Cosmological model based on epistemological principles

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Abstract

A simple epistemological principle implying that if an attribute of a system is fundamentally unknowable, then a choice is available in the assignment of the attribute. This principle is derived from a class of interaction free measurement experiments proposed by Elitzur and Dolev, and shown to underly the indeterminate behavior of all quantum system. An important implication of the principle is that any initial condition assigned to the universe must always contain a degree of choice, *ex post facto*. This mechanism therefore requires a first cause selection agency and it is proposed that life emerged with at least a limited ability to fulfill this role; not just as a consequence of the universe, but as much a part of its ultimate ontology.

An epistemological approach to cosmology is developed using this simple principle: A finite age of the universe implies a causality horizon surrounding every observable point and recedes at the speed of light. This horizon provides a minimum amount of information regarding the position of any particle and therefore limits the knowledge of momentum and energy. This leads to a limit at the Planck scale, but with a fundamental unit of energy that must increase linearly with time. An equivalence is shown where the universe can be examined in terms of physical quantities made up of multiples of fixed Planck units, or fixed multiples of a changing Planck scale. The first model is the more conventional, but relies on strong determinism, whilst the second shows an indeterminate evolution where a degree of choice can be exercised.

An epistemological relativity principle is introduced, where a physical constant can differ between physical locations, but the relations are invariant such that the local laws of physics are always equivalent. It is shown how this difference does have observable implications, such that a lower Planck energy in the past will lead to an observable redshift equivalent to a spatially flat expansion within the causality horizon. This model correctly predicts a low baryon ratio where the product of $H_0 t_0$ equals unity (comparable to the WMAP observation of 0.995). The need for both dark matter and energy is thus removed, with the additional benefit of a simple resolution to both the horizon and flatness problems. A final confirmation of this theory is provided by the prediction and accurate calculation of the blue shift seen in the Pioneer 10/11 Doppler tracking signals (as a consequence of the changing Planck scale).

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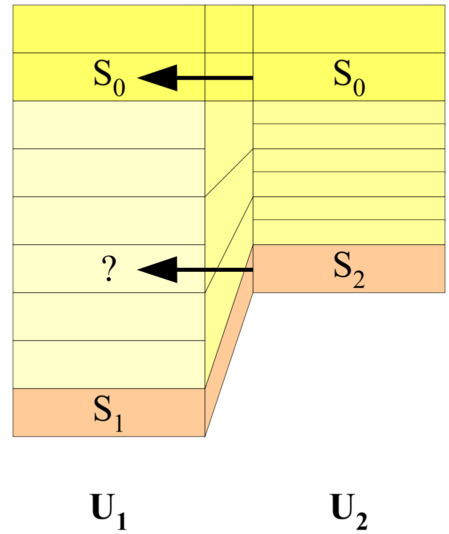
Determinism fails for internal observer

Given an initial condition and the rules of deterministic system, the state of the system **can not** be determined from the inside: Two identical universes U_1 and U_2 start from an identical initial condition S_0. U_1 will evolve to state S_1 while U_2 is sped up to arrive at the identical state $S_2=S_1$. Information about S_2 can now be used in U_1 to *predict* state S_1. However, adding information to U_1 will change $S_1 \neq S_2$ and prediction will fail.



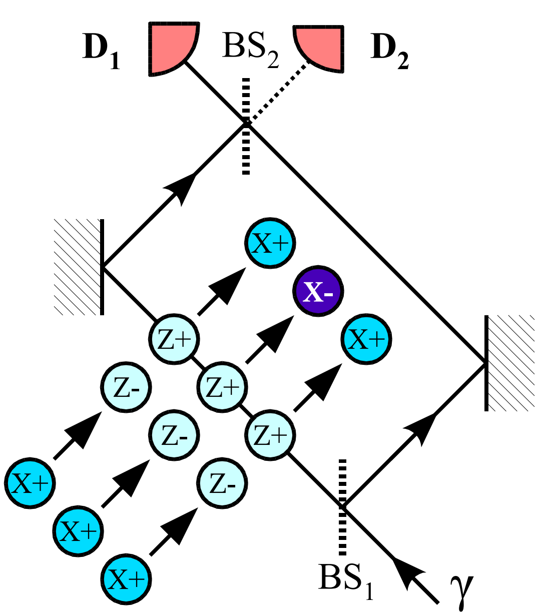
Epistemological Principle of Choice

If S_2 exists, then S_1 is knowable. If information about S_2 is added to U_1, then U_1 is changed such that S_1 is unknowable. All choice is incompatible with determinism, hence:

What is knowable can not be changed, what is changeable can not be known.

