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The Discovery of Accelerating Expansion of Universe 8.8 Billion Years after the Big Bang Vindicates M1 World One Out of the Six Solutions of Einstein's General Theory of Relativity

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ABSTRACT

This paper gives the mathematical methodology (Tensor mathematics) of describing the surfaces of our Universe in General Theory of Relativity. It expresses the mass energy equivalence formula. It introduces the concept of time dilation, length contraction and mass increment in high speed frame of reference. Minowski space time 4D manifold is illustrated for representing the flat spacetime fabric Reimannian Metric is enumerated. Schwarzschild metric and how mass is accounted for is given. Warping of spacetime fabric (Geodetic Effect) and Frame-dragging is illustrated. General Relativistic Theory field equations mathematically modelling our Universe and their six solutions are given. Einstein solution is static solution. de-Sitter model is a non-static model with exponentially growing radius of our Universe. The third, fourth, fifth and sixth solution are enumerated. Friedmann predicted three major scenarios: M1 World scenario is Lemaitre scenario, M2 World solution evolves from non-zero radius to infinity , P-world solution shows periodic expansion and contraction. Two scenarios correspond to two degenerate roots: limiting case of P-World and the limiting case of M2 World. These two limiting cases are Eddington-Lemaitre cases. Perlmutter, Schmidt, and Riess jointly received the Nobel Prize in physics in 2011 for proving that Universe corresponds to M1 World which is expanding in decelerating manner for first 8.8 billion years and for the remaining 5 billion years Universe has expanded in accelerating fashion with an inflexion point (Cosmic Jerk) at 8.8 billion years after the Big Bang.

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Introduction

Our Universe in General Theory of Relativity

At the turn of 19th and 20th Century there was a definite irreconcilability between Newtonian Mechanics and Electromagnetism. In Electromagnetism it had been established that the velocity of light is invariant no matter what the Frame of Reference is but Newtonian Mechanics maintained that the velocity of light will depend on the frame of Reference relative to which it is measured [1]. This irreconcilability was resolved by Albert Einstein in 1905 by introducing Special Theory of Relativity [2].

He postulated that any object moves with velocity of light in 4D Space-Time Universe where velocity is expressed as a 4D vector (3Spatial Component+1Temporal Component):

$v=(v_x,v_y,v_z,v_t)$ where (the modulus of velocity)^2= $v_x^2+v_y^2+v_z^2-v_t^2=c^2$ 1.1

This clearly shows that if it was possible for a finite mass body to accelerate to the velocity of light 'c' then the time would come to a standstill and if the body is at stand still then time would pass by at speed of light. From this concept emerged time dilation, length contraction and effective mass Lorentz Transformation [3]:

$$t = \frac{t_0}{\gamma}, L = L_0 \times \gamma \text{ and } m^* = \frac{m_0}{\gamma} \text{ and } \gamma = \sqrt{1-(\frac{v}{c})^2} \qquad 1.2$$

In (1.2), t_0, L_0 and m_0 are time, length and mass in Rest Frame. The effective mass formula tells us that it is impossible to accelerate a finite rest mass to velocity of light because in the process the accelerating body would become near-infinity. The Special Theory of Relativity gave the Energy – Mass Equivalence Formula namely [4]:

$$E^2 = (m_0c^2)^2 + (pc)^2 = (m_0c^2)^2 + (m^*vc)^2 \qquad 1.3$$

(1.3) gives the total energy equivalent of relativistic particle which has effective mass = $m^*= m_0/\gamma$ and which is equal to Rest Energy (i.e. energy associated with a rest mass) plus the Kinetic Energy imparted to the particle. In process of imparting the KE the inertial mass has increased.

Special Theory of Relativity is an appropriate description of Space-Time in the absence of Gravity and hence in the absence of Mass.

Special Theory of Relativity has Metric:$(ds)^2=(c.dt)^2$ 1.4

Irrespective of the position of the observer hence irrespective of the Frame of Reference, velocity of light is 'c'. (1.4) is the metric for measuring the Space-Time interval in Vaccum where there is no Gravity. This is also known as Minowskian Metric. Minkowski space or Minkowski spacetime (named after the mathematician Hermann Minkowski) is the mathematical space setting in which Einstein's theory of special relativity is most conveniently formulated. In this setting the three ordinary dimensions of space are combined with a single dimension of time to form a four-dimensional manifold for representing a space-time [5].

