Appendix 1

Relativity in the Zero-Energy Dynamic Universe

This document presents the theoretical framework for relativity in the Dynamic Universe (DU) theory, providing essential background for understanding DU's predictions compared to the ΛCDM cosmological model. The DU theory reinterprets relativistic phenomena through a dynamic, energy-based approach rather than the kinematic/metric spacetime framework of Special and General Relativity. In DU, space is described as the 3-dimensional surface of a 4-dimensional sphere (3-sphere) undergoing contraction and expansion, governed by a fundamental zero-energy balance of gravitation and motion. This framework aims to produce relativistic effects—including time dilation, mass-energy equivalence, and gravitational phenomena—as consequences of energy conservation and the linkage between local systems and the universe as a whole, without requiring modifications to time and distance as coordinate quantities.

1. Introduction

1.1 Historical Context

Modern physics has been shaped by two major theoretical frameworks: Special Relativity (SR) and General Relativity (GR), developed by Albert Einstein in the early 20th century, and Quantum Mechanics (QM), developed by Planck, Bohr, Schrödinger, Heisenberg, and others. These theories emerged from empirical observations that classical Newtonian physics could not explain.

Special Relativity addressed the constancy of the speed of light demonstrated by the Michelson-Morley experiment and the failure of Galilean transformations to apply to electromagnetic phenomena. Einstein's solution was to postulate that the speed of light is a fundamental constant in all reference frames and that simultaneity, time, and distance are relative to the observer. This led to coordinate transformations (Lorentz transformations) that modified observed time and distance as functions of relative velocity.

General Relativity extended this framework to accelerating reference frames and gravitation by interpreting gravity as spacetime curvature. In GR, the presence of mass-energy warps the 4-dimensional spacetime fabric, and objects follow geodesics in this curved geometry governed by field equations. Time and distance become functions of both motion and gravitational potential.

While enormously successful in predicting observations, the SR/GR framework is built on kinematic and metric principles: it describes *how* observations appear to different observers but does not provide a deeper physical mechanism for *why* relativity occurs. The principle of relativity declares that all inertial observers are equivalent—that the universe must *appear* the same to all observers, even though their measurements of time and distance differ.

1.2 The Dynamic Universe Alternative

The Dynamic Universe theory proposes a fundamentally different approach: rather than making the universe *appear* the same for all observers through coordinate transformations, DU describes the *same universe* for all observers. In this framework:

- Time and distance are universal coordinate quantities, not observer-dependent

- The coordinate speed of light is not a fundamental constant but is determined by the expansion velocity of space
- Relativistic effects emerge from energy availability in different gravitational and motion states
- All local systems are linked to the universe as a whole through a system of nested energy frames
- The zero-energy balance of gravitation and motion governs cosmic evolution and local dynamics

This approach provides a holistic, physically intuitive picture of reality where relativity is a direct consequence of energy conservation rather than an axiomatic principle about the equivalence of observers.

2. The Zero-Energy Balance and 3-Sphere Geometry

2.1 Spherically Closed Space

The Dynamic Universe describes space as the 3-dimensional surface of a dynamic 4-dimensional sphere, mathematically termed a 3-sphere. This geometry, also Einstein's initial vision for cosmological space, provides natural closure without boundaries or edges. Just as the 2-dimensional surface of a sphere (like Earth's surface) is finite yet unbounded, the 3-sphere provides a finite, unbounded 3-dimensional space.

Critically, the fourth dimension in DU is ***spatial*** and ***metric*** in nature—measured in meters, not seconds. The line element in the fourth dimension is $ds = c \cdot dt$, where c is the expansion/contraction coordinate velocity and dt is a differential of universal coordinate time. This contrasts sharply with Minkowski spacetime in SR/GR, where the fourth dimension is considered as temporal (although measured in meters $ds = c \cdot dt$ [(m/s)·s = m]).

The curvature of space is characterized by 4-radius R_4, determining the size of the 3-sphere. In the current epoch, $R_4 \approx 13.8$ billion light-years. The 3-sphere undergoes dynamic evolution: contraction followed by expansion, analogous to a spherical pendulum converting between gravitational potential energy and kinetic energy.

