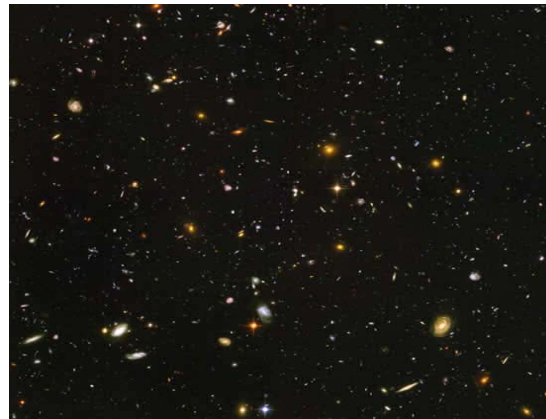


The
Grand Unified Theory
of
Classical Physics

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Part 3:
Cosmology

Maxwell's Equations and Special Relativity

Maxwell's equations and special relativity are based on the law of propagation of a electromagnetic wave front in the form

$$\frac{1}{c^2} \frac{\partial^2 \omega}{\partial t^2} - \left[\frac{\partial^2 \omega}{\partial x^2} + \frac{\partial^2 \omega}{\partial y^2} + \frac{\partial^2 \omega}{\partial z^2} \right] = 0$$

For any kind of wave advancing with limiting velocity and capable of transmitting signals, the equation of front propagation is the same as the equation for the front of a light wave.

Thus, the equation

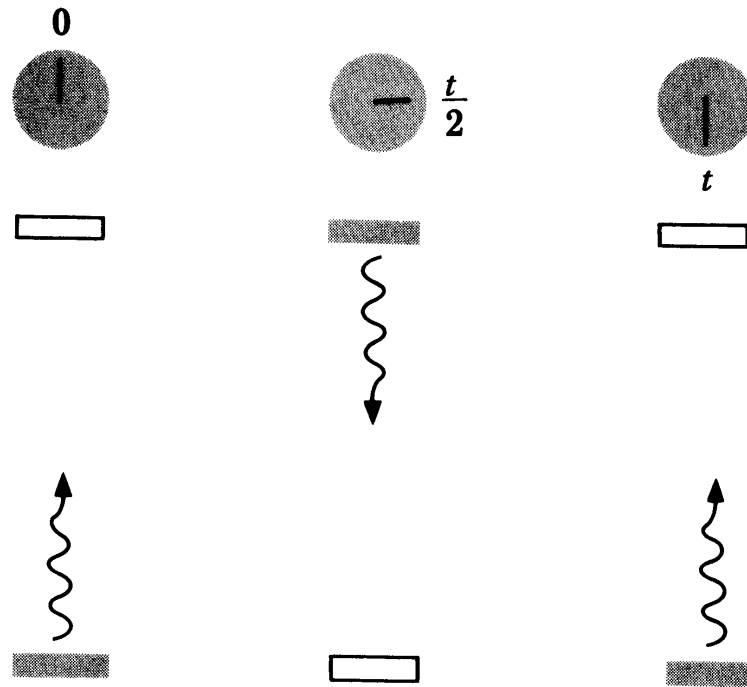
$$\frac{1}{c^2} \left(\frac{\partial^2 \omega}{\partial t^2} \right) - \left(\text{grad}^2 \omega \right) = 0$$

acquires a general character; it is more general than Maxwell's equations from which Maxwell originally derived it.

The Classical Wave Equation Governs:

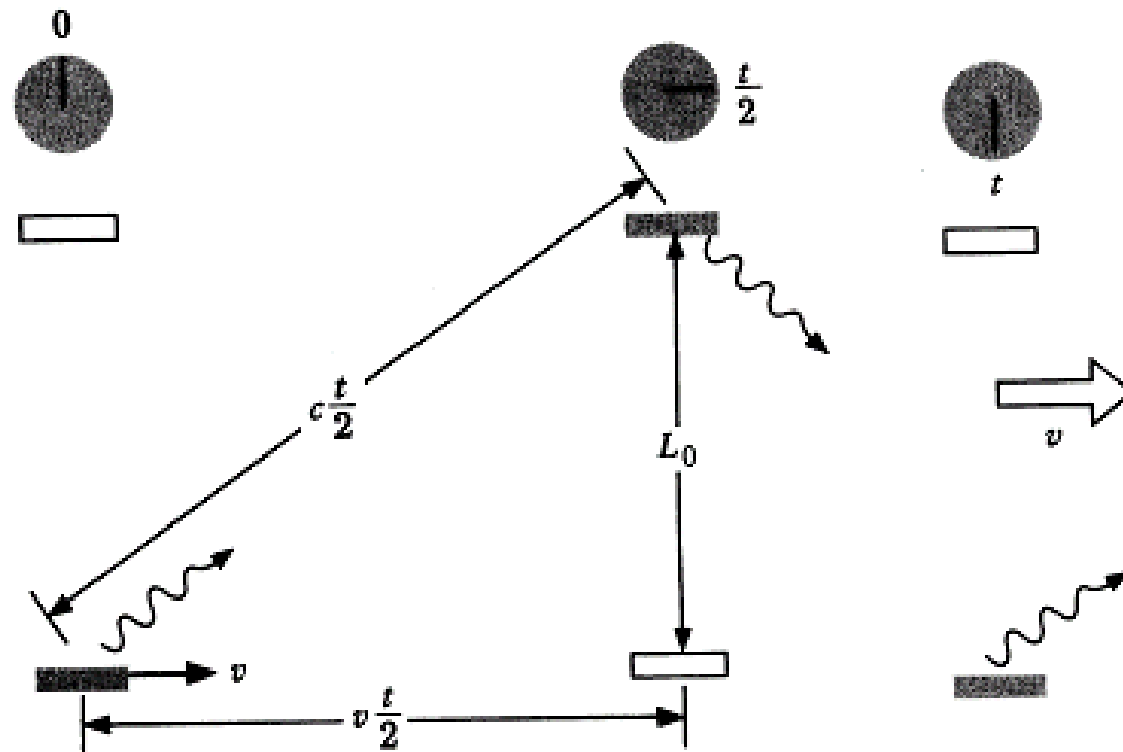
- The motion of bound electrons
- The propagation of any form of energy
- Measurements between inertial frames of reference such as time, mass, momentum, and length (**Minkowski tensor**)
- A relativistic correction of spacetime due to particle production or annihilation (**Schwarzschild metric**)
- Fundamental particle production and the conversion of matter to energy
- The expansion and contraction of the Universe
- The basis of the relationship between Maxwell's equations, Planck's equation, the de Broglie equation, Newton's laws, and special, and general relativity

A Light-Pulse Clock at Rest on the Ground As Seen by an Observer on the Ground



The dial represents a conventional clock on the ground.

A Light-Pulse Clock in a Spacecraft As Seen by an Observer on the Ground



The mirrors are parallel to the direction of the motion of the spacecraft. The dial represents a conventional clock on the ground.

Time Interval Relation Between Ticks t of the Moving Clock and L_0 , the Vertical Distance Between the Mirrors

$$\left(c\frac{t}{2}\right)^2 = L_0^2 + \left(v\frac{t}{2}\right)^2 \qquad t = \frac{\frac{2L_0}{c}}{\sqrt{1 - \frac{v^2}{c^2}}}$$

But $\frac{2L_0}{c}$ is the time t_0 interval between ticks on the clock on the ground, and so the

time dilation relationship based on the constant maximum speed of light in any inertial frame is

$$t = \frac{t_0}{\sqrt{1 - \frac{v^2}{c^2}}}$$

wherein the parameters are:

t_0 = time interval on clock at rest relative to an observer

t = time interval on clock in motion relative to an observer

v = speed of relative motion

c = speed of light

Minkowski Tensor $\eta_{\mu\nu}$

The Metric $g_{\mu\nu}$ for Euclidean Space Called the Minkowski Tensor $\eta_{\mu\nu}$ is

$$\eta_{\mu\nu} = \begin{pmatrix} -1 & 0 & 0 & 0 \\ 0 & \frac{1}{c^2} & 0 & 0 \\ 0 & 0 & \frac{1}{c^2} & 0 \\ 0 & 0 & 0 & \frac{1}{c^2} \end{pmatrix}$$

In this case, the separation of proper time between two events x^μ and x^ν is $d\tau^2 = -\eta_{\mu\nu} dx^\mu dx^\nu$

$$d\tau^2 = -\eta_{\mu\nu} dx^\mu dx^\nu$$

The Equivalence of the Gravitational Mass and the Inertial Mass

Experimentally, mass causes time dilation, and $\frac{m_g}{m_i} = \text{universal constant}$ which is predicted by Newton's Law of mechanics and gravitation.

The energy equation of Newtonian gravitation

$$E = \frac{1}{2}mv^2 - \frac{GMm}{r} = \frac{1}{2}mv_0^2 - \frac{GMm}{r_0} = \text{constant}$$

Since h , the angular momentum per unit mass, is

$$h = L / m = |\mathbf{r} \times \mathbf{v}| = r_0 v_0 \sin \phi$$

Eccentricity e may be written as

$$e = \left[1 + \left(v_0^2 - \frac{2GM}{r_0} \right) \frac{r_0^2 v_0^2 \sin^2 \phi}{G^2 M^2} \right]^{1/2}$$

m is the inertial mass of a particle

v_0 is the speed of the particle

r_0 is the distance of the particle from a massive object

ϕ is the angle between the direction of motion of the particle and the radius vector from the object

M is the total (including a particle) of mass of the object

Classification of the Orbits

The eccentricity e given by Newton's differential equations of motion in the case of the central field permits the classification of the orbits.

According to the total energy E :

$E < 0, \quad e < 1$	ellipse
$E < 0, \quad e = 0$	circle (special case of ellipse)
$E = 0, \quad e = 1$	parabolic orbit
$E > 0, \quad e > 1$	hyperbolic orbit

Classification of the Orbits cont'd

According to the orbital velocity relative to the gravitational velocity squared $\frac{2GM}{r_0}$:

$$v_0^2 < \frac{2GM}{r_0} \quad e < 1 \quad \text{ellipse}$$

$$v_0^2 = \frac{2GM}{r_0} \quad e = 0 \quad \text{circle (special case of ellipse)}$$

$$v_0^2 = \frac{2GM}{r_0} \quad e = 1 \quad \text{parabolic orbit}$$

$$v_0^2 > \frac{2GM}{r_0} \quad e > 1 \quad \text{hyperbolic orbit}$$

Continuity Conditions for the Production of a Particle From a Photon Traveling at Light Speed

- A photon traveling at the speed of light gives rise to a particle with an initial **radius equal to its Compton wavelength bar**

$$r = \hat{\lambda}_C = \frac{\hbar}{mc}$$

- The particle must have an **orbital velocity equal to Newtonian gravitational escape velocity v_g of the antiparticle**

$$v_g = \sqrt{\frac{2Gm}{r}} = \sqrt{\frac{2Gm_0}{\hat{\lambda}_C}}$$

- The eccentricity is one
- The orbital energy is zero
- The particle production trajectory is a parabola relative to the center of mass of the antiparticle

A Gravitational Field As a Front Equivalent to a Light Wave Front

The particle with a finite gravitational mass gives rise to a gravitational field that travels out as a front equivalent to a light wave front

The form of the outgoing gravitational field front traveling at the speed of light is

$$f\left(t - \frac{r}{c}\right)$$

and $d\tau^2$ is given by

$$d\tau^2 = f(r)dt^2 - \frac{1}{c^2} \left[f(r)^{-1} dr^2 + r^2 d\theta^2 + r^2 \sin^2 \theta d\phi^2 \right]$$

The Speed of Light

The speed of light as a constant maximum as well as phase matching and continuity conditions of the electromagnetic and gravitational waves require the following form of the squared displacements:

$$(c\tau)^2 + (v_g t)^2 = (ct)^2$$

$$\tau^2 = t^2 \left(1 - \left(\frac{v_g}{c} \right)^2 \right)$$

Thus,

$$f(r) = \left(1 - \left(\frac{v_g}{c} \right)^2 \right)$$

In order that the wave front velocity does not exceed c in any frame, spacetime must undergo time dilation and length contraction due to the particle production event.