Interaction free measurement and choice of histories

Note: *quantum vs. classical* is strictly a case of s*imple vs. complex* – physical size is irrelevant. From principle, an event in the past is changeable if the event is fundamentally unknowable; this is the case for an interaction free measurement where two superimposed quantum entities are known to have interacted, but a choice still remains in the final state of the interaction.

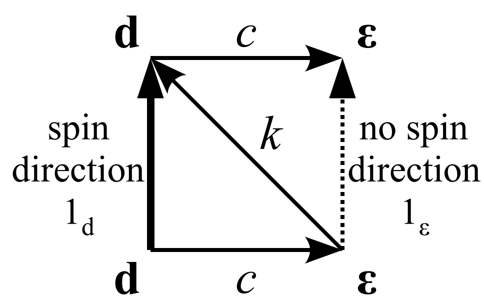


A photon travels down both arms of a Mach-Zehnder interferometer in superposition; both paths interfere to always arrive at detector D_1. Three atoms, starting from a spin $|X+\rangle$ state, are split into superimposed Z components and $|Z+\rangle$ is placed in path of photon γ. If photon is detected at D_2, then we know an interaction has occurred, but choice still remains in which atom. Measure middle atom, classical expectation is 33% chance, but choice effects outcome *ex post facto*. In reality probability of random selection is 56%. [1]

Epistemological part of observable

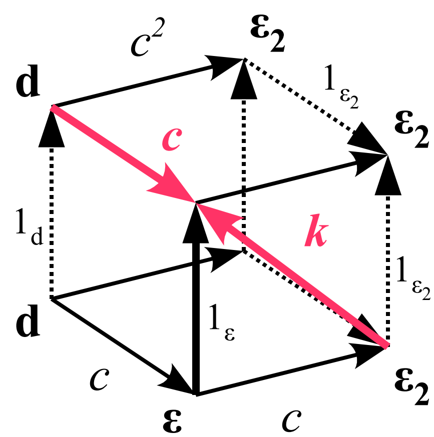
Attributes have a deterministic part (the observable) and an epistemological part. Deterministic part $\boldsymbol{d}$ (direction of spin for example) only exists if the epistemological part $\boldsymbol{\varepsilon}$ is in the knowable state ($k{:}\varepsilon \rightarrow d$). There is no deterministic part ($c{:}d \rightarrow \varepsilon$) until the measurement act, or until decoherence causes the attribute to become knowable via any possible form of correlated or indirect measurement.

Category theory



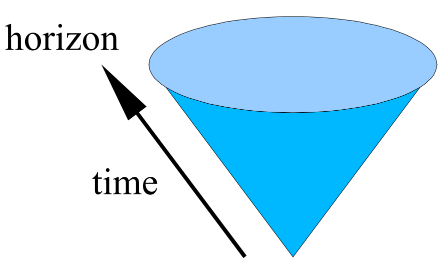
Implicit indeterminism

The epistemological part $\boldsymbol{\varepsilon}$ is also an attribute of the system and therefore has an epistemological part $\boldsymbol{\varepsilon_2}$: If we *know* ($k{:}\varepsilon_2 \rightarrow \varepsilon$) attribute is changeable ($c{:}d \rightarrow \varepsilon$), then it is always changeable (since the epistemological part is knowable). An internal observer can never determine the relative state of the observed system because it **has no** deterministic part.