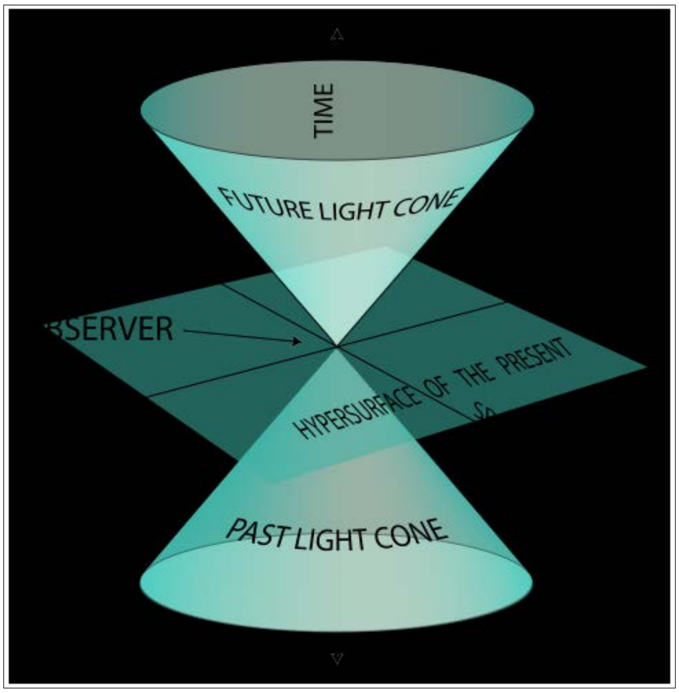


Figure 1: Minkowski Space or Minkowski Spacetime

But in presence of mass the frame of reference changes. Hence to maintain velocity of light invariance we must introduce an external metric.

In 1915 Einstein gave his basic postulate of General Theory of Relativity namely inertial Mass changes the geometry of the Space-Time 4D Fabric. Curvature in the fabric produces the gravitational pull for peripheral bodies as shown in the Figure 2.

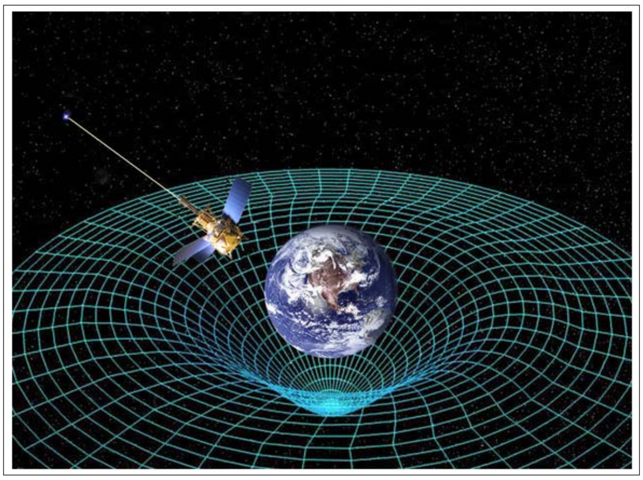


Figure 2: Einstein's Theory of General Relativity Predicted that the Space-Time Around Earth Would be not only Warped (Geodetic Effect) but also Twisted by the Planet's Rotation (Frame Dragging Effect). Gravity Probe B Showed this to be Correct. Credit: NASA

Einstein used Riemannian Metric to combine Differential Geometry (the curvature of 4D Space-Time Fabric) with Physics (Energy Momentum of stable System) into one comprehensive Equation [6]:

$$R_{ab} - \frac{1}{2}R.g_{ab} = (\frac{8\pi G^*}{c^4})T_{ab} \qquad 1.5$$

In (1.5) R_{ab} = Ricci Tensor, R = Ricci Scalar, g_{ab} = Riemannian Metric Tensor and T_{ab} = Energy-Momentum Tensor.

The Left-Hand Side of (1.5) is called Einstein Tensor G_{ab} and G^*= Universal Gravitational Constant.

