lateral motion giving the appearance of a 3-D space. Relativity becomes the mathematics of perspective.

In section 4 orbitals are treated as units of momentum, as these are 'physical' links the (gravity, electric) forces may be dispensed with, instead orbitals and orbits (being the sum of the individual orbitals) reflect the conservation of (angular) momentum. It is offered that atomic spectra may emerge naturally from the geometry of the respective particles.

In section 5, the parameters for a 14.6 billion year old Planck black hole are compared with the CMB. The Casimir force can be described by the radiation density.

2 Space-time

Particles oscillate between an electric wave-state and a Planck mass, Planck time point-state. Here particle A is mapped onto a space-time graph (fig.1). Although A does not move in space (v = 0), it does move in time (vertical axis).

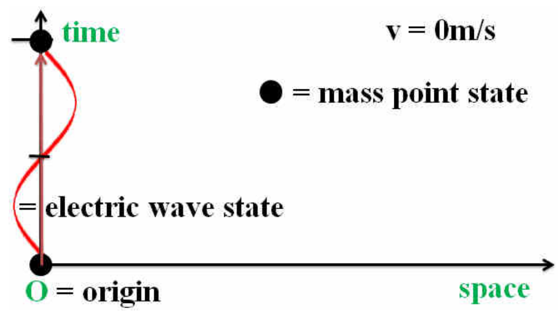

Fig. 1: particle A, v = 0

Particle B, $v = 0.866c$ is added (fig.2). After 1s B will have traveled 0.866 x 299792458 = 259620km from A along the horizontal space axis.

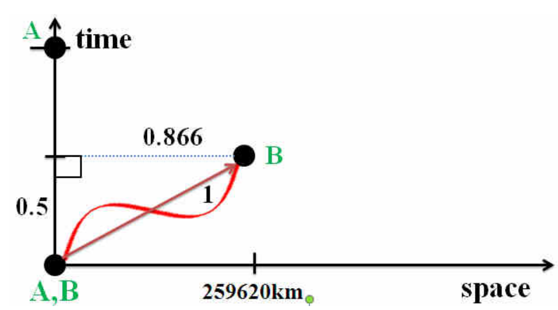

Fig. 2: particle B, v = 0.886c

Particles A and B both have a frequency = 6 ($5t_p$ in the wave-state then $1t_p$ in the point-state). As the A point-state occurs once every $6t_p$, mass of A $m_A = m_P/6$, however the point-state of B occurs after $3t_p$ and so $m_B = m_P/3$ (fig.3).

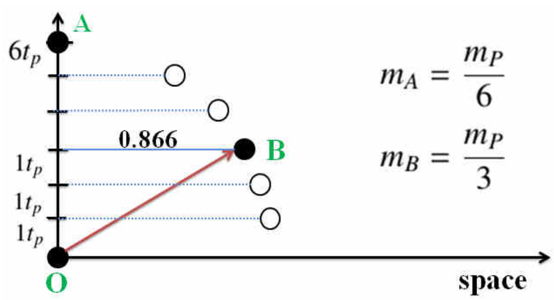

Fig. 3: particle B, relative mass

As each step on the time axis involves $1t_p$, there are 6 possible velocity solutions, this also means that m_B can reach Planck mass m_P, but B ($v = v_{max}$, $m_B = m_P/1$, fig.4) can never attain the (horizontal axis) speed of light c. The vertical axis

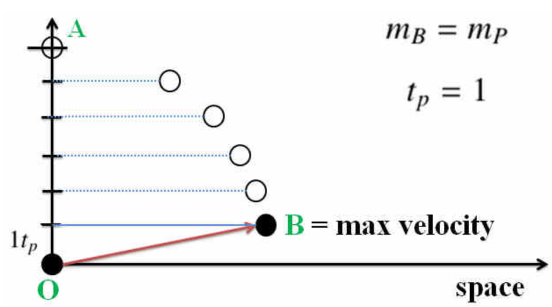

Fig. 4: particle B, maximum velocity

would be measured as $1/\gamma$. For a particle that has only 6 divisions (6 steps from point to point), the maximum $\gamma = 6$. To determine the maximum velocity that a particle can attain (y-axis = v/c) we simply calculate when that particle will have reached Planck mass, because from there it can go no faster. A small particle such as an electron has more possible divisions along the vertical axis and so a higher possible γ and so can go faster in 3-D space than a larger particle such as a proton with a smaller γ (a smaller number of divisions).

$$\frac{1}{\gamma} = \sqrt{1 - \frac{v^2}{c^2}} \tag{1}$$

$$\gamma_{electron} = m_P/m_e, \gamma_{proton} = m_P/m_p$$

3 Virtual universe

3.1. Replacing the above with a 4-axis co-ordinate system, to illustrate the concept are shown the (h, x) axis with particles represented as semi-circles. Depicted is particle B at some arbitrary universe time t. B begins at origin O and is pulled along by the virtual universe expansion (fig.5, 6, 7).