*The derivation and result of spacetime time dilation is analogous to the derivation and result of **special relativistic time dilation** wherein the relative velocity of two inertial frames replaces the gravitational velocity.*

Quadratic Form Of The Infinitesimal Squared Temporal Displacement

General form of the metric due to the relativistic effect on spacetime due to mass m_0

$$d\tau^2 = \left(1 - \left(\frac{v_g}{c}\right)^2\right) dt^2 - \frac{1}{c^2} \left[\left(1 - \left(\frac{v_g}{c}\right)^2\right)^{-1} dr^2 + r^2 d\theta^2 + r^2 \sin^2 \theta d\phi^2 \right]$$

Gravitational radius, r_g , of each orbitsphere of the particle production event, each of mass m

$$r_g = \frac{2Gm}{c^2}$$

$$d\tau^2 = \left(1 - \frac{r_g}{r}\right) dt^2 - \frac{1}{c^2} \left[\left(1 - \frac{r_g}{r}\right)^{-1} dr^2 + r^2 d\theta^2 + r^2 \sin^2 \theta d\phi^2 \right]$$

Masses and their effects on spacetime **superimpose**. The separation of proper time between two events and x^μ is $x^\mu + dx^\mu$

$$d\tau^2 = \left(1 - \frac{2GM}{c^2 r}\right) dt^2 - \frac{1}{c^2} \left[\left(1 - \frac{2GM}{c^2 r}\right)^{-1} dr^2 + r^2 d\theta^2 + r^2 \sin^2 \theta d\phi^2 \right]$$

The Origin of Gravity

The Schwarzschild metric gives the relationship whereby matter causes relativistic corrections to spacetime that determines the curvature of spacetime and is the origin of gravity.

The metric $g_{\mu\nu}$ for non-Euclidean space due to the relativistic effect on spacetime due to mass m_0 is

$$g_{\mu\nu} = \begin{pmatrix} -\left(1 - \frac{2Gm_0}{c^2 r}\right) & 0 & 0 & 0 \\ 0 & \frac{1}{c^2} \left(1 - \frac{2Gm_0}{c^2 r}\right)^{-1} & 0 & 0 \\ 0 & 0 & \frac{1}{c^2} r^2 & 0 \\ 0 & 0 & 0 & \frac{1}{c^2} r^2 \sin^2 \theta \end{pmatrix}$$

Particle Production Continuity Conditions

- The photon to particle event requires a transition state that is continuous.
- The velocity of a transition state orbitsphere is the speed of light.
- The radius, r_n , is the Compton wavelength bar, $\hat{\lambda}_C$

$$\hat{\lambda}_C = \frac{\hbar}{m_0 c} = r_\alpha^*$$

- The Planck equation energy, the electric potential energy, and the magnetic energy are equal to $m_0 c^2$.

The Masses of Fundamental Particles

The Schwarzschild metric gives the relationship whereby matter causes relativistic corrections to spacetime that determines the masses of fundamental particles.

Substitution of $r = \hat{\lambda}_c$; $dr = 0$; $d\theta = 0$; $\sin^2 \theta = 1$ into the Schwarzschild metric gives

$$d\tau = dt \left(1 - \frac{2Gm_0}{c^2 r_\alpha^*} - \frac{v^2}{c^2} \right)^{\frac{1}{2}}$$

with , $v^2 = c^2$

$$\tau = ti \sqrt{\frac{2GM}{c^2 r_\alpha^*}} = ti \sqrt{\frac{2GM}{c^2 \hat{\lambda}_c}} = ti \frac{v_g}{c}$$

Relationship of the Equivalent Particle Production Energies

When the orbitsphere velocity is the speed of light:

Continuity conditions based on the constant maximum speed of light given by **Maxwell's equations**:

(Mass energy = Planck equation energy = electric potential energy = magnetic energy = mass/spacetime metric energy)

$$m_0 c^2 = \hbar \omega^* = V = E_{mag} = E_{spacetime}$$

$$m_0 c^2 = \hbar \omega^* = \frac{\hbar^2}{m_0 \hat{\lambda}_C^2} = \alpha^{-1} \frac{e^2}{4\pi\epsilon_0 \hat{\lambda}_C} = \alpha^{-1} \frac{\pi\mu_0 e^2 \hbar^2}{(2\pi m_0)^2 \hat{\lambda}_C^3} = \frac{\alpha h}{1 \text{ sec}} \sqrt{\frac{\hat{\lambda}_C c^2}{2Gm}}$$

Continuity Conditions Based on the Constant Maximum Speed of Light Given by the Schwarzschild Metric

$$\frac{\text{proper time}}{\text{coordinate time}} = \frac{\text{gravitational wave condition}}{\text{electromagnetic wave condition}} = \frac{\text{gravitational mass phase matching}}{\text{charge/inertial mass phase matching}}$$

$$\frac{\text{proper time}}{\text{coordinate time}} = i \frac{\sqrt{\frac{2Gm}{c^2 \lambda_c}}}{\alpha} = i \frac{v_g}{\alpha c}$$

Masses of Fundamental Particles

- Each of the Planck equation energy, electric energy, and magnetic energy corresponds to a particle given by the relationship between the proper time and the coordinate time.
- The electron and antielectron correspond to the Planck equation energy.
- The muon and antimuon correspond to the electric energy.
- The tau and antitau correspond to the magnetic energy.
- The particle must possess the escape velocity v_g relative to the antiparticle where $v_g < c$.
- According to Newton's law of gravitation, the eccentricity is one and the particle production trajectory is a parabola relative to the center of mass of the antiparticle.

The Electron-Antielectron Lepton Pair

A clock is defined in terms of a self-consistent system of units used to measure the particle mass.

$$2\pi \frac{\hbar}{mc^2} = \text{sec} \sqrt{\frac{2Gm^2}{c\alpha^2\hbar}}$$

$$m_e = \left(\frac{h\alpha}{\text{sec} c^2} \right)^{\frac{1}{2}} \left(\frac{c\hbar}{2G} \right)^{\frac{1}{4}} = 9.1097 \times 10^{-31} \text{ kg}$$

$$m_{e \text{ experimental}} = 9.1095 \times 10^{-31} \text{ kg}$$

The Muon-Antimuon Lepton Pair

$$2\pi \frac{\hbar}{mc^2} = 2\pi \text{ sec} \sqrt{\frac{2Gm_e \alpha^2 m}{c\hbar}}$$

The mass of the muon/antimuon is

$$m_{\mu} = \frac{\hbar}{c} \left(\frac{1}{2Gm_e (\alpha \text{ sec})^2} \right)^{\frac{1}{3}} = 1.8902 \times 10^{-28} \text{ kg}$$

$$m_{\mu \text{ experimental}} = 1.8836 \times 10^{-28} \text{ kg}$$

The Tau-Antitau Lepton Pair

$$2\pi \frac{\hbar}{mc^2} = 2 \text{ sec} \sqrt{\frac{2Gm_e (2\pi)^2 \alpha^4 m}{c\hbar}}$$

The mass of the tau/antitau is

$$m_\tau = \frac{\hbar}{c} \left(\frac{1}{2Gm_e} \right)^{\frac{1}{3}} \left(\frac{1}{2 \text{ sec} \alpha^2} \right)^{\frac{2}{3}} = 3.17 \times 10^{-27} \text{ kg}$$

$$m_{\tau \text{ experimental}} = 3.17 \times 10^{-27} \text{ kg}$$

Down-Down-Up Neutron (DDU)

$$2\pi \frac{2\pi\hbar}{\frac{m_N}{3} \left[\frac{1}{2\pi} - \frac{\alpha}{2\pi} \right] c^2} = \sec \sqrt{\frac{2G \left[\frac{m_N}{3} \left[\frac{1}{2\pi} - \frac{\alpha}{2\pi} \right] \right]^2}{3c(2\pi)^2 \hbar}}$$

The neutron mass is

$$m_{N \text{ calculated}} = (3)(2\pi) \left(\frac{1}{1-\alpha} \right) \left(\frac{2\pi\hbar}{\sec c^2} \right)^{\frac{1}{2}} \left(\frac{2\pi(3)ch}{2G} \right)^{\frac{1}{4}}$$

$$= 1.6744 \times 10^{-27} \text{ kg}$$

$$m_{N \text{ experimental}} = 1.6749 \times 10^{-27} \text{ kg}$$

Strange-Strange-Charmed Neutron (SSC)

$$2\pi \frac{2\pi\hbar}{\frac{m_{ssc}}{3} \left[\frac{1}{2\pi} - \frac{\alpha}{2\pi} \right] c^2} = 2\pi \sec \sqrt{\frac{2G\alpha^2 m_{ddu} \left[\frac{m_{ssc}}{3} \left[\frac{1}{2\pi} - \frac{\alpha}{2\pi} \right] \right]}{3c(2\pi)^2 \hbar}}$$

The strange-strange-charmed neutron mass is

$$m_{ssc \text{ calculated}} = (3)(2\pi) \left(\frac{1}{1-\alpha} \right) \left(\frac{h}{\sec c^2} \right)^{\frac{2}{3}} \left(\frac{2\pi(3)ch}{2m_{ddu} G\alpha^2} \right)^{\frac{1}{3}}$$

$$m_{ssc \text{ calculated}} = 4.89 \times 10^{-27} \text{ kg} = 2.74 \text{ GeV} / c^2$$

The observed mass of the Ω^- hyperon that contains three strange quarks (sss) is

$$m_{\Omega^-} = 1673 \text{ MeV} / c^2$$

Strange-Strange-Charmed Neutron (SSC) cont'd

Thus, an estimate for the dynamical mass of the strange quark, m_s , is

$$m_s = \frac{m_{\Omega^-}}{3} = \frac{1673 \text{ MeV} / c^2}{3} = 558 \text{ MeV} / c^2$$