2.2 The Fundamental Zero-Energy Balance

The foundation of DU is the assumption of the zero-energy balance between the gravitational energy and the energy of motion in the contraction-expansion process of the 3-sphere space. For the mass M_{tot} uniformly distributed in the 3-sphere, the gravitational energy can be expressed using a mass equivalence $M'' = 0.776 \cdot M_{tot}$ or $M'' = 0.991 \cdot M_{tot}$, integrated through π or 2π, respectively across the 3-sphere, located at the 4-center of the sphere:

$$E_g = -GM''M_{tot}/R_4 \tag{1}$$

The rest energy of all mass in space is:

$$E_m = M_{tot}c^2 \tag{2}$$

Setting $E_g + E_m = 0$ and solving for the expansion velocity c gives:

$$c = \pm\sqrt{GM''/R_4} \tag{3}$$

Using current observational estimates for cosmic mass density $\rho \approx 5\times10^{-27}$ kg/m³ and $R_4 \approx$ 13.8 billion light-years, this equation predicts $c \approx 3\times10^8$ m/s—precisely matching the observed speed of light today. In DU framework, this reveals the physical nature of the speed of light: it is the expansion velocity of space in the fourth (radial) dimension.

2.3 Implications of the Zero-Energy Balance

Non-Constant Speed of Light: Unlike SR/GR where c is a fundamental constant, in DU the speed of light varies with the expansion velocity c, which decreases as R_4 increases during expansion. In the early universe (small R_4), c was much larger; as the universe expands, c decreases proportionally to $1\big/\sqrt{R_4}$.

Energy Evolution: During the contraction phase (before the singularity), gravitational potential energy was converted to kinetic energy, building up the rest mass energy mc^2. After passing through the singularity approximately 9.2 billion years ago (in current years), the expansion phase gradually converts this energy back to gravitational potential. The zero-energy balance is maintained *at all times*—not just today (as given by Friedmann's critical mass condition).

Universal Frame of Reference: The 3-sphere structure with its 4-center provides a natural universal frame of reference. The state of rest in this frame is defined by motion only in the fourth dimension (expansion with space). Any motion within the 3-dimensional space represents deviation from this universal rest state.

No Big Bang Origin: The zero-energy balance throughout time eliminates the need for a singular creation event. Energy, space, and matter are not created at a Big Bang but undergo cyclic transformation between gravitational potential and kinetic (rest mass) energy through a contraction-expansion process.

3. Momentum and Energy in 4-Dimensional Universe

3.1 Rest Energy and 4-Momentum

In the 3-sphere framework, any mass m at rest in space (moving only with the expansion) possesses momentum in the fourth dimension:

$$p_4 = mc \tag{4}$$

The rest energy is:

$$E_{rest} = mc^2 = cp_4 \tag{5}$$

This provides the physical basis for Einstein's famous $E=mc^2$ without requiring it as a postulate. The rest energy is the kinetic energy of mass moving at velocity c in the fourth dimension.

To be more precise, the equation shall be written as

$$E_{rest} = c_0 mc = c_0 p_4 \tag{6}$$

where c_0 is the 4-velocity of the 3-sphere and the velocity of light in a hypothetical homogeneous space, and c is the 4-velocity and the velocity of light in local space bent near mass centers.

For an object moving with velocity v in 3-dimensional space, the total momentum can be expressed as a complex quantity:

$$p^{\text{¤}} = p + \mathrm{i}p_4 \tag{7}$$

where the imaginary component represents momentum in the fourth dimension. The total energy is:

$$E_{tot} = c_0 \left| p^{\text{¤}} \right| = c_0 \sqrt{p^2 + (mc)^2} \tag{8}$$

This is formally identical to the relativistic energy-momentum relation, but here it emerges naturally from the 4-dimensional geometry and the zero-energy balance, without postulating the relativity principle, the constancy of c, or time dilation.

3.2 Buildup of Kinetic Energy

A critical distinction in DU is how kinetic energy is acquired:

At Constant Gravitational Potential (acceleration by an external system like a particle accelerator):

Accelerating a mass m to velocity v requires energy insertion ΔE from the accelerating system:

$$E_{kin} = \Delta E = c_0 \Delta m \cdot c \tag{9}$$

This energy appears as an increase in the object's total mass-energy: the object now has momentum $p = (m+\Delta m)v$ and total energy $E_{tot} = c_0(m+\Delta m)c$. The mass increase Δm represents the *substance of energy* supplied by the accelerating system. Formally, the acceleration of an object in Coulomb field supplies the energy

$$\Delta E_{Coulomb} = \Delta\left(\frac{e^2 \mu_0}{4\pi r}\right) \cdot c^2 = \Delta m_{Coulomb} \cdot c^2 \qquad \left[\mathrm{kg} \cdot \left(\frac{\mathrm{m}}{\mathrm{s}}\right)^2\right] \tag{10}$$

to the accelerated object, where the quantity $\Delta(e^2\mu_0/4\pi r) = \Delta m_{Coulomb}$ [kg] is the Coulomb mass equivalence as the energy substance supplied to the accelerated object.