Einstein using Rectangular Coordinates could arrive at approximate solution only.

Karl Schwarzschild (October 9, 1873-May 11,1916) the very same year using Polar Coordinates arrived at an exact solution [7]:

$$ds^2 = c^2d\tau^2 = -B(r)dt^2 + B(r)^{-1}dr^2 + r^2d\theta^2 + r^2Sin\theta^2dØ^2 \qquad 1.6$$

Where $B(r) = \left(1 - \frac{2m}{r}\right)$ and τ =Proper Time, t=time

coordinate, r=orbital radius,θ = Co-latitude varying from 0 to π, φ=Longitude varying from 0 to 2π;

(1.6) is known as Schwarzschild Metric and accounts for the curvature in Space –Time Fabric due to mass (m).

In Flat Space the elemental volume is given as follows:

$$(dV)_{Spherical} = \sqrt{r^4Sin(\theta)^2}dt.dr.d\theta.dØ = r^2Sin(\theta)dt.dr.d\theta.dØ$$
$$= dt.dr.rd\theta.rSin(\theta)dØ \text{ where } dt \text{ is the elemental time interval} \qquad (1.7)$$

dr is the elemental space interval along r (radius vector),
rθ is the elemental space interval along dθ and
rSin(θ)dø is the elemental space interval along dø

But in curved space applying Schwarzschild Metric (1.6) we get a diagonal matrix:

	t	r	θ	Φ
t	**-B(r)**	**0**	**0**	**0**
r	**0**	**1/B(r)**	**0**	**0**
θ	**0**	**0**	**r^2**	**0**
Φ	**0**	**0**	**0**	**$r^2Sin^2\theta$**

If time is variable then the determinant of the above Matrix is:

$$g = -r^4Sin(\theta)^2 \qquad 1.8$$

The elemental Volume Space is:

$$dV_{Schwarschild} = \sqrt{-(g)}dt.\,dr.\,d\theta.\,d\emptyset \;= \sqrt{-(-r^4 Sin(\theta)^2)}dt.\,dr.\,d\theta.\,d\emptyset \quad 1.9$$

If we are looking at a rest mass then the determinant of the diagonal matrix is changed. TIME dimension is left out. Then we consider only 3 by 3 Matrix with r, θ, Φ Columns and r, θ, Φ Rows. This gives the following determinant:

$$dV_{Schwarzschild} = \sqrt{-\left(-\left(1-\frac{2m}{r}\right)^{-1})r^4 Sin(\theta)^2\right)}.\,dr.\,d\theta.\,d\emptyset$$

This simplifies to:

$$dV_{Schwarzschild} = r^2 Sin(\theta)\left(1-\frac{2m}{r}\right)^{-\frac{1}{2}} dr.\,d\theta.\,d\emptyset \quad 1.10$$

(1.10) takes into account of space curvature. If m is massive then we get curved space otherwise we have the classical Flat Space given by (1.7) and shown in Figure 1.

Let us examine correction factor B(r) introduced in the External Metric (1.6)

$$B(r) = \left(1-\frac{2m}{r}\right) = \left(1-\frac{2Gm}{c^2 \times r}\right) \quad 1.11$$

In (1.11) we have reintroduced G, the Universal Gravitational Constant, and velocity of light 'c'. The total quantity [(2Gm/(c^2) (m/r)] is dimensionless and the original Schwarzschild Metric never included it. These two quantities 'c' and G are taken as Unity in Relativity Mathematics.

We know from Newtonian Mechanics that a body of mass 'm' and radius 'r' has a escape velocity:

$$v_{esc} = \sqrt{\frac{2Gm}{r}} \quad \text{therefore } v_{esc}^2 = \frac{2Gm}{r} \text{ therefore } \frac{v_{esc}^2}{c^2} = \frac{2Gm}{c^2 \times r} \quad 1.12$$

If a body is massive enough or compact enough:
$v_{esc} = c$ under such a condition nothing can escape