The dynamical mass of the charmed quark, m_c , has been determined by fitting quarkonia spectra; and from the observed masses of the charmed pseudoscalar mesons $D^0(1865)$ and $D^+(1869)$.

$$m_c = 1.580 \text{ GeV} / c^2$$

Thus,

$$m_{SSC \text{ experimental}} = 2m_s + m_c = 2(558 \text{ MeV} / c^2) + 1580 \text{ MeV} / c^2$$

$$m_{SSC \text{ experimental}} = 2.70 \text{ GeV} / c^2$$

Bottom-Bottom-Top Neutron (BBT)

$$2\pi \frac{2\pi\hbar}{\frac{m_{bbt}}{3} \left[\frac{1}{2\pi} - \frac{\alpha}{2\pi} \right] c^2} = 2 \text{ sec} \sqrt{\frac{2G\alpha^4 m_{ddu} \left[\frac{m_{bbt}}{3} \left[\frac{1}{2\pi} - \frac{\alpha}{2\pi} \right] \right]}{3c2(2\pi)^2 \hbar}}$$

The bottom-bottom-top neutron mass is

$$m_{bbt \text{ calculated}} = (3)(2\pi) \left(\frac{1}{1-\alpha} \right) \left(\frac{2\pi\hbar}{2 \text{ sec } c^2} \right)^{\frac{2}{3}} \left(\frac{2\pi(3)ch}{m_{ddu} G \alpha^4} \right)^{\frac{1}{3}}$$

$$m_{bbt \text{ calculated}} = 3.48 \times 10^{-25} \text{ kg} = 195 \text{ GeV} / c^2$$

The dynamical mass of the bottom quark, M_B , has been determined by fitting quarkonia spectra; and from the observed masses of the bottom pseudoscalar mesons $B^0(5275)$ and $B^+(5271)$.

$$m_b = 4.580 \text{ GeV} / c^2$$

Bottom-Bottom-Top Neutron (BBT) cont'd

Thus, the predicted dynamical mass of the top quark based on the dynamical mass of the bottom quark is

$$m_{t \text{ calculated}} = m_{bbt \text{ calculated}} - 2m_b = 195 \text{ GeV} / c^2 - 2(4.580 \text{ GeV} / c^2)$$

$$m_{t \text{ calculated}} = 187 \text{ GeV} / c^2$$

Considering all jets, the CDF collaboration determined the mass of the top quark to be

$$186 \pm 13 \text{ GeV} / c^2$$

Relations Between Fundamental Particles

The relations between the lepton masses and neutron to electron mass ratio which are independent of the definition of the imaginary time ruler t_i including the contribution of the fields due to charge production are given in terms of the dimensionless fine structure constant α only:

$$\frac{m_\mu}{m_e} = \left(\frac{\alpha^{-2}}{2\pi}\right)^{\frac{2}{3}} \frac{\left(1 + 2\pi \frac{\alpha^2}{2}\right)}{\left(1 + \frac{\alpha}{2}\right)} = 206.76828 \quad (206.76827)$$

$$\frac{m_\tau}{m_\mu} = \left(\frac{\alpha^{-1}}{2}\right)^{\frac{2}{3}} \frac{\left(1 + \frac{\alpha}{2}\right)}{\left(1 - 4\pi\alpha^2\right)} = 16.817 \quad (16.817)$$

$$\frac{m_\tau}{m_e} = \left(\frac{\alpha^{-3}}{4\pi}\right)^{\frac{2}{3}} \frac{\left(1 + 2\pi \frac{\alpha^2}{2}\right)}{\left(1 - 4\pi\alpha^2\right)} = 3477.2 \quad (3477.3)$$

$$\frac{m_N}{m_e} = \frac{12\pi^2}{1-\alpha} \sqrt{\frac{\sqrt{3}}{\alpha}} \frac{\left(1 + 2\pi \frac{\alpha^2}{2}\right)}{\left(1 - 2\pi \frac{\alpha^2}{2}\right)} = 1838.67 \quad (1838.68)$$

Relations Between Fundamental Particles

cont'd

The relations between the masses of members of the neutron family which are independent of the definition of the imaginary time ruler ti are given in terms of the dimensionless fine structure constant α only:

$$\frac{m_{ssc}}{m_{ddu}} = \frac{m_{ssc}}{m_N} = \frac{1}{2\pi} \left(\frac{1-\alpha}{3\alpha^2} \right)^{\frac{1}{3}} = 2.926$$

$$\frac{m_{bbt}}{m_{ssc}} = \left(\frac{2\pi^2}{\alpha^2} \right)^{\frac{1}{3}} = 71.8$$

$$\frac{m_{bbt}}{m_{ddu}} = \frac{m_{bbt}}{m_N} = \left(\frac{1-\alpha}{12\pi\alpha^4} \right)^{\frac{1}{3}} = 210$$

Gravitational Potential Energy

A Fourth Family?

The gravitational radius, α_G or r_G , of an orbitsphere of mass m_0 is defined as

$$\alpha_G = r_G = \frac{Gm_0}{c^2}$$

When the $r_G = r_\alpha^* = \hat{\lambda}_c$, the gravitational potential energy equals m_0c^2

$$\frac{Gm_0}{c^2} = \hat{\lambda}_c = \frac{\hbar}{m_0c}$$

$$\frac{Gm_0^2}{\hat{\lambda}_c} = \frac{Gm_0^2}{r_\alpha^*} = \hbar\omega^* = m_0c^2$$

Gravitational Potential Energy cont'd

The mass m_0 is the Planck mass, m_U ,

$$m_U c^2 = \hbar \omega^* = V = E_{mag} = \frac{G m_U^2}{\lambda_C^*}$$

$$m_U = m_0 = \sqrt{\frac{\hbar c}{G}}$$

The corresponding gravitational velocity, v_G , is defined as

$$v_G = \sqrt{\frac{G m_0}{\lambda_C}} = \sqrt{\frac{G m_u}{\lambda_C}}$$

Relationship of the Equivalent Planck Mass Particle Production Energies

(Mass energy = Planck equation energy = electric potential energy = magnetic Energy = gravitational potential energy = mass/spacetime metric energy)

$$m_0 c^2 = \hbar \omega^* = V = E_{mag} = E_{grav} = E_{spacetime}$$

$$m_0 c^2 = \hbar \omega^* = \frac{\hbar^2}{m_0 \hat{\lambda}_C^2} = \alpha^{-1} \frac{e^2}{4\pi \epsilon_0 \hat{\lambda}_C} = \alpha^{-1} \frac{\pi \mu_0 e^2 \hbar^2}{(2\pi m_0)^2 \hat{\lambda}_C^3} = \alpha^{-1} \frac{\mu_0 e^2 c^2}{2h} \sqrt{\frac{G m_\theta}{\hat{\lambda}_C}} \sqrt{\frac{\hbar c}{G}} = \frac{ch}{1 \text{sec}} \sqrt{\frac{\hat{\lambda}_C c^2}{2Gm}}$$

Equivalent energies give the particle masses in terms of the gravitational velocity, v_G , and the Planck mass, m_U

$$m_0 = \alpha^{-1} \frac{\mu_0 e^2 c}{2h} \frac{\sqrt{\frac{G m_\theta}{\hat{\lambda}_C}}}{c} m_u = \alpha^{-1} \frac{\mu_0 e^2 c}{2h} \sqrt{\frac{G m_\theta}{c^2 \hat{\lambda}_C}} m_u = \alpha^{-1} \frac{\mu_0 e^2 c}{2h} \frac{v_G}{c} m_u = \frac{v_G}{c} m_u$$

Planck Mass Particles

- A pair of particles each of the **Planck mass** corresponding to the **gravitational potential energy** is not observed since the velocity of each transition state orbitsphere is the **gravitational velocity** v_G that in this case is **the speed of light**; **whereas, the Newtonian gravitational escape velocity** v_g is $\sqrt{2}$ **the speed of light**.
- In this case, an electromagnetic wave of mass energy equivalent to the Planck mass travels in a **circular orbit** about the center of mass of another electromagnetic wave of mass energy equivalent to the Planck mass wherein the **eccentricity is equal to zero** and the **escape velocity can never be reached**.

Planck Mass Particles cont'd

- The Planck mass is a "**measuring stick.**" The extraordinarily high Planck mass ($\sqrt{\frac{\hbar c}{G}} = 2.18 \times 10^{-8} \text{ kg}$) is the unobtainable mass bound imposed by the angular momentum and speed of the photon relative to the gravitational constant.
- It is analogous to the unattainable bound of the speed of light for a particle possessing finite rest mass imposed by the Minkowski tensor.

Astrophysical Implications of Planck Mass Particles

- The limiting speed of light **eliminates the singularity** problem of Einstein's equation that arises as the radius of a black hole equals the Schwarzschild radius.
- When the **gravitational potential energy density** of a massive body such as a **blackhole** equals that of a particle having the Planck mass, the **matter may transition to photons of the Planck mass/energy**.
- Even light from a black hole will escape when the decay rate of the trapped matter with the concomitant spacetime expansion is greater than the effects of gravity which oppose this expansion.

Astrophysical Implications of Planck Mass Particles cont'd

- Gamma-ray bursts are the most energetic phenomenon known that can release an explosion of gamma-rays packing 100 times more energy than a Supernova explosion.
- The annihilation of a black hole may be the source of γ -ray bursts.
- The source may be due to **conversion of matter to photons of the Planck mass/energy, which may also give rise to cosmic rays.**
- According to the GZK cutoff, the cosmic spectrum cannot extend beyond $5 \times 10^{19} \text{ eV}$, but AGASA, the world's largest air shower array, has shown that the spectrum is extending beyond 10^{20} eV without any clear sign of cutoff. **Photons each of the Planck mass may be the source of these inexplicably energetic cosmic rays.**

The Schwarzschild Metric Gives the Relationship Whereby Matter Causes Relativistic Corrections to Spacetime

- The limiting velocity c results in the **contraction of spacetime due to particle production**. The contraction is given by $2\pi r_g$ where r_g is the gravitational radius of the particle. This has implications for the expansion of spacetime when matter converts to energy
- Q **The mass/energy to expansion/contraction quotient** of spacetime is given by the ratio of the mass of a particle at production divided by T the period of production.

$$Q = \frac{m_0}{T} = \frac{m_0}{\frac{2\pi r_g}{c}} = \frac{m_0}{\frac{2\pi \frac{2Gm_0}{c^2}}{c}} = \frac{c^3}{4\pi G} = 3.22 \times 10^{34} \frac{\text{kg}}{\text{sec}}$$

- The gravitational equations with the equivalence of the particle production energies permit the **conservation of mass/energy** ($E = mc^2$) and **spacetime** ($\frac{c^3}{4\pi G} = 3.22 \times 10^{34} \frac{\text{kg}}{\text{sec}}$).

Cosmological Consequences

The *Universe is closed* (it is *finite but with no boundary*).

The **Universe is a 3-sphere Universe-Riemannian** three dimensional hyperspace plus time of constant positive curvature at each r-sphere.