Simultaneously, with the increasing kinetic energy, the object's rest energy *decreases* due to the work done against global gravitation in the fourth dimension (via central force from motion relative to the mass equivalence global mass). This provides a physical explanation of *Mach's principle*: resistance to acceleration arises from the work done against the global gravitation arising from the total mass represented by the mass equivalence *M"*.

In Free Fall (in gravitational potential field):

No external energy is added. Instead, kinetic energy is obtained by *reducing rest energy*, conserving total energy. This occurs through local bending (tilting) of space near mass centers. The momentum of free fall p_{ff} appears as the component of rest momentum mc tilted from the fourth dimension into the 3-dimensional space direction. The reduction of rest energy occurs via the reduction of the 4-velocity

$$c = c_0 \cos\varphi \tag{11}$$

in bent space near mass centers, where φ is the bending angle. Kinetic energy can be expressed as

$$E_{kin(ff)} = \Delta E = c_0 m |\Delta c| . \tag{12}$$

This fundamental difference—energy addition vs. energy conversion—distinguishes inertial motion from free fall and shows why the equivalence principle of GR is an approximation rather than an exact principle in DU.

4. The Mass Wave Concept

4.1 Mass as Wavelike Substance

One of the most profound insights from the DU framework is understanding mass as a wavelike substance for the expression of energy. This concept emerges from analyzing Planck's constant and the nature of electromagnetic radiation.

Planck's equation $E = hf = h/T$ (where $T = 1/f$ is the cycle time) can be decomposed to reveal its physical meaning. Solved from Maxwell's equations, the energy radiated by a one-wavelength dipole antenna in one cycle, with N oscillating electrons is:

$$E = N^2 \cdot A_0 \cdot 2\pi^3 e^2 \mu_0 c \cdot f \tag{13}$$

where N is the number of electrons, e is the electron charge, μ_0 is the vacuum permeability, f is frequency, and A_0 is the geometrical factor describing the spreading of the radiation emitted. For a Hertzian dipole A_0 =2/3, for a hypothetical isotropic antenna, like a point source, as one-wavelength antenna, for any cycle, in the fourth dimension ($\lambda \approx c{\cdot}dt = cT$), $A_0 \approx 1$. The energy emitted into a cycle of radiation by a single electron oscillation (N=1), and $A_0 \approx 1.1049$ is

$$E = 1.1049 \cdot 2\pi^3 e^2 \mu_0 \cdot c \cdot f \tag{14}$$

where the quantity $1.1049{\cdot}2\pi^3 e^2 \mu_0 {\cdot} c = h \approx 6.626 \cdot 10^{-34}$ [Js] can be identified as the Planck constant. The linkage of the Planck constant to the electromagnetic constants reveals the fine structure constant α as a pure geometrical factor without linkage to the velocity of light, electron charge, or vacuum permeability

$$\alpha \equiv \frac{e^2 \mu_0 c}{2h} \approx \frac{e^2 \mu_0 c}{2 \cdot 1.1049 \cdot 2\pi^3 e^2 \mu_0 c} = \frac{1}{1.1049 \cdot 4\pi^3} \approx \frac{1}{137.036} \tag{15}$$

Critically, the velocity of light c appears as a hidden factor in h. Removing it, defines the ***intrinsic Planck constant***:

$$h_0 = h/c \approx 1.1049 \cdot 2\pi^3 e^2 \mu_0 \tag{16}$$

The intrinsic Planck constant has dimensions of [kg·m], not [J·s] as the current Planck constant. This allows writing Planck's equation as:

$$E = hf = h_0 / \lambda \cdot c^2 = m_\lambda c^2 = pc \tag{17}$$

where $m_\lambda = h_0 / \lambda$ is the ***mass equivalence of a cycle of radiation***. This shows that electromagnetic radiation, traditionally considered "massless," actually carries mass—as abstract, non-inertial "energy carrier", or a wavelike substance for expressing energy.