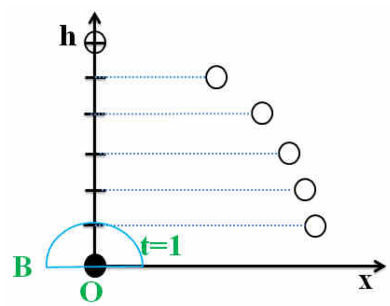

Fig. 5: $t = 1$

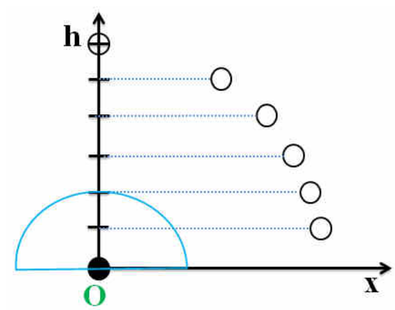

Fig. 6: $t = 2$

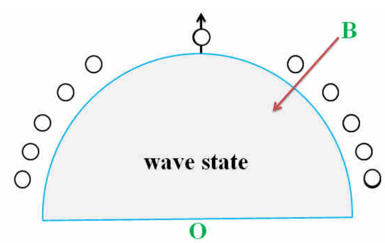

Fig. 7: $t = 6$

At $t = 6$, B collapses into the mass point state and now has a defined co-ordinate position which becomes the new origin O' (fig.8), the above repeating ad infinitum $t = 7, 8, \ldots$ (fig.9, 10).

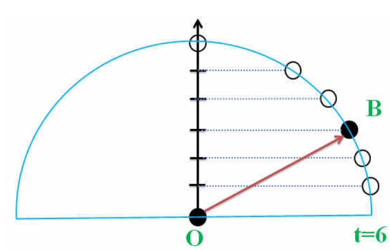

Fig. 8: $t = 6$, point-state

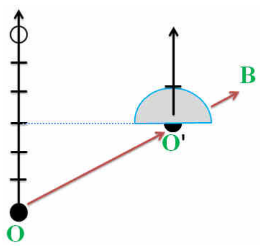

Fig. 9: t = 6+1

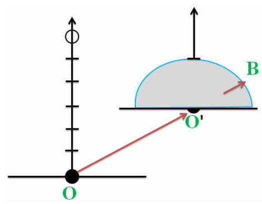

Fig. 10: t = 6+2

The process also repeats for A (fig.11). The virtual universe hypersphere can be understood as a particle presently in the wave-state. Each particle origin O is thus repeating fractal-like within the universe-as-a-particle hyper-sphere whose origin O is the big bang.

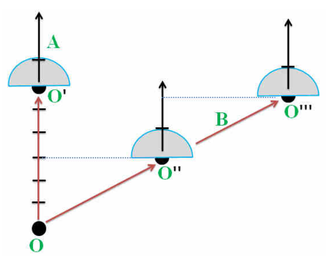

Fig. 11: Origin points; A, B

3.2. In the space-time examples was depicted graphs A; v = 0, $m_A = m_P/6$ and for B; $v = 0.866c, m_B = m_P/3$ (fig.12).

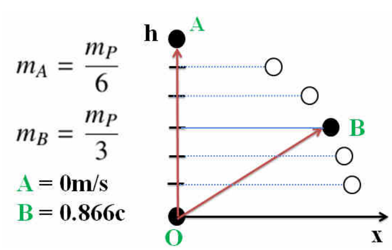

Fig. 12: relative mass A to B

However in the (h, x) graphs we find that as A and B have the same frequency, f = 6, the lengths OA = OB = 6, this is because the hyper-sphere expands radially. As a consequence B can rightly claim that it is A whose velocity is at $v = 0.866c$ and for B velocity $v = 0$ (fig.13).