The radius at which this no escape condition occurs is defined as $R_{Schwarzschild}$. Hence

$$R_{Schwarzchild} = \frac{2Gm}{c^2} \quad 1.12A$$

Substituting the results of (1.12A) in (1.11) we get the correction factor as

$$B(r) = \left(1-\frac{2Gm}{c^2 \times r}\right) = \left(1-\frac{v_{esc}^2}{c^2}\right) = (1-\frac{R_{Schwarzschild}}{r}) \quad 1.13$$

(1.13) conveys a very important information. If a body of radius 'r' is sufficiently massive of mass 'M' then with addition of further mass as its escape velocity approaches 'c' a singularity occurs at the surface of such a body and the spherical surface is called the EVENT HORIZON. (a hypersurface in spacetime that can only be crossed in one direction). This can also be interoperated as follows:

When a particle reaches the event horizon i.e. r = $R_{Schwarzschild}$, there is a singularity and Spacetime Interval (ds) in (1.6) becomes infinity. This is known as spurious Singularity. There is a Physical Singularity at r = 0.

The Event Horizon radius is known as the Schwarzschild Radius given as follows:

$$R_{Schwarzschild} = \frac{2GM}{c^2}$$

Schwarzchild Radius divides the Space-Time in two unconnected patches:
One patch is r > $R_{Schwarzschild}$ and the other patch is r < $R_{Schwarzschild.}$

This disconnection is only because of a bad choice of coordinates. When changing to a different coordinate system (for example Lemaitre coordinates, Eddington–Finkelstein coordinates, Kruskal – Szekeres coordinates, Novikov coordinates, or Gullstrand–Painlevé coordinates) the metric becomes regular at r = $R_{Schwarzschild}$ and can extend the external patch to values of r smaller than $R_{Schwarzschild}$. Using a different coordinate transformation one can then relate the extended external patch to the inner patch.

For r < RSchwarzschild, the Schwarzschild radial coordinate r becomes time-like and the time coordinate t becomes space-like. A curve at constant r is no longer a possible world-line of a particle or observer, even if a force is exerted to try to keep it there; this occurs because space-time has been curved so much that the direction of cause and effect (the particle's future light cone) points into the singularity. The surface *r* = $R_{Schwarzschild}$ demarcates what is called the event horizon of the black hole. It represents the point past which light can no longer escape the gravitational field. Any physical object whose radius R becomes less than or equal to the Schwarzschild radius will undergo gravitational collapse and become a black hole.

For most practical cases where r >> rs, (rs/r) term can be neglected and (1.6) reduces to:

$$-ds^2 = c^2 d\tau^2 = c^2 dt^2 - dr^2 - r^2 d\theta^2 - r^2 Sin\theta^2 d\emptyset^2 \quad 1.15$$

(1.15) is the description of Flat Space or Euclidean Space. When relativistic corrections are made then we have curved Space-Time metric. It is no more Euclidean.

General Relativist Theory (GRT) Field Equations Describing our Universe

In Section 1 we saw that Space-Time (ST) Fabric is FLAT and Euclidean [8]. Sum of three angles is 180degree

$$-ds^2 = c^2 d\tau^2 = c^2 dt^2 - dr^2 - r^2 d\theta^2 - r^2 Sin\theta^2 d\emptyset^2 \quad 1.15$$

(1.15) Space-Time metric in vacuum without mass and hence without curvature.
But if we introduce mass the ST Fabric becomes curved. It is given by Schwarzschild metric:

$$ds^2 = c^2 d\tau^2 = -B(r)dt^2 + B(r)^{-1}dr^2 + r^2 d\theta^2 + r^2 Sin\theta^2 d\emptyset^2 \quad 1.6$$

Here B(r) takes care of the mass and the curvature introduced by it.

$$Where\ B(r) = \left(1-\frac{2Gm}{c^2 \times r}\right)$$

Einstein Field Equations are originally published as "Einstein, Albert (Nov 25,1915) [8]:

The Field Equations of the Gravitation, Published in Sitzungsberichte der Preussischen Akademia-der-Wissenschaften zu Berlin, 844-847", They are as follows

$$G_{\mu\nu} + \Lambda g_{\mu\nu} = \frac{8\pi G}{c^4} T_{\mu\nu} \qquad 2.1$$

2.1) enumerates fundamental interaction of gravitation as a result of ST-Fabric being curved by Matter and Energy. In explicit form of einstein tensor it is non-linear function of the metric tensor but is linear in the second partial derivatives of the metric. As a symmetric 2nd rank Tensor, Einstein Tensor has 10 independent components in a 4D ST fabric. Therefore, it contains 10 quasilinear 2nd order partial differential equation.