- *The Universe is oscillatory in matter/energy and spacetime* with a finite minimum radius, the gravitational radius.



Expanding
Spacetime



Expansion and
Contraction

Spacetime expands as mass is released as energy which provides the basis of the **atomic, thermodynamic, and cosmological arrows of time.**

Different regions of space are **isothermal** even though they are separated by greater distances than that over which light could travel during the time of the expansion of the Universe.

Cosmological Consequences cont'd

- Presently, stars and celestial bodies exist which are older than the elapsed time of the present expansion as stellar and large scale evolution also occurred during the contraction phase.
- Observations beyond the beginning of the expansion phase are not possible since the Universe is entirely matter filled.
- The maximum power radiated by the Universe which occurs at the beginning of the expansion phase is

$$P_U = \frac{c^5}{4\pi G} = 2.89 \times 10^{51} \text{ W}$$

$$P_U = \frac{c^5}{4\pi G} = 2.89 \times 10^{51} \text{ W}$$

Photo Courtesy of NASA, ESA, S. Beck with STCcl and the HUDF Team

The Period of Oscillation Based on Closed Propagation of Light

- Conservation of mass/energy during harmonic expansion and contraction

- The gravitational potential energy E_{grav}

$$E_{grav} = \frac{Gm_U^2}{r}$$

is equal to $m_U c^2$ when the radius of the Universe r is the gravitational radius r_G .

- The gravitational velocity v_G is the speed of light in a circular orbit wherein the eccentricity is equal to zero and the escape velocity from the Universe can never be reached.
- The period of the oscillation of the Universe and the period for light to transverse the Universe corresponding to the gravitational radius r_G must be equal.

The Period of Oscillation Based on Closed Propagation of Light cont'd

- The harmonic oscillation period, T , is

$$T = \frac{2\pi r_G}{c} = \frac{2\pi G m_U}{c^3} = \frac{2\pi G (2 \times 10^{54} \text{ kg})}{c^3} = 3.10 \times 10^{19} \text{ sec} = 9.83 \times 10^{11} \text{ years}$$

where the mass of the Universe, m_U , is approximately $2 \times 10^{54} \text{ kg}$ (The initial mass of the Universe of $2 \times 10^{54} \text{ kg}$ is based on internal consistency with the size, age, Hubble constant, temperature, density of matter, and power spectrum of the Universe.)

- Thus, the observed **Universe will expand as mass is released as photons for $4.92 \times 10^{11} \text{ years}$. At this point in its world line, the Universe will obtain its maximum size and begin to contract.**

The Differential Equation of the Radius of the Universe

- Simple harmonic oscillator having a restoring force, F , which is proportional to the radius.
- The proportionality constant, k , is given in terms of the potential energy, E , gained as the radius decreases from the maximum expansion to the minimum contraction.

$$\frac{E}{\mathfrak{R}^2} = k$$

- The gravitational potential energy E_{grav}

$$E_{grav} = \frac{Gm_U^2}{r}$$

- Is equal to $m_U c^2$ when the radius of the Universe r is the gravitational radius r_G .

$$F = -k \mathfrak{R} = -\frac{m_U c^2}{r_G^2} \mathfrak{R} = -\frac{m_U c^2}{\left(\frac{Gm_U}{c^2}\right)^2} \mathfrak{R}$$

The Differential Equation of the Radius of the Universe \mathfrak{R} , Is

$$m_U \ddot{\mathfrak{R}} + \frac{m_U c^2}{r_G^2} \mathfrak{R} = 0$$

$$m_U \ddot{\mathfrak{R}} + \frac{m_U c^2}{\left(\frac{Gm_U}{c^2}\right)^2} \mathfrak{R} = 0$$

The *Maximum Radius of the Universe*

The *Maximum Radius of the Universe*, the amplitude, r_0 , of the time harmonic variation in the radius of the Universe, is given by the quotient of the total mass of the Universe m_U and the mass/energy to expansion/contraction quotient Q .

$$r_0 = \frac{m_U}{Q} = \frac{m_U}{\frac{c^3}{4\pi G}}$$

$$r_0 = \frac{2 \times 10^{54} \text{ kg}}{\frac{c^3}{4\pi G}} = 1.97 \times 10^{12} \text{ light years}$$

The *Minimum Radius*

The *Minimum Radius* corresponds to the gravitational radius

$$r_g = \frac{2Gm_U}{c^2}$$
$$r_g = \frac{2G(2 \times 10^{54} \text{ kg})}{c^2} = 3.12 \times 10^{11} \text{ light years}$$

When the gravitational radius r_g is the radius of the Universe, the proper time is equal to the coordinate time by

$$\tau = ti \sqrt{\frac{2GM}{c^2 r_\alpha^*}} = ti \sqrt{\frac{2GM}{c^2 \tilde{\lambda}_c}} = ti \frac{v_g}{c}$$

And the gravitational escape velocity v_g of the Universe is the speed of light.

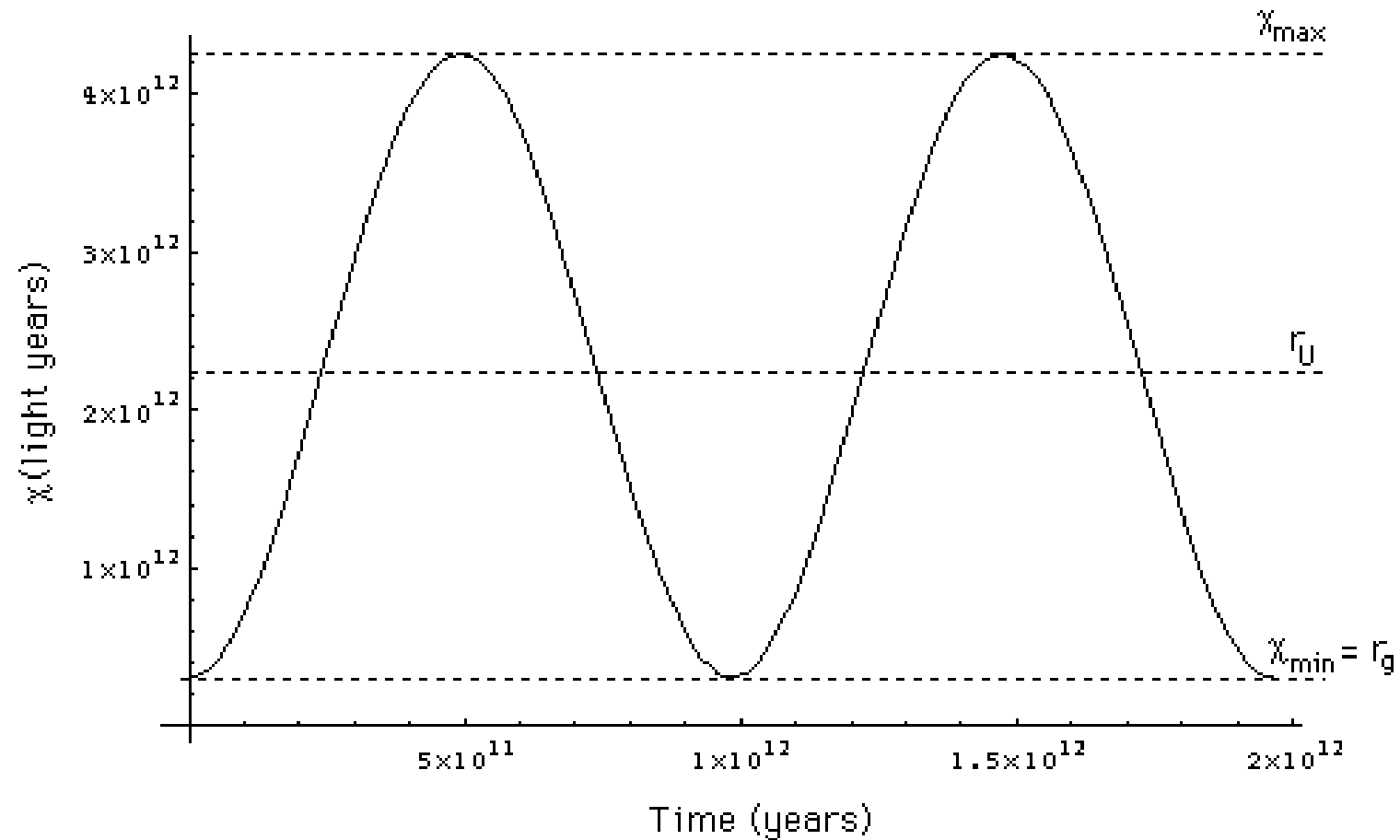
The Radius of the Universe As a Function of Time

$$\mathfrak{R} = \left(r_g + \frac{cm_U}{Q} \right) - \frac{cm_U}{Q} \cos \left(\frac{2\pi t}{\frac{2\pi r_G}{c}} \right)$$

$$\mathfrak{R} = \left(\frac{2Gm_U}{c^2} + \frac{cm_U}{\frac{4\pi G}{c^3}} \right) - \frac{cm_U}{\frac{4\pi G}{c^3}} \cos \left(\frac{2\pi t}{\frac{2\pi Gm_U}{c^3}} \right)$$

$$\mathfrak{R} = 2.28 \times 10^{12} - 1.97 \times 10^{12} \cos \left(\frac{2\pi t}{9.83 \times 10^{11} \text{ yrs}} \right) \text{ light years}$$