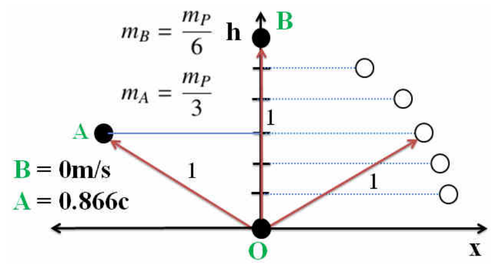

Fig. 13: relative mass B to A

Both A and B are traveling at the speed of expansion (which translates to c) from the origin O. In the virtual co-ordinate system everything travels at, and only at, the speed of expansion as this is the origin of all motion, particles and planets do not have any inherent motion of their own, they are simply pulled by this expansion. After 1 second both A and B will therefore have traveled the equivalent of 299792458m in virtual co-ordinates from origin O. Each of the 11 depicted solutions are equally valid as the radii are the same (fig.14).

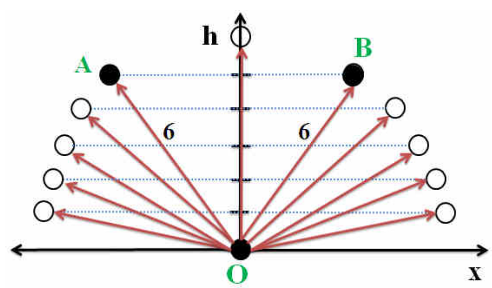

Fig. 14: radial expansion

3.3. Particles are assigned an N-S spin axis (fig.15). As the universe expands, it stretches particle A (position and motion of the wave-state are undefined). When t = 6, the wave state collapses to the defined point state, as represented by the N. This means that of all the possible solutions, it is the particle N-S axis which determines where the point state will actually occur.

Thus if we can change the N-S axis angle of B, then as the universe expands the B wave state will be stretched as with A. But the point of collapse will now reflect the new N-S axis angle. B does not need to have an independent motion; B is simply being dragged by the universe in a different direction as the universe expands.

We can simulate the addition of a physical momentum to B by simply changing the N-S axis. The radial universe expansion does the rest.

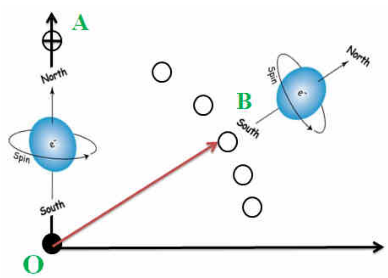

Fig. 15: N-S axis; A v = 0, B v = 0.886c

3.4. Information between particles is exchanged by photons. Photons do not have a point-state (N-S axis) and so travel horizontally and therefore travel at the speed of light in 3-D space. The period required for particles to emit and to absorb photons is proportional to the particle wavelength. In the following diagram (fig.16) A emits a photon. B travels towards A, as such it will take B less time to absorb that photon than if B was parallel to A. If the x-axis length $x = v/c$, then the h-axis length $h = \sqrt{1^2 - x^2}$ and the common relativistic Doppler equation can be written;

$$v_{observed} = v_{source} . \frac{\sqrt{1 - \frac{v^2}{c^2}}}{1 - \frac{v}{c}} = v_{source} . \frac{h}{1 - x} \tag{2}$$

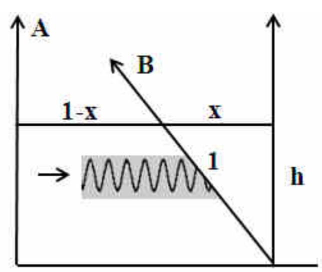

Fig. 16: Doppler shift

In the article on the virtual electron [7], the electron enters the mass point-state when the condition $(AL)^3/T$ is reached where T=2π. If time T is not circular (rotation around an axis) but linear then this condition is not reached and the photon will remain in the wave-state (no mass point-state). Thus photons travel horizontally, particles radially.

$E_{wave} = hv$ applies to both particle and photon wave-states but $E_{mass} = mc^2$ applies only to the particle mass point state. For each particle oscillation there is 1 Planck energy wave-state followed by 1 Planck mass point-state; and thus $E_{wave} = E_{mass}$, however as particle mass is the average frequency of occurrence of units of Planck mass then the formula $E = mc^2$ in the context of this model is misleading for $E = mc^2$ assumes particles have a constant property defined as mass.

3.5. Returning to our ABC particles, if photons (information) can only be exchanged along the horizontal axis which are the (x, y, z) axis, ABC will only 'see' this horizontal information. Instead of OA, OB and OC, the (x, y, z) axis will be able to measure only the horizontal AB, BC and AC (fig.17). There is no depth perception.