Our Universe is Monotonic M1 Model, one of the Six Solutions of Einstein's General Theory of Relativity, which has a Cosmic Jerk

Friedmann (1922) set the correct framework for General Theory of Relativity (GR), derived the set of correct equations (now known as Friedman Equations), solved them and discussed all three major scenarios for the expanding Universe. Friedman (1924) presented the idea of infinite Universe, static or non-static, with a constant negative curvature, completing what would later be known as Friedmann-Lemaitre-Robertson-Walker (FLWR) metric [9-11].

$$R_{ik} - \frac{1}{2} g_{ik} \overline{R} - \Lambda g_{ik} = -kT_{ik} \qquad 2.2$$

$$R_{ik} - (1/2)\, g_{ik}\dot{R} - \boldsymbol{\Lambda}\, g_{ik} = -kT_{ik}$$

Here i & k run from 1 to 4. 1,2,3 correspond to x, y, z and 4 corresponds to time.

Here g_{ik} = metric tensor. R_{ik}= Ricci tensor representing 2-D curvature

$\overline{R} = scalar\_space-time\_curvature$ 'k' =8πG/c²=1.87×10⁻²⁷cm/g.

T_{ik}= energy-matter tensor→ this represents the inertia of our Universe.

T_{11}, T_{22}, T_{33} = - p where p is the radiation pressure. For non-diagonal terms T_{ik}= 0.

Equation (2.2) Shows the Equivalence between Gravity (LHS) and Inertia (RHS)

Due to non-linearity in 'gik' on LHS of the Equation, Einstein introduced a linear term '(Λ)gik' where Λ is a cosmological constant which Author has referred to as normalized Vacuum Energy Density (ΩΛ) and its value determined by Planck's collaboration is 68.3% and has remained constant for Hubble Time as a cosmological constant should. The original motivation of Einstein for introducing a cosmological constant was to make an expanding Universe static.

First Solution of (2.2) is proposed by Einstein, this is called Solution A, a static model of Universe where R = radius of our Universe is constant in space and time. Einstein Static Universe is 3-D sphere with R= constant and evolving in time as 4-D cylinder.

Einstein arrived at $R=750\times10^{24}$cm = 800Mly, $\rho = 2/(kR^2)$ = matter density $=2\times10^{-27}$g/cm³, Volume of a hypersphere = $V = 2\pi^2R^3$, M (mass) = $V\times\rho = 4\pi^2R/k$ Second Solution of (2.2) was proposed by de Sitter as Solution B, which had no density and hence no mass [12]. This violated Mach's Principle of inertia being associated with mass. Therefore, Solution B was unacceptable. But Solution B predicted red-shift in the observed galaxies. Astronomical Observation of galaxies by Hubble and Humason did show Doppler's red-shift. Therefore, the characteristics of recession was well represented by Solution B. Evidence was mounting for receding galaxies. and hence for Doppler Red-shift and de-Sitter Solution B seemed to explain this recession. Hence Solution B was non-static with exponentially growing R. This will be invoked in INFLATIONARY theory of Big Bang.

Third, Fourth, Fifth and Sixth solution of (2.2). At the time in 1922, Friedman published his paper "On the curvature of Space". Friedman proposed a new class of non-static solution of Equation (2.2) Friedman's dynamical solution of Equation (2.2) is a generalization of Einstein's 3-D hyper-sphere with constant in space but evolving R(t). Equation (2.2) yields two ordinary linear differential Equation for R(t). These are known as Friedman's Equations in Modern Terminology and are given as follows:

$$\frac{2R''}{R} + \frac{R'^2}{R^2} + \frac{c^2}{R^2} - \Lambda = 0 \qquad 2.3$$

$$\frac{3R'^2}{R} + \frac{3c^2}{R^2} - \Lambda = kc^2\rho \qquad 2.4$$

Equation 2.3 is integrated to obtain:

$$\frac{1}{c^2} R'^2 = \frac{A - R + \frac{\Lambda}{3c^2} R^3}{R} \qquad 2.5$$

By correspondence between Equation (2.5) and Equation (2.4) we arrive at

$$\rho(average\_matter\_density) = \frac{3A}{kR^3} \qquad 2.6$$

$$A = \frac{kM}{6\pi^2} = gravitational\_radius\_of\_Universe\_\&\_M = massofUniverse = V \times \rho \qquad 2.7$$