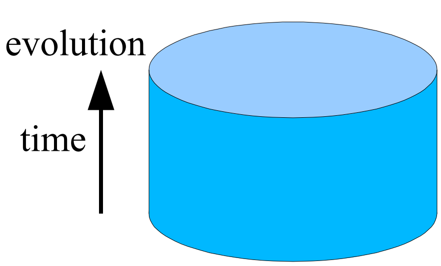


Evolution of horizon

Initial condition of universe is changeable and must always lie just beyond horizon. Horizon must move relative to a static observer, since information about an initial condition can never reach the observer and become knowable. All information currently available is the knowable state of the universe contained within horizon at that point in time.



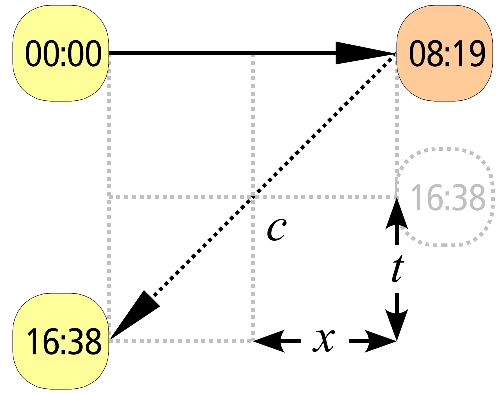
Temporal evolution – horizon recedes from observer at the maximum rate information can travel, defined as the fixed rate of causality; one unit of space per unit of time (dynamic initial condition with static post condition).



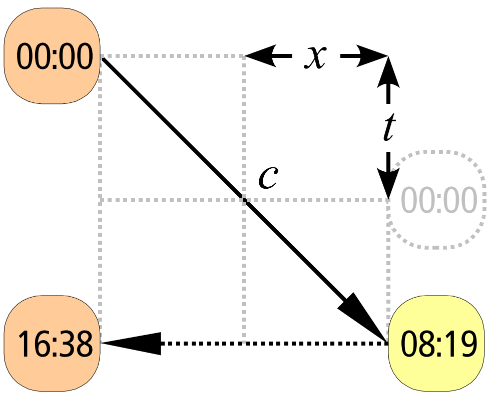
Causal evolution – observation of the universe is done from a fixed point (knowable age) and the evolution of the universe has occurred within this fixed horizon for the entire age of the universe (static initial condition with dynamic post condition).

Causal simultaneity

Conventional simultaneity assumes the universe is the same age everywhere; events in the distance appear in the past due to information travel time – cause and effect are equivalent.



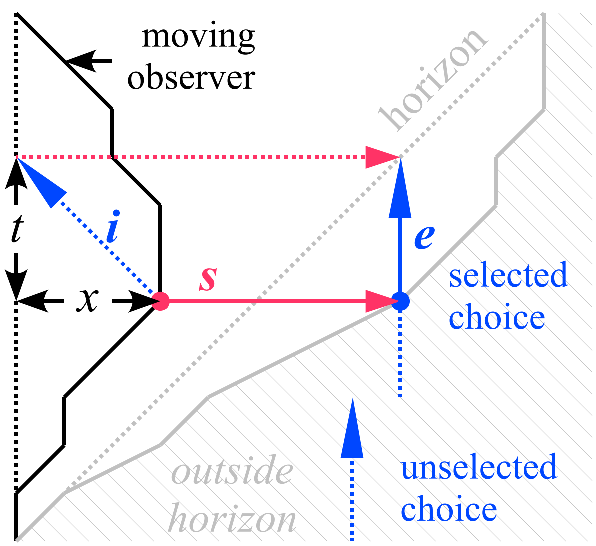
After choice, an *effect* will propagate at the speed of light and thus **cannot** be caught up with and stopped. Causal simultaneity treats an outbound effect as instantaneous. If an observer sends a signal to the Sun (499 seconds travel time), then it arrives at the same *instant* it is transmitted. Therefore the Sun is displaced by 499 seconds into the observer's future and the inbound return journey will now take twice as long.



A distant observer transmits a signal at midday and it is received at the Sun when a local (synchronized) clock reads 12:08:19. A displacement of the clocks in space includes an additional causal displacement in time. Every observer is therefore located at the oldest *knowable* location in the universe (information arrives from the past), and at the youngest *changeable* location (choice effects the future).