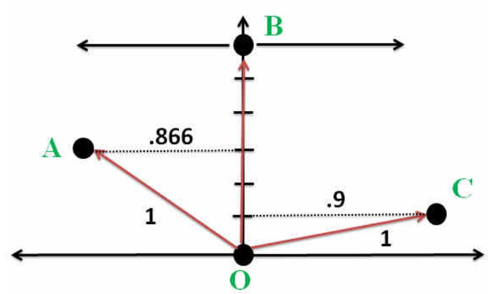

Fig. 17: 3-axis hyper-sphere surface

Thus although in Virtual Universe co-ordinates time and velocity are constants, particles ABC will observe only the horizontal (AB, BC, AC) co-ordinates = 3-D space.

And so if we define our virtual space as a black-hole, then the information (particles ABC) will appear to be on the surface of that black-hole, the radius of the black-hole being dimensionless, thus we would expect entropy only to increase when the surface area of the black hole changes.

Furthermore time for ABC translates as motion, without motion in the (x, y, z) axis there will be no means to measure time, thus the dimension time for the ABC world derives from simulation time (the clock-rate) and may equate to simulation time (as measured in units of Planck time), but it is a measure of particle motion.

4 Orbits

In quantum mechanics an atomic orbital is a mathematical function that can be used to calculate the probability of finding any electron of an atom in any specific region around the atom's nucleus. This model replaces the (non-physical) probability orbital + electric force with a 'physical' orbital (a unit of momentum). This mechanism is illustrated by the Rydberg formula.

4.1. Atomic electron transition is a change of an electron from one energy level to another within an atom, theoretically this should be a discontinuous electron 'jump' from one energy level to another although how this happens is not clear.
Consider the Hydrogen Rydberg formula for transition between and initial i and a final f orbit. The incoming photon λ_R causes the electron to 'jump' from the $n = i$ to $n = f$ orbit.

$$\frac{1}{\lambda_R} = R.(\frac{1}{n_i^2} - \frac{1}{n_f^2}) = \frac{R}{n_i^2} - \frac{R}{n_f^2} \tag{3}$$

The above could be interpreted as referring to 2 photons;

$$\lambda_R = (+\lambda_i) - (+\lambda_f)$$

Let us suppose a region between a free proton p^+ and a free electron e^- which we may define as zero. This region then divides into 2 waves of momentum of inverse phase which we may designate as photon $(+\lambda)$ and anti-photon $(-\lambda)$ whereby

$$(+\lambda) + (-\lambda) = zero$$

The photon $(+\lambda)$ leaves (at the speed of light), the anti-photon $(-\lambda)$ however is trapped between the electron and proton and forms a standing wave orbital. Due to the loss of the photon, the energy of $(p^+ + e^- + -\lambda) < (p^+ + e^- + 0)$ and so stable.

Let us define an $(n = i)$ orbital as $(-\lambda_i)$. The incoming Rydberg photon $\lambda_R = (+\lambda_i) - (+\lambda_f)$ arrives in a 2-step process. First the $(+\lambda_i)$ adds to the present $(-\lambda_i)$ orbital.

$$(-\lambda_i) + (+\lambda_i) = zero$$

The $(-\lambda_i)$ orbital is canceled and we revert to the free electron and free proton; $p^+ + e^- + 0$ (ionization). However we still have the Rydberg $-(+\lambda_f)$ and 0.

$$0 - (+\lambda_f) = (-\lambda_f)$$

From this wave addition followed by subtraction we have replaced the $n = i$ orbital with an $n = f$ orbital. The electron has not moved (the electron was not directly involved, there was no transition from an n_i to n_f orbital), however the electron region (boundary) is now determined by the new $n = f$ orbital $(-\lambda_f)$.