Conversely, for any mass m, we can define its ***wavelength equivalence***:

$$\lambda_m = h_0 / m \tag{18}$$

which is the *Compton wavelength* of mass m. The rest energy can now be written:

$$E = c_0 mc = c_0 \cdot \frac{h_0}{\lambda_m} c = c_0 \cdot \hbar_0 k_m c \tag{19}$$

where $\hbar_0$ is the *reduced intrinsic Planck constant*, and k_m is the Compton wavenumber of mass m.

These forms reveal that mass is not a form of energy [J] but the energy carrier, the substance [kg] for expressing ***energy***, present in all forms of energy, including radiation, Coulomb energy (eq. 10), kinetic energy, and gravitational energy.

The antenna analysis discloses the physical meaning of Planck's equation as the energy conversion in emission and absorption, not as an intrinsic property of propagating radiation.

4.2 Mass Wave Resonators and de Broglie Waves

Localized mass objects (particles) can be described as ***mass wave resonators***—standing wave patterns of the mass wave substance. For a particle at rest in space expanding at c, the resonator oscillates at the Compton frequency f_m:

$$f_m = \frac{c}{\lambda_m} \tag{20}$$

When the resonator moves at velocity v, the Compton wavelength is subject to an increase

$$\lambda_{m(v)} = \lambda_{m(0)} \Big/ \sqrt{1 - \left(\frac{v}{c}\right)^2} \tag{21}$$

and the wave pattern experiences Doppler shifts: the forward wave is compressed and the backward wave is extended. The sum of these Doppler-shifted components creates a wave pattern propagating parallel to the particle's motion, carrying the momentum alongside the particle

$$p = \frac{h_0 / \lambda_{m(0)}}{\sqrt{1 - (v/c)^2}} \cdot v = \frac{h_0}{\lambda_{dB(v)}} \cdot c = \frac{m_0}{\sqrt{1 - (v/c)^2}} \cdot v \approx m_0 v \tag{22}$$

where the second form shows the de Broglie wave

$$\frac{h_0}{\lambda_{dB(v)}} = \frac{h_0/\lambda_{m(0)}}{\sqrt{1-(v/c)^2}} \cdot \frac{v}{c} \tag{23}$$

propagating at velocity c. The de Broglie wave number is

$$k_{dB(v)} = \frac{h_0/\lambda_{m(0)} \cdot v/c}{\hbar_0\sqrt{1-(v/c)^2}} = \frac{m \cdot v/c}{\hbar_0\sqrt{1-(v/c)^2}} \approx \frac{m \cdot v/c}{\hbar_0} \tag{24}$$

where the last form is equal to the wave number in the non-relativistic Schrödinger equation for a free particle moving at velocity v

$$k_{dB(v)} = \sqrt{\frac{2mE}{\hbar_0^2}} = \sqrt{\frac{2m \cdot ½mv^2}{\hbar_0^2 c^2}} = \frac{m \cdot v/c}{\hbar_0} \tag{25}$$

The mass wave picture offers powerful insights into quantum phenomena:

- **Double-slit experiment:** The de Broglie wave passes through both slits, creating an interference pattern, while the localized resonator (particle) goes through one slit. The probability of detection follows the intensity pattern of the interfering de Broglie waves.
- **Wave function:** The quantum mechanical wave function ψ can be understood as describing the amplitude of the mass wave pattern. $|\psi|^2$ gives the probability density of finding the resonator (particle) at a given location.
- **Particle-wave duality:** Mass itself is a wave phenomenon. In particles, mass waves form closed standing wave structures (Compton resonators), and the momentum is carried by the de Broglie wave as a field phenomenon outside the particle.

The wave nature of mass may also give new insights into the uncertainty principle.

4.3 Quantum States as Energy Minima

The mass wave concept provides a new approach to understanding quantized energy levels. For an electron in a hydrogen atom, we can assume a resonance condition: the de Broglie wave must fit an integer number of wavelengths around a Coulomb equipotential orbit.

For principal quantum number n, the boundary condition is $n\lambda_{dB} = 2\pi r$, equivalent to the wave number condition $k_{dB} = n/r$. The total energy (kinetic plus Coulomb potential) can be written as a continuous function of orbital radius r:

$$E_{n(r)} = c_0\hbar_0 k_m c\left[\sqrt{1+\left(\frac{n}{k_m r}\right)^2} - 1\right] - Z\alpha\frac{\hbar_0}{r}c_0 c \tag{26}$$

For each value of n, this energy has a ***minimum*** at a specific radius

$$E_{n,Z} = -c_0 m_e c\sqrt{1-\left(1-\frac{Z\alpha}{n}\right)^2} \approx -m_e c^2\left(\frac{Z}{n}\right)^2 \cdot \frac{\alpha^2}{2} \tag{27}$$

where $m_e = h_0/\lambda_m$ is the electron rest mass, Z is the number of charges, and n the principal quantum number. The first expression is the DU (relativistic) expression of the energy states. The last form is the approximation corresponding to the quantized energy levels predicted by Schrödinger's equation. The "quantization" emerges naturally from finding stable (minimum energy) configurations for mass wave resonances in the Coulomb potential—the principal energy states are obtained without separate quantization postulates.