The Radius of the Universe as a Function of Time

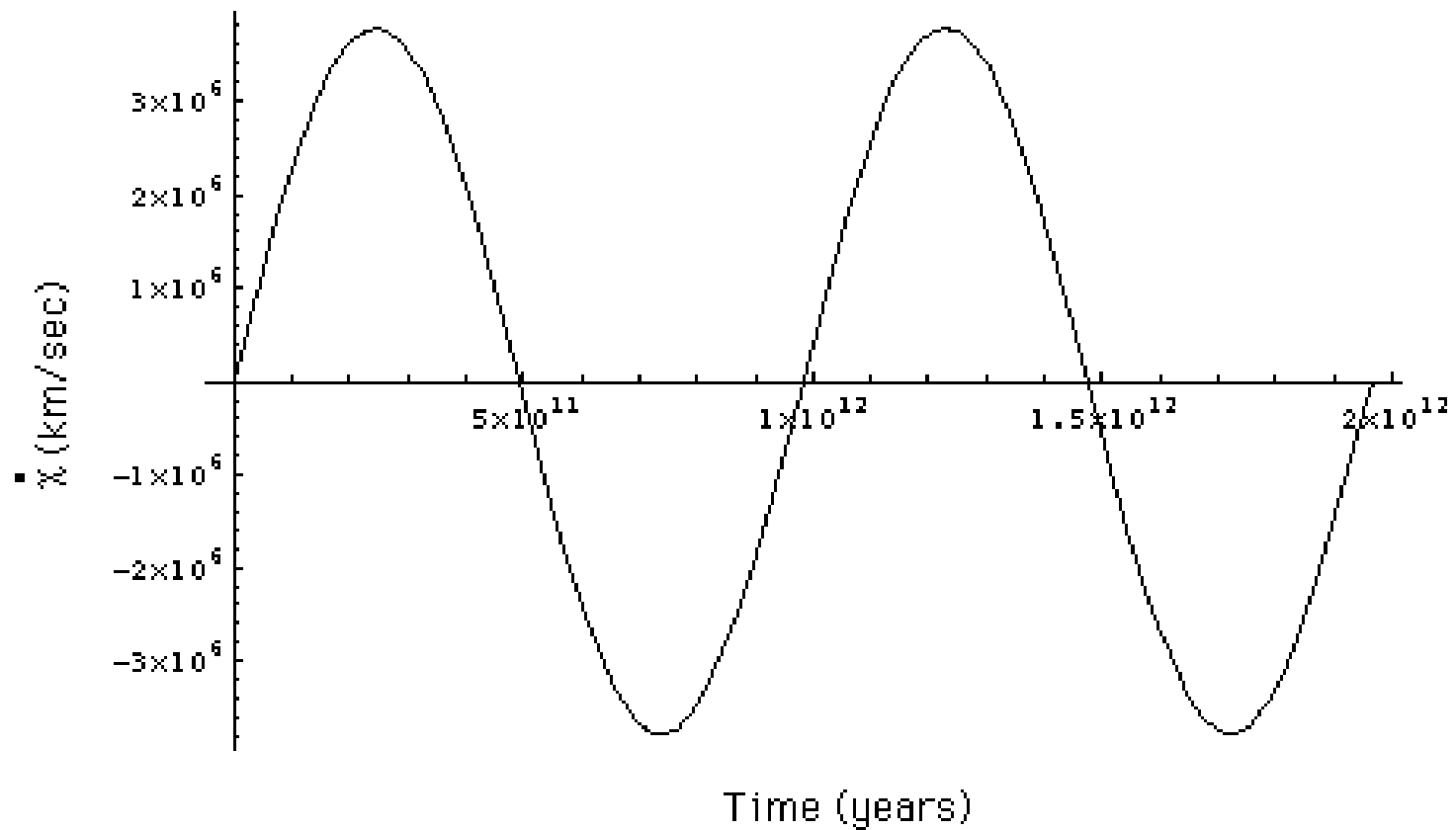


The Expansion/Contraction Rate, $\dot{\mathfrak{N}}$

$$\dot{\mathfrak{N}} = 4\pi c X 10^{-3} \sin\left(\frac{2\pi t}{\frac{2\pi G m_U}{c^3}}\right) \frac{km}{sec}$$

$$\dot{\mathfrak{N}} = 3.77 X 10^6 \sin\left(\frac{2\pi t}{9.83 X 10^{11} yrs}\right) \frac{km}{sec}$$

The Expansion/Contraction Rate of the Universe As a Function of Time



The Hubble Constant

The *Hubble Constant* is given by the ratio of the expansion rate given in units of $\frac{\text{km}}{\text{sec}}$ divided by the radius of the expansion in Mpc . The radius of expansion is equivalent to the radius of the light sphere with an origin at the time point when the Universe stopped contracting and started to expand. The radius is the time of expansion $ct(Mpc)$.

$$H = \frac{\dot{\mathfrak{N}}}{ct} = \frac{4\pi c \times 10^{-3} \sin\left(\frac{2\pi t}{\frac{2\pi Gm_U}{c^3}}\right) \frac{\text{km}}{\text{sec}}}{ct (Mpc)}$$

$$H = \frac{\dot{\mathfrak{N}}}{ct} = \frac{3.77 \times 10^6 \sin\left(\frac{2\pi t}{9.83 \times 10^{11} \text{ yrs}}\right) \frac{\text{km}}{\text{sec}}}{ct (Mpc)}$$

The Hubble Constant cont'd

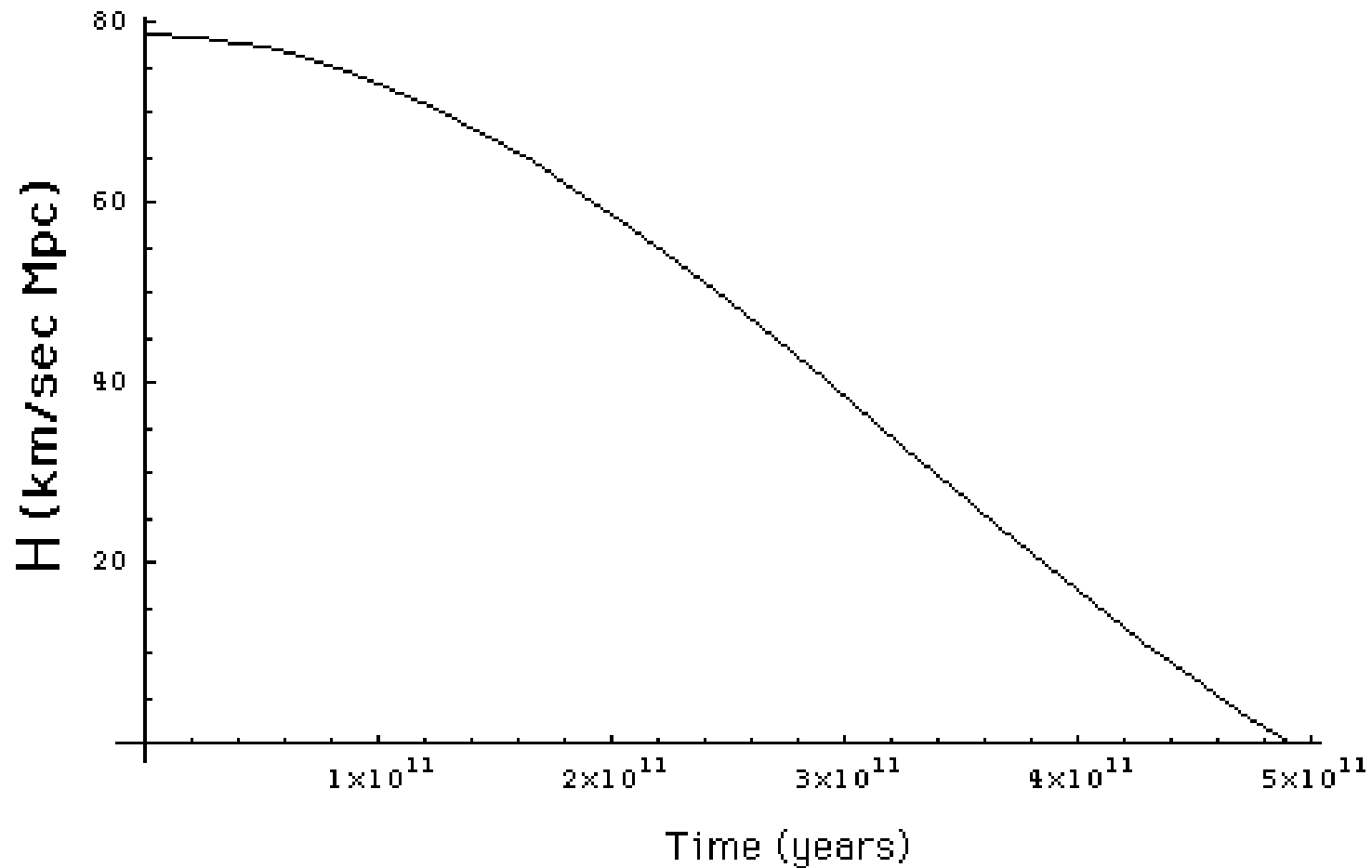
For $t = 10^{10}$ light years; $ct = 3.069 \times 10^3$ Mpc, the Hubble, H_0 , constant is

$$H_0 = 78.6 \frac{\text{km}}{\text{sec} \cdot \text{Mpc}}.$$

The experimental value is

$$H_0 = 80 \pm 17 \frac{\text{km}}{\text{sec} \cdot \text{Mpc}}.$$

The Hubble Constant of the Universe As a Function of Time



The Density of the Universe As a Function of Time

- The density of the Universe as a function of time $\rho_U(t)$ is given by the ratio of the mass as a function of time and the volume as a function of time.

$$\rho_U(t) = \frac{m_U(t)}{V(t)} = \frac{m_U(t)}{\frac{4}{3}\pi R(t)^3} = \frac{\frac{m_U}{2} \left(1 + \cos \left(\frac{2\pi t}{\frac{2\pi G m_U}{c^3}} \right) \right)}{\frac{4}{3}\pi \left(\left(\frac{2Gm_U}{c^2} + \frac{cm_U}{4\pi G} \right) - \frac{cm_U}{4\pi G} \cos \left(\frac{2\pi t}{\frac{2\pi G m_U}{c^3}} \right) \right)^3}$$

$$\rho_U(t) = \frac{1 \times 10^{57} \left(1 + \cos \left(\frac{2\pi t}{9.83 \times 10^{11} \text{ yrs}} \right) \right) \text{ g}}{\frac{4}{3}\pi \left(2.16 \times 10^{30} - 1.86 \times 10^{30} \cos \left(\frac{2\pi t}{9.83 \times 10^{11} \text{ yrs}} \right) \text{ cm} \right)^3}$$