4.2. We take 2 objects A and B and form a link l_i (a physical orbital) between each point in A with each point in B. Let us suppose A is a sphere of points where $P \sim 4\pi r^3/3$ = total number of points (even mass distribution) and L = distance from a (single) orbiting point B to the center of sphere A. L is measured in terms of r and the fine structure constant α (for convenience I am using the commonly recognized value $\alpha \sim 137$), and w adjusts the wavelength of the orbital in reference to α. The formulas cited here can be downloaded [8].

$$L = r\alpha w \tag{4}$$

We then find the average distance S between point B and each point in A.

$$S = \frac{(l_1 + l_2 + l_3 ...)}{P} \tag{5}$$

L (radial axis) and S are not equivalent, a correction factor V is included (sect 4.6);

$$V^2 = \frac{3}{10\alpha^2 w^2} \tag{6}$$

$$L_{axis} \sim S_{orbit}\sqrt{1 - V^2} \sim \frac{S_{orbit}}{1 + V^2/2} \tag{7}$$

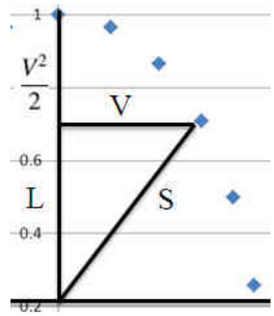

Fig. 18: approximate relativistic orbit

This can be illustrated using simple 1-electron atoms. The orbital wavelength L is de-constructed into S and V;

Example: Positronium (using $w_{pos}^2 = 5\alpha/16$)

$f_{pos}(1s - 2s)$ = 1233 607 216.4 MHz [11]

$$S_{pos} = (\lambda_e + \frac{\lambda_p}{8}) \tag{8}$$

$$L_{pos} = r_{pos}\alpha w_{pos} = S.\sqrt{(1 - \frac{48}{25\alpha^3})} \tag{9}$$

$$R_{pos}c(1 - \frac{1}{2^2}) = 1233\ 607\ 214.9 MHz \tag{10}$$

Example: Hydrogen (using $w_H^2 = \alpha/80$)

$f_H(1s - 2s)$ = 2466 061 413 187 035 Hz [12]

$$S_H = (\lambda_e + \lambda_p) \tag{11}$$

$$L_H = r_H\alpha w_H = S.\sqrt{(1 - \frac{48}{\alpha^3})} \tag{12}$$

$$R_H c(1 - \frac{1}{2^2}) = 2466\ 061\ 422\ 987\ 392 Hz \tag{13}$$

Giving a correlation;

$$\frac{10 f_{pos}(1s - 2s)/f_H(1s - 2s)}{r_H/r_{pos}} = 1.000\ 000\ 0050 \tag{14}$$

Referencing standard atomic radius r_0 = .125 x 10^{-14}m gives these relative values for a physical barycenter;

Positronium $2r/r_0$ = 0.6890; L/r = 896.761628

Hydrogen r/r_0 = 1.72338; L/r = 179.352326

4.3. The gravitational orbit becomes the sum of its orbitals. As the points (point-states, sect. 2) are dimensionless, although they are scattered throughout an object (i.e.: planet), they may be treated as occupying a central sphere, thus we can use the Schwarzschild radius of A = $\lambda_g = P2l_p$ where $P = M_A/m_P$, mass $M_A >> m_B$, chosen radius R = $L_g 2l_p$ (the

V term is insignificant). We can simplify to a gravity 'Bohr' model albeit n is not an integer.

$$\alpha n^2 = \frac{3\alpha w_g}{4\pi r^2} = \frac{L_g}{P} \tag{15}$$

$$r_g = R = \alpha n^2 \lambda_g \tag{16}$$

$$v_g^2 = \frac{c^2 P}{2L_g} = \frac{c^2}{2\alpha n^2} \tag{17}$$

$$a_g = \frac{c^2 P}{2L_g^2 2l_p} = \frac{c^2}{2\alpha^2 n^4 \lambda_g} \tag{18}$$

$$T_g^2 = \frac{8\pi^2 L_g^3 4l_p^2}{Pc^2} = \frac{8\pi^2 \alpha^3 n^6 \lambda_g^2}{c^2} \tag{19}$$

Example - Earth surface R = 6374km [2].
$\mu_{earth} = 3.986004418(9)x10^{14}$ [3]
$\lambda_{earth} = 2\mu_{earth}/c^2 = .00887$m
$M_{earth} = \mu_{earth}/G = .597378x10^{25}$kg [8]
$r_g = 6374.0\ km$
$a_g = 9.811\ m/s^2$
$T_g = 5064.4125\ s$
$v_g = 7907.931\ m/s$
$w_g = .35698x10^{29}$
Geosynchronous orbit R = 42164km
$r_g = 42164.0\ km$
$a_g = 0.2242\ m/s^2$
$T_g = 86163.6\ s$
$v_g = 3074.666\ m/s$
$w_g = .23614x10^{30}$