5. Nested Energy Frames and Relativistic Phenomena

5.1 Local Gravitational Centers and Space Bending

The buildup of local gravitational centers (stars, planets, galaxies) involves *local bending or tilting* of space relative to the surrounding space. Near a mass M, space is bent such that the component of expansion velocity in the local fourth dimension is reduced compared to the velocity of light in unbent space.

At a distance r from mass M, the velocity of light c is reduced according to:

$$c = c_0\left(1 - GM/rc_0^2\right) = c_0 \cos\varphi \qquad (28)$$

which is the expression obtained in DU, corresponding to the expression

$$c = c_0\sqrt{1 - 2GM/rc_0^2} \qquad (29)$$

for the coordinate velocity of light in Schwarzschild space. In (29), c_0 is the velocity of light in unbent space (as it were without M). The bending of space has several observable consequences:

- **Gravitational lensing:** Light follows geodesics in bent space, curving near massive objects
- **Shapiro delay:** Light travels at reduced velocity near massive objects, causing time delays in radio signals and radar echoes
- **Perihelion precession:** Planetary orbits precess due to the modified space geometry; DU prediction for perihelion/periastron precession is the same that in GR
- **Free fall:** Objects gain velocity and kinetic energy against the release of gravitational energy and the associated reduction of the local velocity of light. Effectively, the tilting of space converts the rest momentum into momentum of free fall.

Critically, in DU this bending represents an actual geometric effect—a real tilting of the local spatial structure—not a metaphorical "curvature of spacetime." Time remains a universal coordinate quantity; what curves is the 3-dimensional space embedded in the 4-dimensional structure.

5.2 The System of Nested Energy Frames

A profound consequence of the zero-energy balance is that ***all local systems are linked to the universe as a whole*** through a hierarchical system of nested energy frames. Each local frame (defined by a gravitational center and/or a state of motion) exists within a parent frame, which exists within its parent frame, and so on, up to the universal frame (hypothetical homogeneous space as the initial condition).

For example, consider an ion in a particle accelerator on Earth:

- The ion moves in the **accelerator frame**
- The accelerator moves in the **Earth frame** (due to Earth's rotation)
- Earth moves in the **Solar frame** (orbital motion around the Sun)
- The Solar System moves in the **Milky Way frame**
- The Milky Way moves in the **Local Group frame**
- ...ultimately to the **universal frame** (hypothetical homogeneous space)

Following this hierarchical energy structure of space, the rest energy of an object in frame *i* can be expressed as reduced relative to the parent frame (*i*–1) according to:

$$E_{rest(i)} = E_{rest(i-1)}\left(1-\delta_i\right)\sqrt{1-\beta_i^2} \tag{30}$$

where $\delta_i = GM_i/r_i c_0 c_{i-1} \approx GM_i/r_i c_0^2$ is the gravitational factor for frame *i* and $\beta_i = v_i/c$ is the velocity factor for frame *i*. Applying this relation recursively through all frames gives the rest energy in the deepest frame *n* as:

$$E_{rest(n)} = m_0 c_0^2 \prod_{i=1}^{n}\left[\left(1-\delta_i\right)\sqrt{1-\beta_i^2}\right] \tag{31}$$

The "deeper" we are in the system of nested frames, the lower the locally available rest energy, the slower the velocity of light, and the slower the rate of all physical processes. This linkage between local and global is absent in SR/GR, where each frame is considered independently.

5.3 Clock Frequencies and Time Dilation

In the SR/GR framework, clocks are assumed to measure proper time in their local frame, and "time dilation" means that time is observed as running at different rates in frames at different states of gravitation and motion relative to the observer. In DU, ***time is universal***—which allows defining a universal second in a defined state of gravitation and motion to be used as the reference. What changes with gravitation and motion is not time but the *frequency of physical processes*, including atomic clocks which define the local SI second.