Selection from causality horizon

To determine the current state of the universe, an observer must select a changeable event as it crosses the horizon; this event becomes knowable now that it is part of the causal information content of universe. A moving observer can see past horizon of stationary observer, but can only transmit information at speed of light, else violate causality by giving the stationary observer knowledge of selection before the choice.



Proposal – observer has true ability to exercise the quantum meter option [2] and can therefore assign part of the causal history to the universe via choice of interaction [3]. An observer with even the *slightest* ability to select an advantageous history [4] will improve chances of survival. Life will emerge as the *first-cause* selection agent of an emergent *epistemological ontology*.

Knowable uncertainty limits

The quantum meter option offers the observer a choice of measurement in the selection of a determinant; process starts with exercise of choice and results in reduction of epistemological part to knowable. Complementary observables are linked by meter option; a measurement of momentum will result in minimal knowledge of position – *location is contained by horizon*.

Heisenberg's *Uncertainty Principle*: $$\Delta x.\Delta p \geq \frac{h}{4\pi}$$

Dot notation is used to identify fundamental (Planck) units. [5]

$h = e_{\bullet} t_{\bullet}$ $\quad c = x_{\bullet} t_{\bullet}^{-1}$

If R_0 is distance to horizon, then: $\Delta x_{max} = R_0 \therefore \Delta p_{min} > 0$

Momentum of a photon: $$p_{\gamma} = \frac{e_{\gamma}}{c}$$

The smallest momentum uncertainty represents the minimum knowable photon energy:

$$e_{\bullet\bullet} = \Delta p_{\gamma\, min}\, c$$

Minimum energy of photon is maximum wavelength, smallest angular frequency: $\omega_0 = t_0^{-1}$

$$\frac{\omega_0}{c} = \frac{2\pi}{R_0} \qquad \Delta x_{max} = 2\pi c\, t_0$$

Define the age of the universe as finite number N_0 of discrete *Planck time* units: $t_0 = t_{\bullet} N_0$

Then at minimum energy we find: $$e_{\bullet} = 8\pi^2 e_{\bullet\bullet} N_0$$

Changeable Planck units

The available accuracy of a momentum measurement appears to increase as the universe ages; the larger horizon allows greater position uncertainty. However, the minimum is knowable and must be constant (not changeable), this implies the *Planck energy* must change relative to time.

Define a discrete scale factor: $$n(t) = \frac{N}{N_0}$$

Define variable Planck energy: $$e_{\bullet(t)} = e_{\bullet} n(t)$$

$$e_{\bullet(t)} = 8\pi^2 e_{\bullet\bullet} N$$

Planck unit is defined as a constant in present, but relative to past: $N \propto t$

Returning to causal-temporal evolution, introduce two models for defining change in a physical parameters; temporal change keeps units constant, causal change keeps scale constant.

Temporal change – occurs in the number of units, value of unit is constant: $\Delta E = e_{\bullet} \Delta N$

Causal change – occurs in the value of the unit, number of units is fixed: $\Delta E = \Delta e_{\bullet(t)} N_0$

Causal vs. temporal change

Temporal evolution implies distance to horizon increases linearly with time – horizon recedes.

Causal evolution keeps horizon static while parameters change within horizon – space expands.

Define temporal horizon radius:

$$\boldsymbol{R_0}=\frac{r_0}{r_\bullet}$$

Define causal scale factor:

$$a(t)=\frac{\boldsymbol{R}}{\boldsymbol{R_0}}$$

*A **bold** font is used to identify dimensionless parameters:* $\boldsymbol{R}=\frac{r}{r_\bullet}$

Geometry of universe is always spatially flat within horizon.