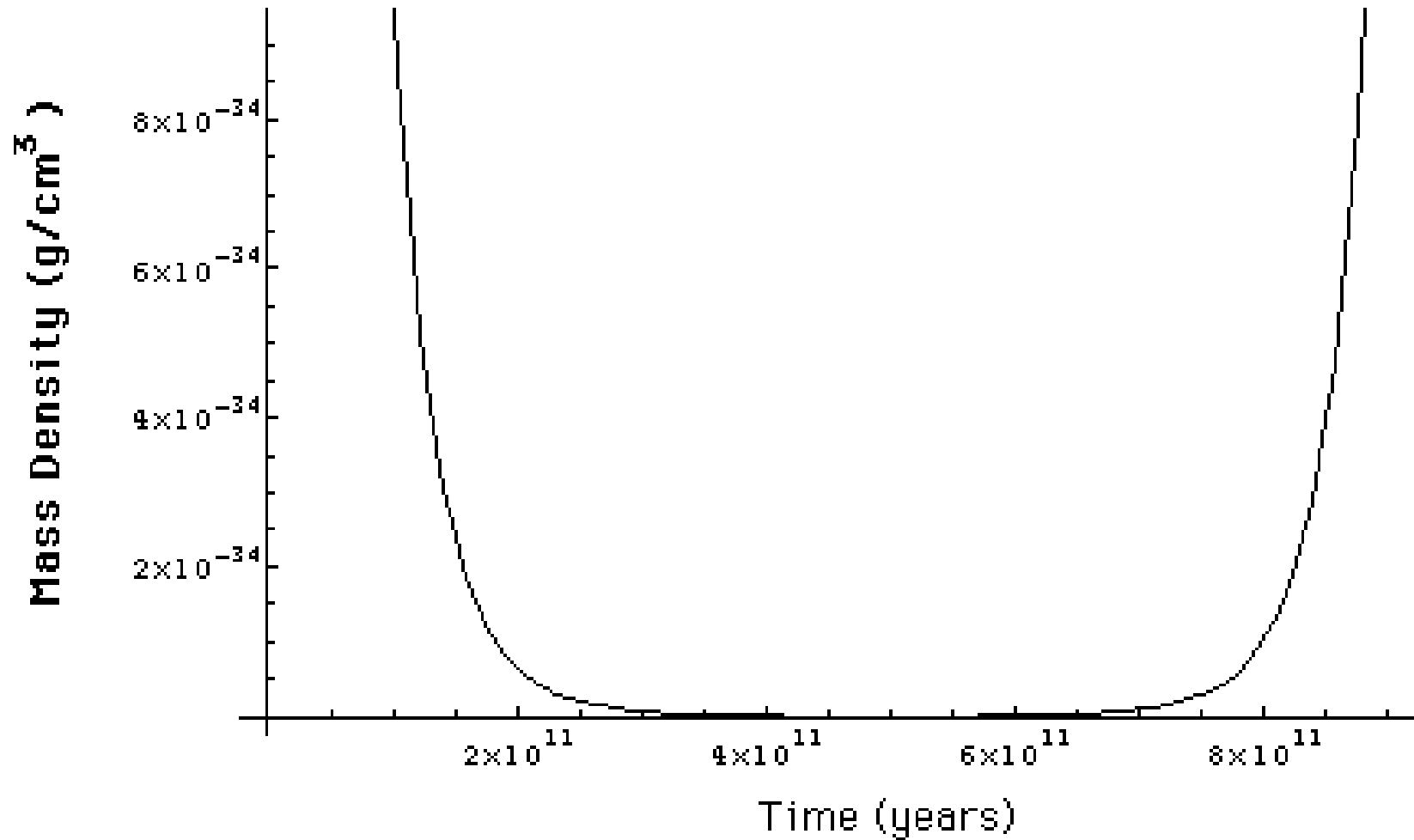
- For $t = 10^{10}$ light years = 3.069×10^3 Mpc

$$\rho_U = 1.7 \times 10^{-32} \text{ g/cm}^3$$

- The density of luminous matter of stars and gas of galaxies is about

$$\rho_U = 2 \times 10^{-31} \text{ g/cm}^3$$

The Density of the Universe As a Function of Time



The Power of the Universe As a Function of Time, $P_U(t)$

$$P_U(t) = \frac{c^5}{8\pi G} \left(1 + \cos \left(\frac{2\pi t}{\frac{2\pi r_G}{c}} \right) \right)$$

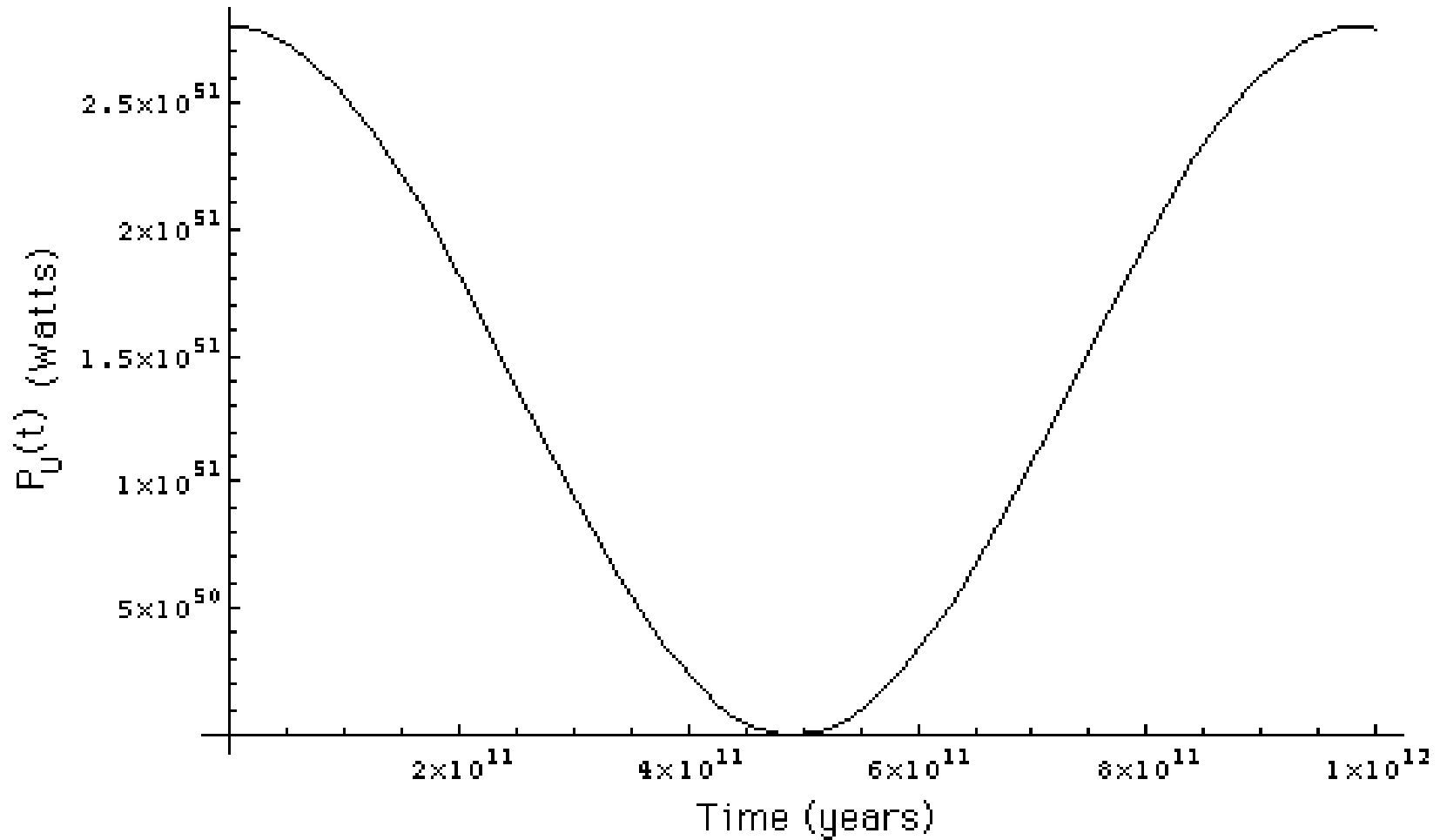
$$P_U(t) = 1.45 \times 10^{51} \left(1 + \cos \left(\frac{2\pi t}{9.83 \times 10^{11} \text{ yrs}} \right) \right) W$$

For $t = 10^{10}$ light years

$$P_U(t) = 2.88 \times 10^{51} W$$

The observed power is consistent with that predicted.

The Power of the Universe As a Function of Time



The Temperature of the Universe as a Function of Time Follows from the Stefan-Boltzman Law

$$T_U(t) = \left(\frac{1}{1 + \frac{Gm_U(t)}{c^2 \mathfrak{N}(t)}} \right) \left[\frac{R_U(t)}{e\sigma} \right]^{\frac{1}{4}} = \left(\frac{1}{1 + \frac{Gm_U(t)}{c^2 \mathfrak{N}(t)}} \right) \left[\frac{P_U(t)}{4\pi \mathfrak{N}(t)^2 e\sigma} \right]^{\frac{1}{4}}$$

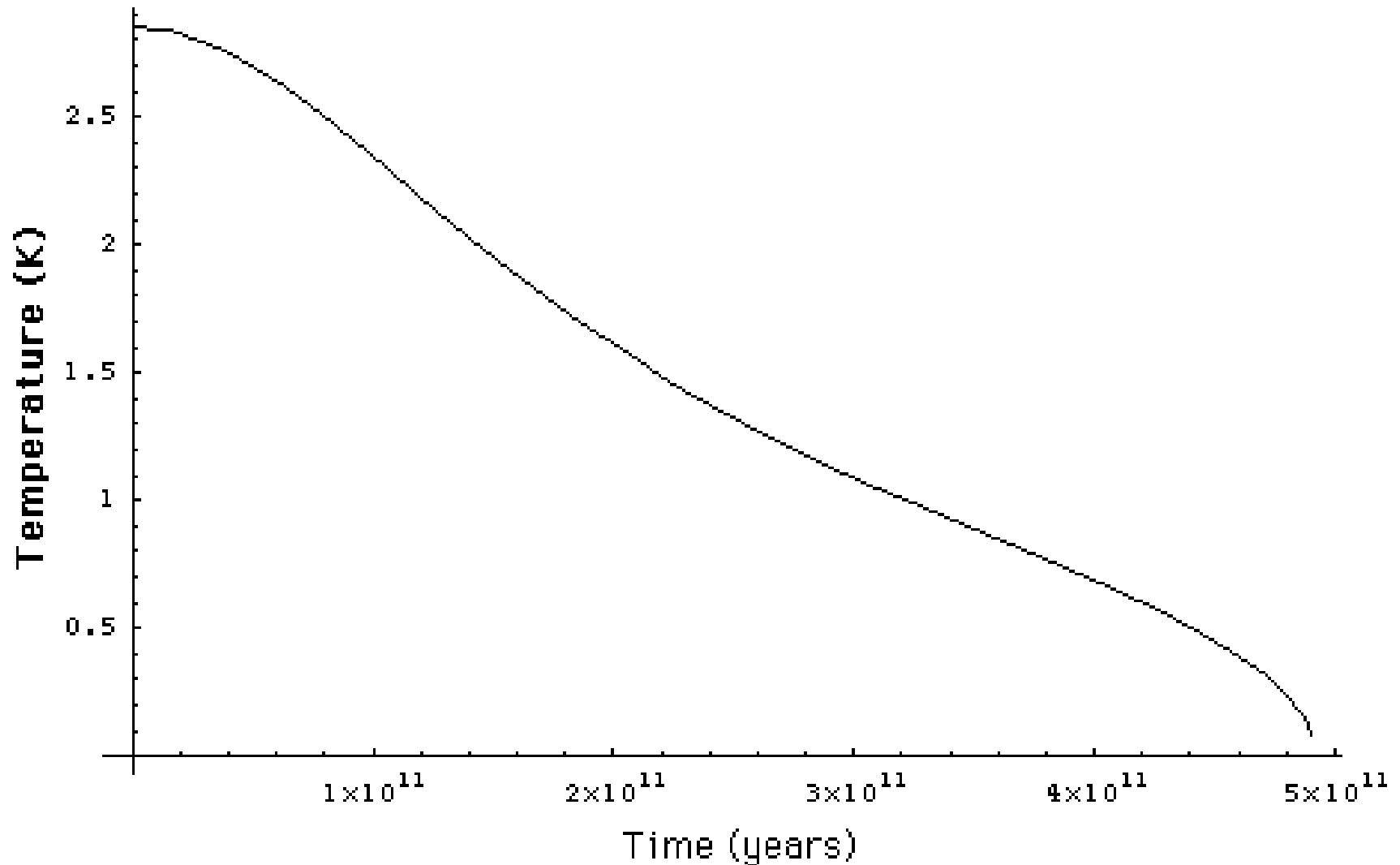
$$T_U(t) = \left[\frac{1}{1 + \frac{\frac{Gm_U}{2} \left(1 + \cos \left(\frac{2\pi t}{\frac{2\pi Gm_U}{c^3}} \right) \right)}{c^2 \left(\frac{2Gm_U}{c^2} + \frac{cm_U}{4\pi G} \right) - \frac{cm_U}{4\pi G} \cos \left(\frac{2\pi t}{\frac{2\pi Gm_U}{c^3}} \right)} + \frac{\frac{c^5}{8\pi G} \left(1 + \cos \left(\frac{2\pi t}{\frac{2\pi r_G}{c}} \right) \right)}{4\pi \left(\left(\frac{2Gm_U}{c^2} + \frac{cm_U}{4\pi G} \right) - \frac{cm_U}{4\pi G} \cos \left(\frac{2\pi t}{\frac{2\pi Gm_U}{c^3}} \right) \right)^2} \right]^{\frac{1}{4}} \frac{1}{e\sigma}$$