The frequency of an atomic clock is determined by quantum transitions, which depend on electron's rest energy $E_e = m_e c^2$. Using the intrinsic Planck constant $h_0 = h/c$, the characteristic frequency can be written:

$$f = \frac{m_e c^2}{h} F\left(\alpha, \Delta\left(n, j\right)\right) = \frac{m_e c}{h_0} F\left(\alpha, \Delta\left(n, j\right)\right) \tag{32}$$

where $F[\alpha, \Delta(n,j)]$ conveys the quantum state transition. This shows how the clock frequency depends on *both* the velocity of light *c* (affected by gravitation) *and* the electron rest mass m_e (affected by motion).

Through the nested energy frames, a clock's frequency in frame *n* relative to a reference clock at rest in hypothetical homogeneous space as frame 0 is:

$$f_n = \frac{c_n}{c_0}\frac{m_{e(n)}}{m_{(0)}} = \prod_{i=1}^{n}\left[\left(1-\delta_i\right)\sqrt{1-\beta_i^2}\right] \tag{33}$$

The effect of gravitation and motion corresponds to the effects motion and gravitation on the coordinate time in the SR/GR framework but has a completely different physical interpretation: the clock frequency actually changes; time itself does not. This allows genuine clock *synchronization* across frames—establishing a common time coordinate by accounting for the frequency differences.

For example, GPS satellites require clock synchronization with ground stations. In DU, this is achieved by determining the energy state difference between the satellite orbit and ground, then counting an appropriately adjusted number of atomic cycles to define a second in common with the Earth second. The GPS satellite clock runs faster (higher frequency) than ground clocks due to its higher gravitational potential (which is a greater effect than the orbital velocity effect). In practice, GPS clocks are synchronized to the Earth reference clock by counting a second from a higher number of cycles.

5.4 The Michelson-Morley Experiment

The Michelson-Morley experiment famously found no variation in the speed of light despite Earth's orbital motion. In SR, this is explained by postulating that the speed of light is constant in all inertial frames. DU explains why the velocity of light is locked to the M-M frame; any local frame moving at constant gravitational potential in its parent frame has a ***fixed 4-velocity***, which determines the local speed of light. For a Michelson-Morley interferometer horizontally on Earth, the velocity of light is *fixed to the interferometer body* (the local frame), regardless of the interferometer's orbital motion and rotation with Earth.

The constancy of c in a local frame emerges from the energy balance: the local 4-velocity is determined by the balance between the rest energy and global gravitational energy in that frame. Thus, the Michelson-Morley and related interferometry experiments show a null result without postulating the constancy of c as a universal principle.

6. Comparison with Special and General Relativity

6.1 Fundamental Principles

Special/General Relativity:

- Principle of relativity: all inertial observers are equivalent
- Equivalence principle: inertial acceleration is equivalent to gravitational acceleration
- The speed of light is a fundamental constant in all frames
- Spacetime is a 4-dimensional continuum; time is the fourth dimension
- Gravitation is a property of spacetime curvature

Dynamic Universe:

- Zero-energy principle: balance between gravitational and kinetic energy throughout dynamic 3-sphere space
- Universal time and distance as coordinate quantities

- Speed of light determined by expansion velocity $c_0 = \sqrt{GM''/R_4}$
- Fourth dimension is understood spatial, measured in meters (although inaccessible from space)
- Gravitation: Local gravitational potential is related to local bending/tilting of 3D space in the 4D structure, maintaining the zero-energy balance
- Gravitational potential is the source for any expression of energy – actualized in the contraction process preceding the ongoing expansion of space

6.2 Interpretational Differences

Velocity and State of Rest:

In SR/GR, velocity is relative to an observer; any inertial observer can consider staying at rest. In DU, *velocity is relative to the local frame* where motion/energy is obtained. An observer cannot arbitrarily choose to be at rest—the state of rest is determined by the energy frame structure.

For example, an observer on Earth's surface is *not* at rest in the ECI (Earth Centered Inertial) frame but moves with the rotation of Earth in the frame, and due to Earth's orbital motion with the frame in the Solar gravitational frame. Similarly, an observer in an accelerator lab moves with the lab equipment in the local gravitational frame but is at rest relative to the accelerator frame.

Time Dilation vs. Clock Frequency Change:

SR/GR interprets clock differences as time itself flowing at different rates (time dilation). DU interprets clock differences as *actual changes in clock frequency* (and all physical processes) due to changes in rest energy and the velocity of light, while time remains universal. Both give the same quantitative predictions, but the physical meaning differs profoundly.