Integrating Equation (2.5) we get:

$$t = \frac{1}{c} \int_{R_0}^{R_1} \sqrt{\frac{R}{A - R + \frac{\Lambda}{3c^2} R^3}}\, dR + t_0 \qquad 2.8$$

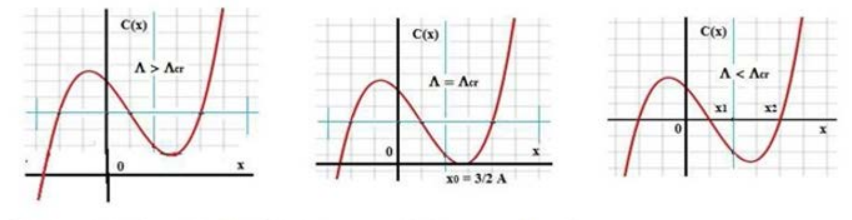
R_0 = radius of our Universe and t_0 = age of our Universe.

RHS of Eq. (2.8) has a physical meaning only if C(R)= [A-R+ (ΛR³)/(3c²)] = Cubic in the denominator of RHS is positive.

In the cubic C(R), A = gravitational radius, Λ=Cosmological Constant,

(-) R= sign of the curvature.

The conditions for C(R) being positive is shown in the Figure 3.

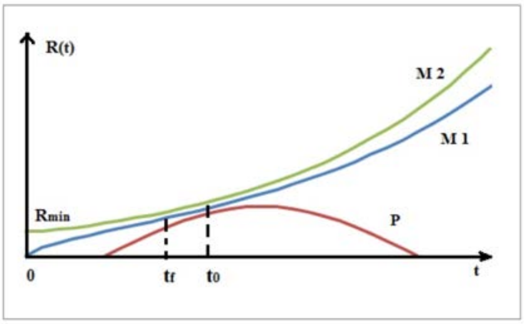


Friedman's fundmental cubic C(x) that governs the dynamics of our Universe.

Figure 3: The Behavior of the Friedman's Fundamental Cubic Term C(x) that Governs the Dynamics of our Universe for Different values of Λ. [Fractal 84.] We define $\Lambda cr = (4c^2)/(9A^2)$

Table 1: Three Scenarios Corresponding to Non-Degenerate Case-no Roots in R

$\Lambda > \Lambda_{cr}$	$\Lambda = \Lambda_{cr}$	$\Lambda < \Lambda_{cr}$	
No roots in RHP	Two repeated roots at x_0=3A/2	Two simple positive roots at x_1 and x_2	
M1 World		C(x) is positive from 0 to x_1 and from x_2 to ∞	
Monotone World Of First Kind		Periodic (2a_scenario))	Monotone World of Second Kind(2b_sce)
Here C(x) is positive From x= 0 to infinity		Oscillates between 0 and x1	M2 World
Starts from singularity R=0 and t=0.This Lemaiter's case.		Decelerating and accelerating	Starts from R_{min}= x_2 and expands to ∞
Universal starts from primeval atom		P-World	Always accelerating kind
Universe end point asymptotic behaviour: $R \approx R_0 Exp[\frac{(t-t_0)}{\tau}]$_where_ $\tau = \frac{1}{\sqrt{\Lambda/3}}$			Universe end point: $R \approx R_{min} Exp[\frac{(t-t_0)}{\tau}]$ $where\_\tau = 1/\sqrt{\Lambda/3}$ $R_{min} = x_2$
Initially from R=0 to Rf, Universe is decelerating and is matter dominated and from Rf to R0 it is accelerating and is dark energy dominated			
R_f = point of inflexion in World evolution. $R_f = (\frac{3c^2A}{2\Lambda})^{1/3} = (\frac{kc^2\rho}{2\Lambda})^{1/3} R_0$ $R_0 = \frac{kM}{4\pi^2}$			



Three possible major scenarios of the Universe's evolution according to Friedman (1922). The M1 world shows expansion from singularity with a flex point that signifies existence of two stages of evolution: deceleration and acceleration. Bondi (1961, p. 84) calls it "Lemaître's case." The M2 world shows expansion from the non-zero radius to infinity. The P world shows periodic evolution, with expansion and contraction phases and point of maximum radius in between. Point t_0 is the current stage of the Universe and point t_f is the inflexion point in the M1 world.