4.4. In this example we connect the points between A = earth and B = 1kg satellite.

$$\delta\mu_{GPE} = \frac{GMm}{r_1} - \frac{GMm}{r_2} \tag{20}$$

$$r_1 = \alpha n_1 \lambda_g$$

$$r_2 = \alpha n_2 \lambda_g$$

As Planck units...

$$\frac{GMm}{r_g} = \frac{hc}{2\pi r_g}.\frac{Mm}{m_P^2} \tag{21}$$

Rydberg (gravity)...

$$R = \frac{1}{2\pi r_g}(\frac{1}{n_1^2} - \frac{1}{n_2^2}) \tag{22}$$

$$f = Rc(\frac{1}{n_1^2} - \frac{1}{n_2^2}) \tag{23}$$

$$N_{orbital} = \frac{Mm}{m_P^2} \tag{24}$$

$$E_{orbital} = hf \tag{25}$$

$$E_{tot} = E_{orbital}\ N_{orbital} \tag{26}$$

Earth mass $M = 5.97x10^{24}kg$
Satellite mass $m = 1kg$
Earth surface $n_g = 2290\ (6374km)$
Geosynchronous orbit $w = 5890\ (42169km)$

$$f_{orbital} = n_{2290}\ orbit - n_{5890}\ orbit$$

$$f_{orbital} = 7.485 - 1.132 = 6.354Hz$$

$$E_{orbital} = 0.412x10^{-32}J$$

$$N_{orbitals} = Mm/m_P^2 = 0.126x10^{41}$$

$$E_{total} = E_{orbital}\ .\ N_{orbitals} = 53MJ/kg$$

Note the gravity Rydberg $R^{-1} = 2\pi r_g$, the electric Rydberg $R^{-1} = 2\alpha 2\pi r_a$.

$N_{orbitals} = (M/m_P).(m/m_P)$= total number of links and also corresponds to the gravitational coupling constant $\alpha_G = m_e^2/m_P^2$ (the probability of 2 electrons being simultaneously in the point state for any chosen unit of Planck time).

If these $0.126x10^{41}$ orbitals are all unaligned the net result of summing their vectors of motion is that the satellite will appear to fall downwards, the acceleration due to the conservation of angular momentum, if they are all aligned, the satellite will be pulled by them in a circular orbit. Elliptical orbits lie in-between.

4.5. Time dilation.
Gravitational:

$$v_s = v_{escape} = \sqrt{2}.v_g \tag{27}$$

$$\sqrt{1 - \frac{2GM}{r_g c^2}} = \sqrt{1 - \frac{v_s^2}{c^2}} \tag{28}$$

Velocity: B (satellite) has a cylindrical orbit around the A (planet) radial axis with orbital period $T_g c$ (from B^1 to B^2) at radius r_g and orbital velocity v_g. The orbital time t_g alongside the A axis (fig. 19);

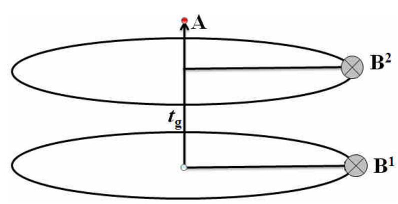

Fig. 19: orbit relative to A timeline axis

$$t_g = \sqrt{(T_g c)^2 - (2\pi r_g)^2} = (T_g c)\sqrt{1 - \frac{v_g^2}{c^2}} \tag{29}$$

The hole in the Earth (a thought experiment [14]). An apple on a tree-top is in the 6374.01km orbit. To dissociate that apple we have to add sufficient momentum to cancel the momentum of the $n_{6374.01}$ orbit (sect 4.1). This can be achieved when the apple reaches escape velocity v_s.

If our apple drops from the tree-top orbit and lands on the ground it will transfer excess momentum to the earth and subsequently change to the lower earth-surface = 6374.0km orbit.

However if there is a hole through the center of the earth then the apple will fall through it to the other side of the earth, then fall back into the hole returning to the tree-top 84mins later. Having no means to transfer momentum it will remain throughout its journey in the tree-top orbit, oscillating back and forth through that hole ad infinitum. The apple is not falling, it is following a 'linear' elliptical orbit.

An apple on the ground is orbiting the earth, it is pinned to the ground by the momentum of this orbit, this orbit however is obscured by the absence of earth holes. An object can only change orbits by changing the total orbit momentum (sect 4.1), a momentum buoyancy (angular momentum is conserved), thus gravitational force equates to the conservation of angular momentum.