From *Einstein-de Sitter Model*:

$$\boldsymbol{R_0}=\boldsymbol{M_0}$$

$$\boldsymbol{M}=\boldsymbol{R}$$

Define variable *Planck mass* to conserve mass within horizon:

$$m_{\bullet(t)}=m_\bullet a(t)^{-1}$$

Planck radius is defined as twice the Planck length: $r_\bullet=2x_\bullet$

Planck density is defined using sphere: $V_\bullet=\frac{4}{3}\pi r_\bullet^3$

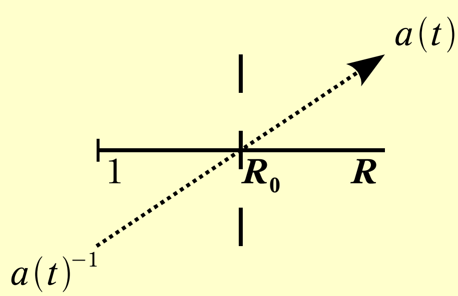
temporal change

$$M=m_\bullet\boldsymbol{R}$$

$$m_\bullet=m_{\bullet\bullet}\boldsymbol{R_0}^{-1}$$

$$M=m_{\bullet\bullet}\frac{\boldsymbol{R}}{\boldsymbol{R_0}}$$

$$M=m_{\bullet\bullet}a(t)$$



$$\rho=\frac{\boldsymbol{M}}{\boldsymbol{R}^3}=\frac{1}{\boldsymbol{R}^2}$$

Density evolves as if universe was *empty* (Milne cosmology [6]).

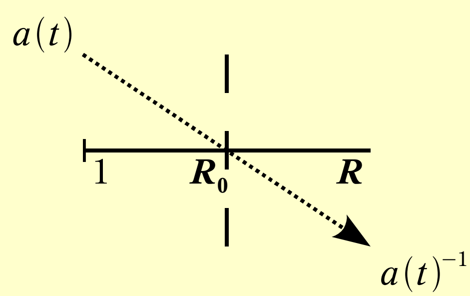
causal change

$$M=m_{\bullet(t)}\boldsymbol{R_0}$$

$$m_{\bullet(t)}=m_{\bullet\bullet}\boldsymbol{R}^{-1}$$

$$M=m_{\bullet\bullet}\frac{\boldsymbol{R_0}}{\boldsymbol{R}}$$

$$M=m_{\bullet\bullet}a(t)^{-1}$$



$$\rho(t)=\frac{\boldsymbol{M}}{\boldsymbol{R}^3}=\frac{\boldsymbol{R_0}^2}{\boldsymbol{R}^4}$$

Density evolves as if universe was radiation dominated ($\boldsymbol{R_0}$ is a *const.*)

Temporal evolution only describes extent of horizon and is independent of contents (empty); distance to horizon $\boldsymbol{R}=N_0$ in the present and leads to the (dimensionless) density relation:

$$\rho_{\boldsymbol{0}}=N_0^{-2}$$

Matter and radiation relationships

Causal evolution is equivalent to a radiation dominated cosmos; using discrete time relation:

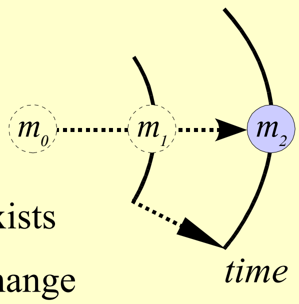
$$N = N_0 a(t)^2$$

$$n(t) = a(t)^2$$

Causal change in Planck mass (energy already defined) is redefined using discrete scale factor:

$$m_{\bullet(t)} = m_{\bullet} n(t)^{-\frac{1}{2}}$$

matter relationship



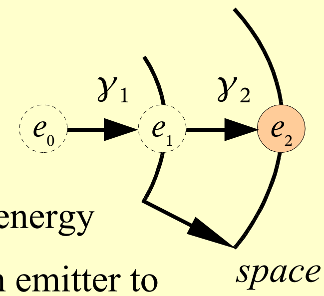
Matter always exists in the present; change is relative to time:

$$\frac{m_{\bullet(t)}}{e_{\bullet}} = \frac{t_{\bullet(t)}^2}{x_{\bullet}^2}$$

Time *slows down* as mass *decreases*:

$$t_{\bullet(t)} = t_{\bullet} n(t)^{-\frac{1}{4}}$$

radiation relationship



Radiation is an energy transaction from emitter to absorber; change is relative to space:

$$\frac{e_{\bullet(t)}}{m_{\bullet}} = \frac{x_{\bullet(t)}^2}{t_{\bullet}^2}$$

Space *expands* as energy *increases*:

$$r_{\bullet(t)} = r_{\bullet} n(t)^{\frac{1}{2}}$$

Temperature of universe

Photons received in the present represent the relative energy at time of emission – lower value in past implies observed redshift and lower temperature of cosmological background radiation:

$$T = T_0 a(t)^{-1}$$

Causal change in *Planck temperature* is opposite to space:

$$T_{\bullet(t)} = T_{\bullet} n(t)^{-\frac{1}{2}}$$

Casual change in temperature of CBR: $T_0 = T_{\bullet(t)} N_0^{-\frac{1}{2}}$

In present $N_0 = \boldsymbol{T}_{\mathbf{0}}^{-2} \therefore \rho_{\mathbf{0}} = \boldsymbol{T}_{\mathbf{0}}^{\mathbf{4}}$

Radiation density from a blackbody: $\rho_\gamma = \Omega_\gamma \boldsymbol{T}_{\mathbf{0}}^{\mathbf{4}}$

$$\Omega_\gamma = \frac{1}{720\pi^2}$$

Coldest possible object is entire universe collapsed to a black hole: $k_B T_{00} = e_{\bullet}$.
Hawking temperature of this black hole: $\boldsymbol{T}_{\boldsymbol{H}} = N_0^{-1}$
Planck temperature [7] *is therefore:* $T_{\bullet} = T_{00} N_0$

Entropy of radiation

Majority of particles in the universe are in the form of background radiation – this represents almost all of the entropy [8]. If the universe was only radiation, then: $\boldsymbol{E_0}=\boldsymbol{S_0}\boldsymbol{T_0} \therefore \boldsymbol{S_0}=N_0^{\frac{3}{2}}$

Total mass of the background radiation:

$$M_{CBR}=n_\gamma \frac{e_\gamma}{c^2}$$

> *Average energy of a black-body photon:* $\boldsymbol{e}_\gamma=\boldsymbol{S}_\gamma \boldsymbol{T}$
> *Where the dimensionless entropy:* $\boldsymbol{S}_\gamma=\frac{3\pi^4}{\zeta(3)}\Omega_\gamma$

Number of photons in CBR from density:

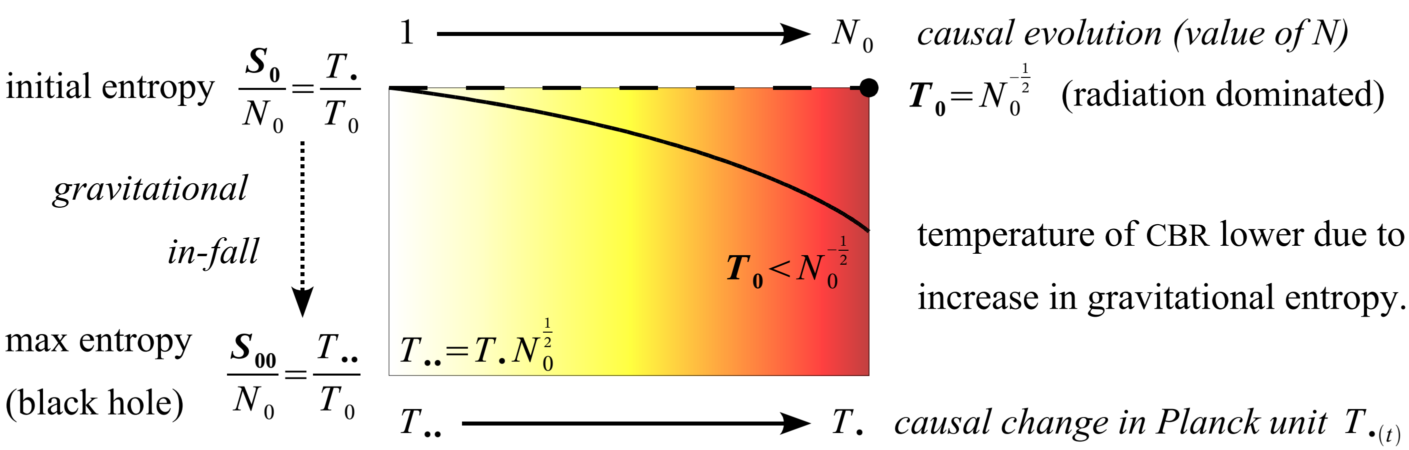
$$n_\gamma=\frac{\rho_\gamma \boldsymbol{R}_0^3}{\boldsymbol{S}_\gamma \boldsymbol{T}_0}$$