Length Contraction:

For moving objects, SR predicts length contraction in the direction of the motion as a part of the kinematic explanation of relativistic effects.

In DU, the Compton wavelength of moving atoms increases with motion as $\lambda_{m(v)} = \lambda_{m(0)} \Big/ \sqrt{1-(v/c)^2}$, which means that the Bohr radius of atoms also increases in proportion to $1 \Big/ \sqrt{1-(v/c)^2}$. This means, e.g., that the dimensions of physical resonators (e.g., lasers) increase in direct proportion to the increasing wavelength in the resonator, which is essential for maintaining the resonance condition of resonators moving in space.

Equivalence Principle:

As a profound difference, the zero-energy balance in DU replaces the equivalence principle (inertial acceleration ≡ gravitational acceleration), which is foundational in GR. In DU, this equivalence is an *approximation*, valid for weak fields. The fundamental difference is that inertial acceleration requires external energy input (building up "relativistic mass" and increased total energy), while free fall converts rest energy of the falling object to kinetic energy through bending of space and the related reduction of the local velocity of light *c* (and thus the rest energy $E=c_0mc$).

6.3 Quantitative Agreement

Despite the profound interpretational differences, DU produces the same quantitative predictions as SR/GR for widely tested phenomena:

- **Lorentz factor:** $\gamma = 1\big/\sqrt{1-\beta^2}$ appears identically in both frameworks
- **Relativistic energy-momentum:** $E^2 = (pc)^2 + (mc^2)^2$ is derived in DU from 4D geometry
- **Gravitational time dilation:** Clock frequency ratio matches GR's prediction in weak fields; on Earth and near space, the difference between GR and DU predictions is of the order of 10^{-17}
- **Light bending:** Same deflection angle in gravitational fields
- **Perihelion precession:** GR and DU predict Mercury's 43″/century anomalous advance
- **Shapiro delay:** Radar echo delays match GR

However, there are some predictions where DU differs from GR:

- **Black hole orbits:** DU predicts stable orbits down to the critical radius $r_c = GM/c_0^2$, whereas GR predicts orbital instability at $r = 3{\cdot}2GM/c_0^2$ (Schwarzschild space)
- **Orbital period minimum:** DU predicts a minimum orbital period at $r = 2r_c$ (observed in Sgr A*), and allows **slow orbits** at $r < 2r_c$, for matter and radiation in different forms, constituting the mass of the black hole.
- **Gravitational wave energy:** DU prediction based on the rotation of 4D orbital angular momentum of a binary system predicts decay for eccentric orbits essentially identically with the GR prediction; perfectly circular orbits would not decay due to the angular momentum rotation.

7. Cosmological Implications

7.1 Expansion of Local Systems

A critical prediction distinguishing DU from ΛCDM (Dark Energy Cold Dark Matter Cosmology) concerns whether gravitationally bound systems expand with space. In GR/ΛCDM, local structures like galaxies, solar systems, and atoms *do not* expand with cosmic expansion—only the space *between* large-scale structures expands (the "Hubble flow").

In DU, conservation of the zero-energy balance requires that ***all gravitationally bound systems expand proportionally with space***. As R_4 increases, planetary orbital radii increase, and galaxy sizes increase. Simultaneously, all velocities in space, e.g., orbital velocities, decrease in direct proportion to the decrease of the velocity of light, $c_0 = \sqrt{GM''/R_4}$, thus maintaining the zero-energy balance.

This prediction is testable through:

- **Lengthening of day:** Combining the effect of tidal friction due to Sun and Moon on the lengthening of a day (2.5 ms/century) with DU expansion, which lengthens the year (−0.6 ms/century), DU predicts 1.9 ms/century lengthening of day, matching fossil coral data and ancient eclipse records.

- **Planetary distances:** Transponder measurements between Earth and Mercury, when interpreted in GR framework, relying on the constant AU unit, do not show expansion of planetary distances. DU predicts expanding planetary distances contrary to the interpretation. The interpretation of data in DU framework needs thorough analysis, because the same observational data may support different conclusions depending on the theoretical framework used for interpretation.
- **Lunar distance:** Laser ranging shows 3.8 cm/year increase; DU attributes 2.8 cm/year to expansion with space and 1.0 cm/year to tidal effects.
- **Angular size of galaxies:** Observations (including JWST) show a Euclidean trend of angular size up to $z > 10$. ΛCDM predicts an increasing angular size for galaxies with $z > 1.5$, challenging the Euclidean trend. In accordance with observations, DU predicts the Euclidean trend for galaxies, as expanding objects, across the entire observed range.