4.6. The strong force is a momentum equivalent to the total orbit momentum such that the total orbit momentum is canceled and the orbit dissociates (sect 4.1).

$$m_{nuc} = m_p + m_n \tag{30}$$

$$\lambda_s = \frac{l_p m_P}{m_{nuc}} \tag{31}$$

$$r_0 = \sqrt{\alpha}\lambda_s \tag{32}$$

$$R_s = \alpha\lambda_s \tag{33}$$

$$v_s^2 = \frac{c^2}{\alpha} \tag{34}$$

The gravitational binding energy (μ) is the energy required to pull apart an object consisting of loose material and held together only by gravity.

$$\mu = \frac{3Gm_{nuc}^2}{5R_s} = \frac{3m_{nuc}c^2}{5\alpha} = \frac{3m_{nuc}v_s^2}{5} \tag{35}$$

Nuclear binding energy is the energy required to split a nucleus of an atom into its component parts. The electrostatic coulomb constant;

$$a_c = \frac{3e^2}{20\pi\epsilon r_0} \tag{36}$$

$$E = \sqrt{(\alpha)}a_c = \frac{3m_{nuc}c^2}{5\alpha} = \frac{3m_{nuc}v_s^2}{5} \tag{37}$$

Average binding energy in nucleus = 8.22MeV/nucleon [4]

4.7. Anomalous precession

semi-minor axis: $b = \alpha l^2 \lambda_{sun}$

semi-major axis: $a = \alpha w^2 \lambda_{sun}$

radius of curvature L

$$L = \frac{b^2}{a} = \frac{al^4\lambda_{sun}}{w^2} \tag{38}$$

$$\frac{3\lambda_{sun}}{2L} = \frac{3w^2}{2\alpha l^4} \tag{39}$$

$$precession = \frac{3w^2}{2\alpha l^4}.1296000.(100T_{earth}/T_{planet}) \tag{40}$$

Mercury = 42.9814 (arc secs per 100yrs)

Venus = 8.6248

Earth = 3.8388

5 Planck black hole

We next need to construct a Planck scaffolding for our particle universe. For each increment (the simulation clock-rate) we increase this 'particle-space' by Planck units, where t_{age} is the age of the universe as measured in units of Planck time and t_{sec} the age of the universe as measured in seconds. Using for universe age [8];

$t_{age} = 0.4281 \text{ x } 10^{61} t_p = 14.624\text{x}10^9$ yrs

5.1. Mass density

For each expansion step, to the particle-space universe is added units of t_p, m_P and volume l_p, such that we can calculate the mass density of this particle-space.

$$mass : m_{particle-space} = 2t_{age}m_P \ (kg)$$

$$volume : v_{particle-space} = 4\pi r^3/3, \quad r = 4l_p t_{age} = 2ct_{sec} \ (m^3)$$

$$\frac{m_{particle-space}}{v_{particle-space}} = \frac{3m_P}{2^7\pi t_{age}^2 l_p^3} \tag{41}$$

Via the Friedman equation; replacing p with the above mass density formula, $\sqrt{\lambda} = 2ct_{sec}$ reduces to the radius of the universe;

$$\lambda = \frac{3c^2}{8\pi Gp} = 4c^2 t_{sec}^2 \tag{42}$$

5.2. Temperature;

$$T_{particle-space} = \frac{T_P}{8\pi\sqrt{t_{age}}} \tag{43}$$

The $mass/volume$ formula uses t_{age}^2, the *temperature* formula uses $\sqrt{t_{age}}$. We may therefore eliminate the age variable t_{age} and combine both formulas into a single constant of proportionality that resembles the radiation density constant.

$$T_p = \frac{m_P c^2}{k_B} = \sqrt{\frac{hc^5}{2\pi G k_B{}^2}} \tag{44}$$

$$\frac{m_{particle-space}}{v_{particle-space}T_{particle-space}^4} = \frac{2^5 3\pi^3 m_P}{l_p^3 T_P^4} = \frac{2^8 3\pi^6 k_B^4}{h^3 c^5} \tag{45}$$

5.3. Radiation density (Stefan Boltzmann constant σ)

$$\sigma = \frac{2\pi^5 k_B^4}{15h^3c^2} \tag{46}$$

$$\frac{4\sigma_{SB}}{c}.T^4_{particle-space} = \frac{c^2}{1440\pi}.\frac{m_{particle-space}}{v_{particle-space}} \tag{47}$$