Figure 4: This shows the three major scenarios of Universe's evolution predicted by Friedman (1922). The M1 world shows expansion from singularity with a flex point that signifies existence of two stages of evolution: deceleration(matter dominates) and acceleration(dark energy dominates). Bondi calls it "Lemaitre case" [13]. The M2 world shows expansion from the non-zero radius to infinity. The P world shows periodic evolution, with expansion and contraction phases and point of maximum radius in between. Point t_0 is the current stage of the Universe and t_f is the point of inflexion in the M1 world [Fractal 82.eps].

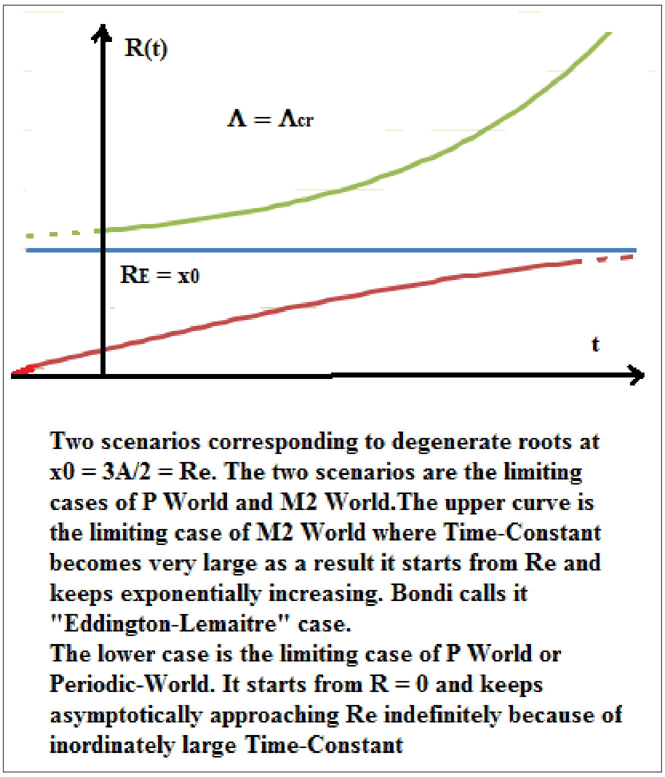


Figure 5: This shows the limiting case of P-World and M2-World in Figure 2.2. There are two scenarios corresponding to the degenerate roots at x_0=3A/2 = R_E. The two scenarios are the limiting cases of P World and M2 World. The upper curve is the limiting case of M2 world where Time-Constant becomes very large as a result it starts at RE and keeps exponentially increasing. Bondi calls it "Eddington-Lemaitre" case [14]. The lower case is the limiting case of P World or Periodic-World. It starts at R = 0 and keeps approaching RE indefinitely because of inordinately large Time Constant [Fractal 85.eps]

Table 2: Two Scenarios Corresponding to the Degenerate or Repeated Roots at x_0=3A/2=R_E

$\Lambda = \Lambda cr$	$\Lambda = \Lambda cr$
Limiting case of scenario_2a	Limiting case of scenario_2b
Time constant of expansion becomes too large hence it keeps expanding from 0 to RE.	Here also because of very large time-constant keeps expanding from RE to infinity
$R \approx R_E - Exp[-\frac{(t-t_0)}{\tau^*}]$ $where\_\tau^* = 1/\sqrt{\Lambda}$ $R_E = \frac{3A}{2} = \frac{2GM}{\pi c^2} = \frac{R_S}{\pi}$	$R \approx R_E + Exp[\frac{(t-t_0)}{\tau^*}]$ $where\_\tau^* = 1/\sqrt{\Lambda}$ $R_E = \frac{3A}{2} = \frac{2GM}{\pi c^2} = \frac{R_S}{\pi}$
At t = 0, R =R_E-Exp(t_0/τ^*) =0 At t = ∞, R=R_E	For t < t_0, R = R_E For t>t_0, $R \approx R_0 Exp[\frac{(t-t_0)}{\tau}]where\_\tau = 1/\sqrt{\Lambda/3}$