**The
Temperature
of the
Universe As
a Function of
Time –
cont'd**

$$T_U(t) = \left[\frac{1}{1 + \frac{0.74 \times 10^{27} \left(1 + \cos \left(\frac{2\pi t}{9.83 \times 10^{11} \text{ yrs}} \right) \right) m}{\left[2.16 \times 10^{28} - 1.86 \times 10^{28} \cos \left(\frac{2\pi t}{9.83 \times 10^{11} \text{ yrs}} \right) m \right]}} \right] X$$

$$\left[\frac{1.45 \times 10^{51} \left(1 + \cos \left(\frac{2\pi t}{9.83 \times 10^{11} \text{ yrs}} \right) \right) W}{4\pi \left[2.16 \times 10^{28} - 1.86 \times 10^{28} \cos \left(\frac{2\pi t}{9.83 \times 10^{11} \text{ yrs}} \right) m \right]^2} \right]^{\frac{1}{4}} \frac{1}{5.67 \times 10^{-8} W m^{-2} K^{-4}}$$

The Temperature of the Universe As a Function of Time During the Expansion Phase



Power Spectrum of the Cosmic Microwave Background measured with the Degree Angular Scale Interferometer (DASI)

The cosmic microwave background radiation is an average temperature of 2.7 ° K, with deviations of 30 or so μK in different parts of the sky representing slight variations in the density of matter.

The spherical harmonic parameter ℓ is given by the ratio of the amplitude, r_0 , of the time harmonic variation in the radius of the universe, divided by the present radius of the light sphere where the universe is a 3-sphere universe-Riemannian three dimensional hyperspace plus time of constant positive curvature at each r-sphere. For $t = 10^{10}$ light years = $3.069 \times 10^3 \text{ Mpc}$, the fundamental ℓ is given by

$$\ell = \frac{r_0}{t} = \frac{\frac{2 \times 10^{54} \text{ kg}}{c^3}}{4\pi G t} = \frac{1.97 \times 10^{12} \text{ light years}}{10^{10} \text{ light years}} = 197$$

Power Spectrum of the Cosmic Microwave Background cont'd

The peaks are predicted to occur at the fundamental plus harmonics of the fundamental—integer multiples, $n = 2,3,4,5$, and 6, of the fundamental $\ell = 197$.

$$\ell = 197 \text{ (fundamental)}$$

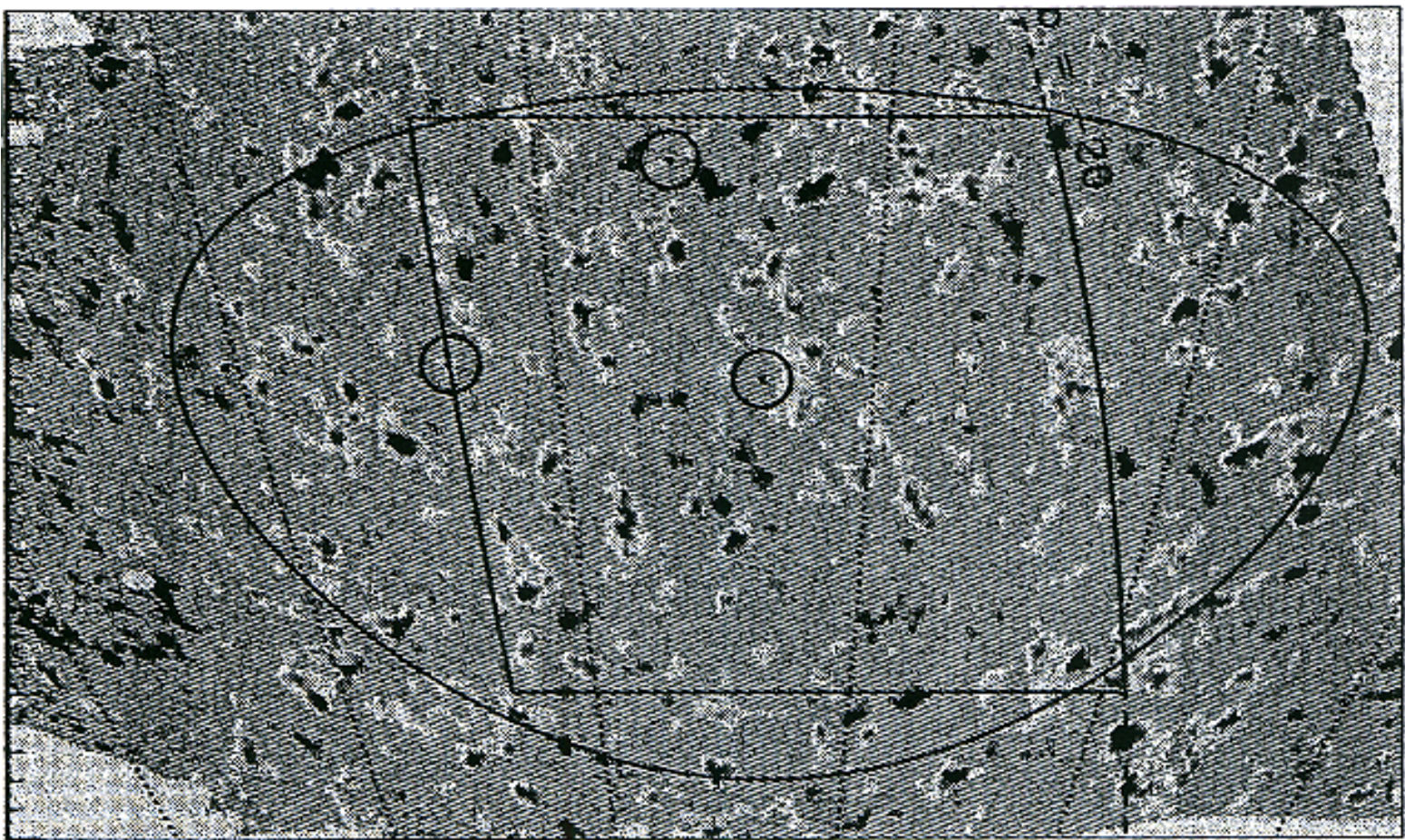
$$\ell = 197 + n197 \quad n = 2,3,4,5, \text{ and } 6 \text{ (harmonics)}$$

The relative intensities

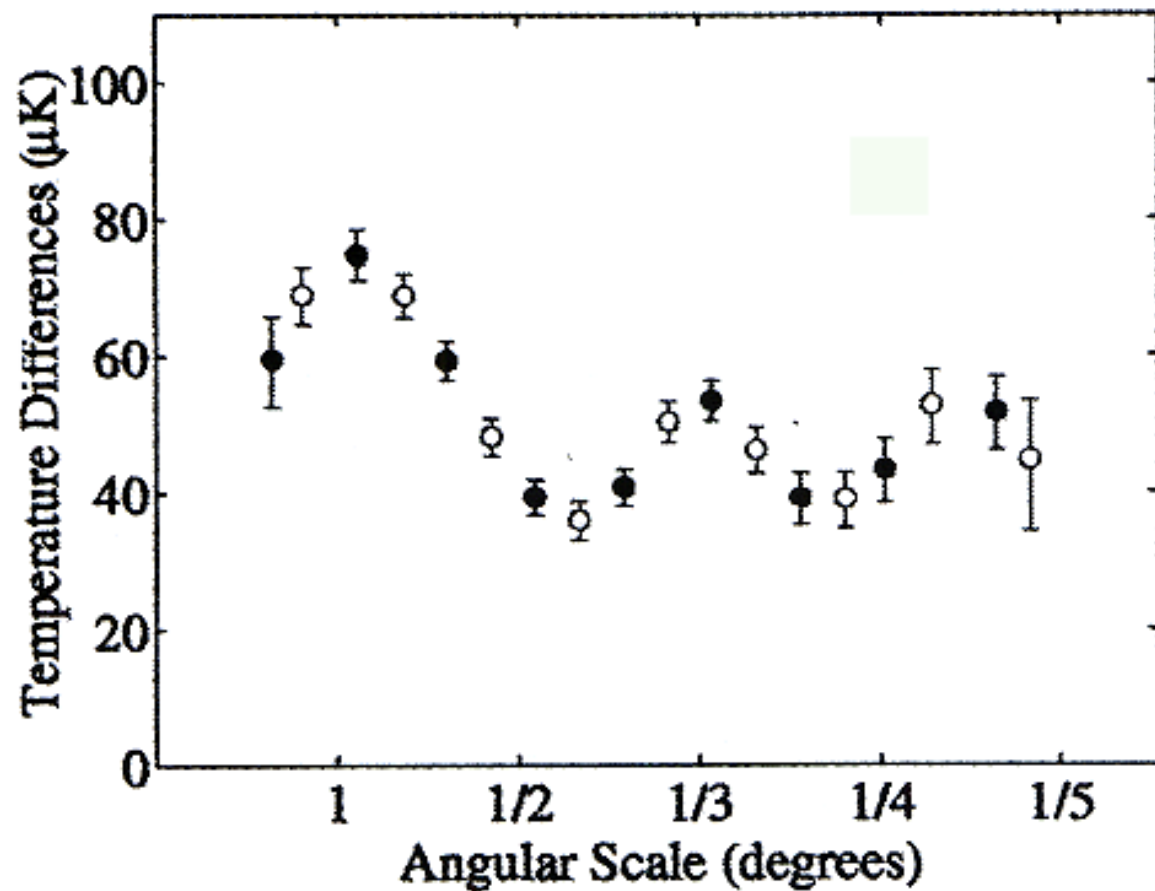
$$I(n) = \cos \left(\frac{2\pi \left(1.564 \times 10^{11} \cos^{-1} \left(\frac{1}{n} \right) \text{ yrs} \right)}{9.83 \times 10^{11} \text{ yrs}} \right) = \frac{1}{n}$$

are given by the normalized power at times when the radius is

$$r_0(n) = \frac{r_0}{n} = \frac{\frac{2 \times 10^{54} \text{ kg}}{c^3}}{4\pi G} = \frac{1.97 \times 10^{12} \text{ light years}}{n}$$



Hot (red) and cold (blue) spots in the microwave background detected by BOOMERANG.