5.4. Casimir formula

F = force, A = plate area, $d_c 2l_p$ = distance between plates

$$\frac{-F_c}{A} = \frac{\pi hc}{480(d_c l_p)^4} \tag{48}$$

if $d_c = 2\pi\sqrt{t_{age}}$ then eq.(47) = eq.(49);

$$\frac{-F_c}{A} = \frac{c^2}{1440\pi}.\frac{m_{particle-space}}{v_{particle-space}} \tag{49}$$

5.5. Hubble constant (1 Mpc = 3.08567758 x 10^{22}m)

$$H = \frac{1Mpc}{t_{age}t_p} \tag{50}$$

5.6. Wien's displacement law

$$\frac{xe^x}{e^x-1} - 5 = 0, x = 4.96511423174427630... \tag{51}$$

$$\lambda_{peak} = \frac{2\pi l_p T_P}{xT_{particle-space}} = \frac{16\pi^2 l_p\sqrt{t_{age}}}{x} \tag{52}$$

5.7. Black body peak frequency

$$\frac{xe^x}{e^x-1} - 3 = 0, x = 2.82143937212207889... \tag{53}$$

$$v_{peak} = \frac{k_B T_{particle-space} x}{h} = \frac{x}{8\pi^2 t_p\sqrt{t_{age}}} \tag{54}$$

$$f_{peak} = \frac{xc}{16\pi^2 l_p\sqrt{t_{age}}} \tag{55}$$

5.8. Cosmological constant

The maximum temperature T_{max} would be when t_{age} = 1 (big-bang). What is of equal importance is the minimum possible temperature T_{min} - that temperature 1 unit above absolute zero, for this temperature would signify the limit of expansion (the universe could expand no further). For example, if we simply set the minimum temperature as the inverse of the maximum temperature;

$$T_{min} \sim \frac{1}{T_{max}} \sim \frac{8\pi}{T_P} \sim 0.177\ 10^{-30}\ K \tag{56}$$

This would then give us a value 'the end' in units of Planck time (~ 0.35 10^{73} yrs);

$$t_{end} = T^4_{max} \sim 1.014\ 10^{123} \tag{57}$$

Table 1:

Age (billions of years)	14.624
Age (units of Planck time)	0.4281 x $10^{61} t_p$
Cold dark matter density	0.21 x $10^{-26} kg.m^{-3}$
Radiation density	0.417 x $10^{-13} kg.m^{-3}$
Hubble constant	66.86 km/s/Mpc
CMB temperature	2.7269K
CMB peak frequency	160.2GHz
Cosmological constant	1.0137 x 10^{123}

The mid way point ($T_{mid} = 1K$) becomes T^2_{max} ~ 3.18 10^{61} ~ 108.77 billion years.

Note: I chose the CMB peak spectral density = 160.2 GHz [8] [5] as the reference from which I derived t_{age} (14.6 billion yrs). The above relates to a pure Planck framework, the addition of particles as energy sinks should result in the temperature parameters dropping more quickly and so influence age accordingly. It is estimated that the age of our universe is about 13.8 billion yrs and the matter content is about 5% which corresponds to the age difference (14.6/13.8) and so there may be a correlation for future investigation.

References

1. https://en.wikipedia.org/wiki/Mercury (planet)
2. https://en.wikipedia.org/wiki/Earth
3. https://en.wikipedia.org/wiki/Standard-gravitational-parameter
4. hyperphysics.phy-astr.gsu.edu/hbase/NucEne/nucbin.html
5. https://en.wikipedia.org/wiki/Cosmic-microwave-background
6. Nick Bostrom, Philosophical Quarterly 53 (211):243–255 (2003)
7. Macleod, Malcolm J., Programming Planck units from a virtual electron; a Simulation Hypothesis
   Eur. Phys. J. Plus (2018) 133: 278
8. planckmomentum.com/Gformulas.zip
   (a list of article formulas for download in maple format)
9. https://en.wikipedia.org/wiki/Pilot-wave-theory
10. https://www.mathpages.com/rr/s6-02/6-02.htm
11. M. S. Fee et al., Phys. Rev. Lett. 70, 1397 (1993)
12. Parthey CG et al, Improved measurement of the hydrogen 1S-2S transition frequency, Phys Rev Lett. 2011 Nov 11;107(20):203001. Epub 2011 Nov 11.
13. physics.nist.gov/PhysRefData/Handbook/Tables /heliumtable1.htm
14. hyperphysics.phy-astr.gsu.edu/hbase/Mechanics /earthole.html