The three scenarios described in Table 1 are illustrated in Figure 2 and two scenarios described in Table 2 are illustrated in Figure 5 Thus we have 5 scenarios. The sixth scenario is Einstein Static Model of Universe at Radius R0 = RE = RS/π.

Conclusion

Today M1 World scenario is the accepted Big Bang Scenario. In this BB scenario, Universe starts from a primeval atom (mathematically it is a singularity). It has decelerated expansion because of "Matter Domination" and after a point of inflexion there is accelerated expansion because of "Dark Energy" domination. This has been confirmed by SN Ia studies conducted over a period from 1998 to 2004 as well as by BOSS. The results of this research led to Nobel Prize in Physics to the group which conducted this research namely:Saul Perlmutter +(Adam G.Reiss & Brian P. Schmidt).

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Conflict of Interest

There is no conflict of interest, financial or otherwise, with anybody whatsoever.

Data availability

All the data is available within this paper and the references.

References

1. Michelson AA, Morley EW (1887) On the relative motion of the Earth and luminiferous ether. American Journal of Science 34: 333-345.
2. Einstein, Albert (1905) The Special Theory of Relativity. Annals of Physics.
3. Lorentz Hendrik Antoon (1895) Attempt of a Theory of Electrical and Optical Phenomena.https://en.wikisource.org/wiki/Translation:Attempt_of_a_Theory_of_Electrical_and_Optical_Phenomena_in_Moving_Bodies.
4. Annamalai Chinnaraji (2023) The Einstein's Mass-Energy Equivalence and the Relativistic Mass and Momentum derived from the Newton's Second Law of Motion. https://www.cambridge.org/engage/api-gateway/coe/assets/orp/resource/item/64815099be16ad5c57a08a11/original/the-einstein-s-mass-energy-equivalence-and-the-relativistic-mass-and-momentum-derived-from-the-newton-s-second-law-of-motion.pdf.
5. Minkowski H (1910) Geometrie der Zahlen. Leipzig and Berlin: R. G. Teubner, 1910.
6. Thalman Bernal (2023) Gravitation is not attraction; it is a Push (Space-Time Expansion Theory). Journal of Philosophy 13: 48-75.
7. Fromholz Pierre, Poisson Eric, Will Clifford M (2014) The Schwarzschild metric: it is the coordinate, stupid! American Journal of Physics 82: 295-300.
8. Four papers of Einstein before Prussian Academy of Science on four Thursdays of November 1915: November 4, 1915 On the General Theory of Relativity; November 11, 1915 On the General Theory of Relativity (Addendum); November 18, 1915 Explanation of the perihelion motion of Mercury from the General Theory of Relativity.
9. Belenkiy Ari (2013) Big Bang Paternity in question. Physics Today 66: 10.
10. Belenkiy Ari (2024) The waters I am entering No one yet has crossed-Alexander Friedmann and the origin of Modern Cosmology. arXiv 1302-1498.
11. Melia Fulvia (2022) The Friedmann-Lemaitre-Robertson-Walker metric. Modern Physics Letters 37: 2250016.
12. Mahajan Haradhan (2017) A Brief Analusis of de Sitter Universe in Relativistic Cosmology. Journal of Scientific Achievements 2: 01-17.
13. Cosmic Horizon Curriculum Collection, "George Lamaitre, Father of Big Bang," American Museum of Natural History.
14. O'Raifeartaigh Cormac (2019) Eddington-Lemaitre case and the hypothesis of cosmic expansion in 1927. https://arxiv.org/abs/1907.12297#:~:text=Yet%20when%20his%20former%20assistant,the%20reasons%20for%20this%20oversight.