7.2 Early Universe and Galaxy Formation

Perhaps the most dramatic difference between DU and ΛCDM concerns the early universe. In ΛCDM, the Big Bang occurred ~13.8 billion years ago, and energy/matter appeared suddenly at that event. Structure formation proceeded through gravitational collapse at rates inferred from today's physical processes.

In DU, the singularity occurred ~9.2 billion years ago (in today's years), but this was *not the origin of space and energy*—it was merely the pass-through point from contraction to expansion. Before the singularity, space was contracting, converting gravitational energy to rest mass energy. After the singularity, expansion gradually converts this energy back to gravitational energy.

Critically, in the early expansion phase, when R_4 was small:

- The velocity of light, $c \propto 1/\sqrt{R_4} \propto \sqrt{1+z}$, was *much higher* than today
- All atomic processes ran *much faster* (proportional to c)
- Gravitational collapse proceeded $(1+z)^{3/2}$ *times faster* than today
- Stars formed and evolved *dramatically faster*, producing heavy elements rapidly
- Atomic dimensions (Bohr radius, Compton wavelengths) do not expand with the expansion of space
- The fine structure constant, α, is invariant

At redshift $z = 10$ (in the past), processes ran ~3.3 times faster; at $z = 100$, ~1000 times faster; at $z = 1000$, ~32,000 times faster. This explains how JWST observes massive, mature galaxies at $z > 10$ without requiring exotic physics or modifications to star formation—the universe simply had much more "effective time" in the early expansion due to the higher speed of light and accelerated processes.

7.3 Redshift and Distance Relations

The 3-sphere geometry produces distinct predictions for cosmological observables:

Redshift: $z = R_{4(\text{now})}/R_{4(\text{then})} - 1$. The wavelength of light increases proportionally with space expansion.

Optical distance: The light travel distance (optical distance) equals the increase in R_4 during propagation: $d_{opt} = R_4 \cdot z/(1+z)$.

Comoving distance: The emitter's current distance from the observer: $d_c = R_4 \cdot \ln(1+z)$.

Angular size: For objects that expand with space (e.g., galaxies), the 3-sphere geometry produces an Euclidean angular size relation: $\theta \propto D/d$. 3-sphere optical lensing affects the *observed angular size* of objects near the antipodal point at $z \approx 22$.

Luminosity: Apparent luminosity falls as $(1+z)^3$ rather than ΛCDM's $(1+z)^4$, because energy in each radiation cycle is conserved even when wavelength increases.

These predictions have been supported by JWST observations of galaxy angular sizes and supernova Ia luminosities, as detailed in the accompanying DU vs ΛCDM comparison paper.

8. Conclusions

The Dynamic Universe theory offers a comprehensive reinterpretation of relativistic phenomena based on energy conservation rather than kinematic principles. By starting from the zero-energy balance in a 3-sphere space structure, and recognizing the fourth dimension as spatial rather than temporal, DU derives relativistic effects—time dilation, mass-energy equivalence, gravitational phenomena—as natural consequences of the linkage between local systems and the universe as a whole.

Key achievements of the DU framework include:

- **Unified picture:** Relativity and quantum phenomena emerge from the same foundation—the mass wave concept and energy conservation
- **Physical intuition:** Time and distance remain universal coordinates; relativistic effects have clear physical mechanisms
- **Holistic approach:** Every local system is linked to the whole through nested energy frames
- **Testable predictions:** DU makes distinct predictions about local structure expansion, early universe processes, and cosmological observables
- **Quantitative agreement:** DU reproduces widely SR/GR predictions while offering deep physical insight

The DU framework is particularly powerful in cosmology, where it naturally explains recent JWST observations that challenge ΛCDM: unexpectedly mature galaxies at high redshift, Euclidean angular size evolution, and supernova distance-redshift relations. These successes, combined with its elegant theoretical structure and intuitive physical picture, suggest that DU merits serious consideration as an alternative foundation for understanding physical reality.

A fundamental difference between SR/GR and DU is not merely technical but philosophical: do we prefer building on a framework where the universe *appears* the same to all observers through coordinate transformations (relativity), or one where all observers view the *same universe* through energy-dependent manifestations (DU)? Both approaches have mathematical elegance, but DU offers the additional virtues of physical transparency, holistic unity, and—increasingly—observational support.