The first two peaks—and a hint of a third—in the temperature of the cosmic microwave background as seen by the DASI experiment.

The angular power spectrum was measured in the range $100 < \ell < 900$, and peaks in the power spectrum from the temperature fluctuations of the cosmic microwave background radiation were observed.

Experimental and Calculated Harmonic Parameters ℓ and relative intensities $I(n)$ as a function of peak n

n	ℓ		Angle ($^{\circ}$)		$I(n)$	
	Exp.	Cal.	Exp.	Cal.	Exp.	Cal.
1	200	197	0.9	0.91	1	1
2	550	591	0.32	0.30	0.5	0.50
3	800	788	0.23	0.23	0.3	0.33
4		985		0.18		0.25
5		1182		0.15		0.20
6		1379		0.13		0.17

The Expansion/ Contraction Acceleration, $\ddot{\mathcal{R}}$

$$\ddot{\mathcal{R}} = 2\pi \frac{c^4}{Gm_U} \cos\left(\frac{2\pi t}{\frac{2\pi Gm_U}{c^3} \text{ sec}}\right)$$

$$\ddot{\mathcal{R}} = H_o = 78.7 \cos\left(\frac{2\pi t}{3.01 \times 10^5 \text{ Mpc}}\right) \frac{\text{km}}{\text{sec} \cdot \text{Mpc}}$$

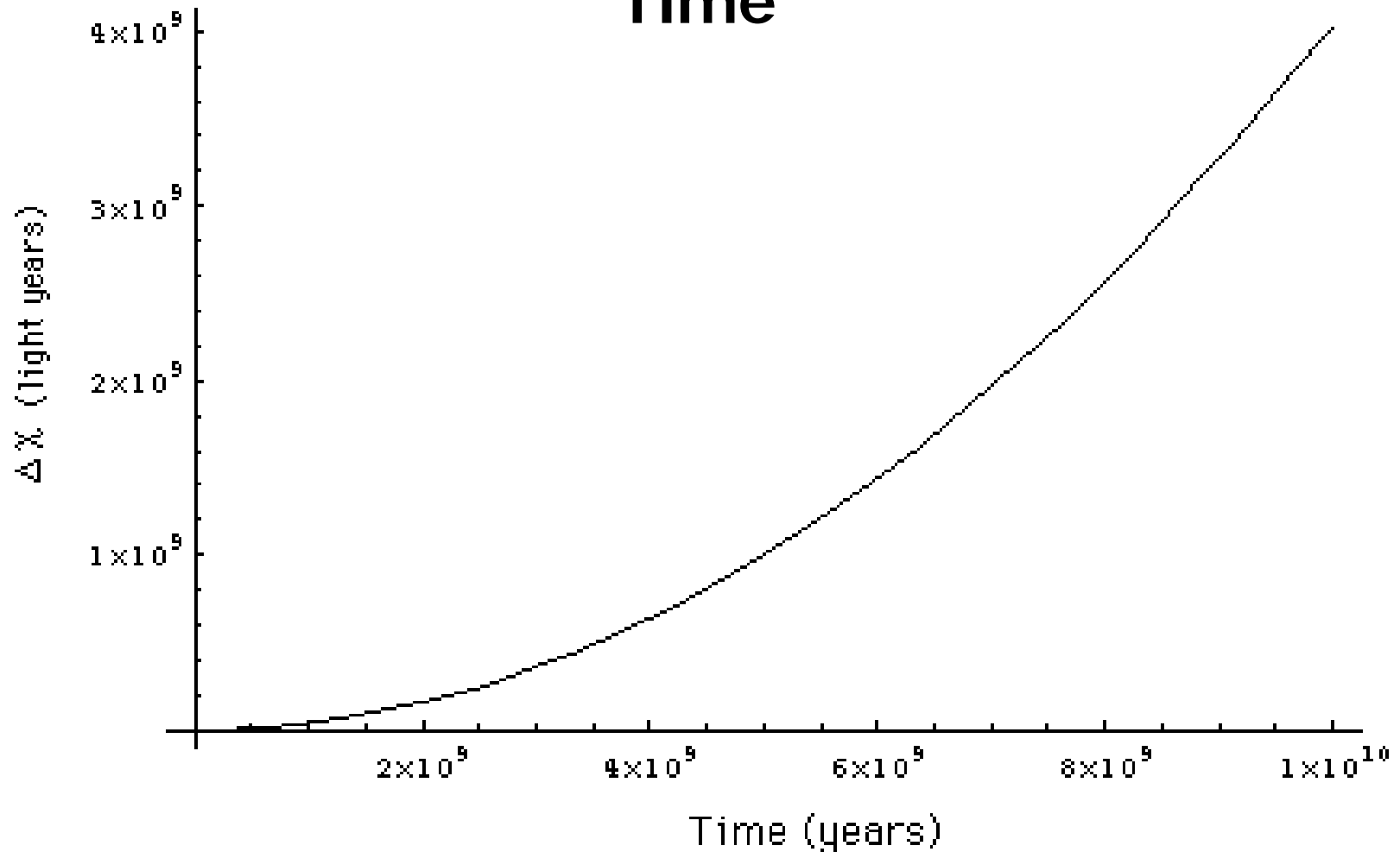
- The differential in the radius of the Universe $\Delta \mathcal{R}$ due to its acceleration is given by

$$\Delta \mathcal{R} = 1/2 \ddot{\mathcal{R}} t^2$$

- The differential in expanded radius for the elapsed time of expansion, $t = 10^{10} \text{ light years} = 3.069 \times 10^3 \text{ Mpc}$ corresponds to a decrease in brightness of a supernovae standard candle of about an order of magnitude of that expected where the distance is taken as $\Delta \mathcal{R}$. This result based on **the predicted rate of acceleration of the expansion is consistent with the experimental observation**

- The **microwave background radiation image** obtained by the **BOOMERANG telescope** was consistent with a Universe of nearly flat geometry since the commencement of its expansion. **The data is consistent with a large offset radius of the Universe with a fractional increase in size since the commencement of expansion about 10 billion years ago.**

The Differential Expansion of the Light Sphere Due to the Acceleration of the Expansion of the Cosmos As a Function of Time



The Periods of Spacetime Expansion/Contraction and Particle Decay/Production for the Universe Are Equal

- The period of the expansion/contraction cycle of the radius of the Universe, T , is

$$T = \frac{2\pi G m_U}{c^3} \text{ sec}$$

- It follows from the Poynting power theorem with spherical radiation that the transition lifetimes are given by the ratio of energy and the power of the transition.

$$\tau = \frac{\text{energy}}{\text{power}} = \frac{[\hbar\omega]}{\left[\frac{2\pi c}{[(2l+1)!!]^2} \left(\frac{l+1}{l}\right) k^{2l+1} |Q_{lm} + Q'_{lm}|^2 \right]} = \frac{1}{2\pi} \left(\frac{h}{e^2}\right) \sqrt{\frac{\epsilon_0}{\mu_0}} \frac{[(2l+1)!!]^2}{2\pi} \left(\frac{l}{l+1}\right) \left(\frac{l+3}{3}\right)^2 \frac{1}{(kr_n)^{2l} \omega}$$

- Exponential decay applies to electromagnetic energy decay.

$$h(t) = e^{-\alpha t} u(t) = e^{-\frac{2\pi}{T} t} u(t)$$

The Coordinate Time Is Imaginary Because Energy Transitions Are Spacelike Due to Spacetime Expansion From Matter to Energy Conversion

- For example, the mass of the electron (a fundamental particle) is given by

$$\frac{2\pi\hat{\lambda}_c}{\sqrt{\frac{2Gm_e}{\hat{\lambda}_c}}} = \frac{2\pi\hat{\lambda}_c}{v_g} = i\alpha^{-1} \text{ sec}$$

where v_g is Newtonian gravitational velocity.

- When the gravitational radius r_g is the radius of the Universe, the proper time is equal to the coordinate time by

$$\tau = ti \sqrt{\frac{2GM}{c^2 r_\alpha^*}} = ti \sqrt{\frac{2GM}{c^2 \hat{\lambda}_c}} = ti \frac{v_g}{c}$$

and the gravitational escape velocity v_g of the Universe is the speed of light.

- Replacement of the coordinate time, t , by the spacelike time, it , gives

$$h(t) = \text{Re} \left\{ e^{-i2\pi \frac{1}{T} t} \right\} = \cos \frac{2\pi}{T} t$$

where the period is T .

Period Equivalents

The periods of spacetime expansion/contraction and particle decay/production for the Universe are equal because only the particles which satisfy Maxwell's equations and the relationship between proper time and coordinate time imposed by the Schwarzschild metric may exist.

Continuity conditions based on the constant maximum speed of light
(Maxwell's equations)

$$m_0 c^2 = \hbar \omega^* = V = E_{mag} = E_{spacetime}$$

$$m_0 c^2 = \hbar \omega^* = \frac{\hbar^2}{m_0 \lambda_C^2} = \alpha^{-1} \frac{e^2}{4\pi\epsilon_0 \lambda_C} = \alpha^{-1} \frac{\pi\mu_0 e^2 \hbar^2}{(2\pi m_0)^2 \lambda_C^3} = \frac{\alpha h}{1 \text{ sec}} \sqrt{\frac{\lambda_C c^2}{2Gm}}$$

Continuity conditions based on the constant maximum speed of light
(Schwarzschild metric)

$$\frac{\text{proper time}}{\text{coordinate time}} = \frac{\text{gravitational wave condition}}{\text{electromagnetic wave condition}} = \frac{\text{gravitational mass phase matching}}{\text{charge/inertial mass phase matching}}$$

$$\frac{\text{proper time}}{\text{coordinate time}} = i \frac{\sqrt{\frac{2Gm}{c^2 \lambda_C}}}{\alpha} = i \frac{v_g}{\alpha c}$$

Wave Equation

$$\frac{1}{c^2} \left(\frac{\delta \omega}{\delta t} \right)^2 - (\text{grad} \omega)^2 = 0$$

The equation of the radius of the Universe, \mathfrak{R} , may be written as

$$\mathfrak{R} = \left(\frac{2Gm_U}{c^2} + \frac{cm_U}{c^3} \right) - \frac{cm_U}{c^3} \cos \left(\frac{2\pi}{\frac{2\pi Gm_U}{c^3} \text{sec}} \left(t - \frac{\mathfrak{R}}{c} \right) \right) m$$

which is a solution to the wave equation.

Conclusion

Maxwell's equations, Planck's equation, the de Broglie equation, Newton's laws, and Special, and General Relativity are Unified.

*The Grand Unified Theory of
Classical Physics*

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