Therefore number of photons is related to entropy:

$$n_\gamma=\frac{\zeta(3)}{3\pi^4}N_0^{\frac{3}{2}}$$

Entropy from gravitation

Entropy is only constant within horizon if universe contains pure radiation; presence of matter causes gravitational in-fall and increase in entropy [9] – maximum at total collapse: $\boldsymbol{S}_{00}=N_0^2$



Baryon-photon ratio

The critical density is related to the matter density (baryons) and the CBR blackbody radiation density using:

$$\rho_0=\frac{n_b \boldsymbol{m}_b}{\Omega_b \boldsymbol{V}_0}=\frac{n_\gamma \boldsymbol{e}_\gamma}{\Omega_\gamma \boldsymbol{V}_0}$$

This gives the baryon-photon ratio as:

$$\eta=\frac{\Omega_b \boldsymbol{e}_\gamma}{\Omega_\gamma \boldsymbol{m}_b}$$

Since the baryon-photon ratio is fixed, then baryon mass is proportional to CBR photon energy!

Cosmological model

Radiation dominated model ignored matter and so far considered no causal change in both Planck mass and time – these changes are *cumulative* over the discrete scale.

Define *Planck time* at Planck time:

$$t_{\bullet\bullet} = t_{\bullet} N_0^{\frac{1}{4}}$$

Total-time from horizon radius $\boldsymbol{R}$:

$$t_R = t_{\bullet\bullet} \int_0^{\boldsymbol{R}} N^{-\frac{1}{4}} dN$$

$$t_{\boldsymbol{R}} = \frac{4}{3} t_{\bullet\bullet} \boldsymbol{R}^{\frac{3}{4}}$$

Present age is when radius $\boldsymbol{R} = N_0$:

$$t_0 = \frac{4}{3} t_{\bullet} N_0$$

Change in proton mass is opposite to change in classical electron radius, so that: $\dfrac{m_p}{m_{\bullet(t)}} = \dfrac{r_{\bullet(t)}}{r_e}$

Entropy change from pure radiation model has increased, such that $\boldsymbol{m_p r_e}$=1.06626:

$T_{CBR} = 2.725(2)\, K$	$T_0 = 2.906(2)\, K$	$N_0 = 2.396(4) \times 10^{60}$	$t_0 = 13.68(2)\, Gyrs$

Total-time relative to scale factor *behaves* as if the universe is ***matter dominated***:

$$t = t_0 a(t)^{\frac{3}{2}}$$

Current observation reveals *present* Hubble parameter as if the universe is ***empty***:

$$H_0 = t_0^{-1} = 71.46(12)\, km\, s^{-1} / Mpc$$

Calculating the equivalent cumulative change in mass leads to the integration result:

$$M_{\boldsymbol{R}} = 2 m_{\bullet\bullet} N^{\frac{1}{2}}$$

A flat space-time implies that the *total-radius* is dependent on *total-mass*; critical density is based on fixed mass, so matter density occupies a larger *total-volume:*

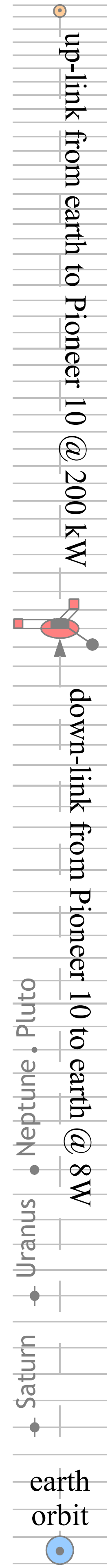
Temporal : $\boldsymbol{R} = N_0$	$M_0 = 2 m_{\bullet} N_0$	$\boldsymbol{V_0} = 8 V_0 V_{\bullet}^{-1}$	$\Omega_b = \frac{1}{8} = 12.5\%$
Causal : $\boldsymbol{R} = 2 N_0$	$M_0 = 2\sqrt{2} m_{\bullet} N_0$	$\boldsymbol{V_0} = 8\sqrt{8} V_0 V_{\bullet}^{-1}$	$\Omega_b = \frac{1}{8\sqrt{8}} = 4.42\%$

Final implication is the change in units between two sequential measurements relative to an observer in the present:

$$\frac{\Delta \boldsymbol{E}}{\boldsymbol{E_0}} = \frac{d}{dN} n(t) = \frac{1}{N_0}$$

This change is seen as a frequency drift in Doppler tracking between Pioneer 10 / 11.

$$\Delta \nu / \nu = t_{\bullet} / t_{\bullet}^2 N_0 = 3.088(5) \times 10^{-18}\, s / s^2$$



Conclusion

Any observation of the universe must be made in the present, and at this point in time we can potentially know any information that has been able to reach us at the current age of the universe. This temporal evolution of the universe behaves as an empty Minkowski space-time; there is no horizon problem since information form any observable part of the cosmos has had enough time to reach any other observable part. Within this horizon, we observe a slice through a causal history bound by a horizon that will appear as an *initial* condition of the universe we now observe. We arrive at a universe that *always behaves* temporally in the present, but will *appear to have behaved* causally in the past.

Compared to the conventional approach, the lower baryon (matter) density of this model also removes the requirement for dark matter. The outstanding issues with galaxy dynamics and large-scale structure formation appear to be resolved with Modified Newtonian Dynamics [10]. A changing unit scale will increase gravitational attraction towards the motion of a body; this is equivalent to the gravitational acceleration of the *entire universe*, which works out to be a_0.

The most significant falsifiable prediction of this model however, is the blue-shift in Doppler tracking signals from space probes traveling in uniform radial motion. With an error margin of 15%, the current observation [11] is just 5.75% below the prediction from this theory.

Notes and references

[1] Dolev, S., Elitzur, A.C. Non-sequential behavior of the wave function. quant-ph/0102109

[2] Herbert, N. Quantum Reality: Beyond the New Physics. Doubleday, 1985, pp. 134-136

[3] Hodgson, D. Plain Person's Free Will. JCS, vol. 12, no. 1, 2005, pp. 4, 7-10
If the universe meets the *alternatives requirement*, then life meets the *selection requirement*.

[4] McFadden, J.J., Al-Khalili. A quantum mechanical model of adaptive mutations. Biosystems 50: 203-211, 1999.
See also by McFadden; http://www.surrey.ac.uk/qe/O5.htm

[5] Conventional Planck units use *h-bar*, but *dot* units use plain *h*: $e_{\bullet}=\sqrt{hc^5G^{-1}}$

[6] McIrvin, M. Milne cosmology; http://world.std.com/~mmcirvin/milne.html

[7] Planck temperature is typically from $e_p=k_BT_p$, but *dot* temperature defined by: $e_{\bullet}=8\pi^2k_BT_{\bullet}$

[8] Hawley, J.F., Holcomb, K.A. Foundations of modern cosmology. Oxford University Press, 1998, p. 454

[9] Penrose, R. The Road to Reality: A Complete Guide to the Laws of the Universe, BCA, 2004, pp. 705-707

[10] McGaugh, S. The MOND Pages; http://www.astro.umd.edu/~ssm/mond

[11] Nieto, M.M., Turyshev, S.G., Anderson, J.D. The Pioneer Anomaly: The Data, its Meaning, and a Future Test, gr-qc/0411077