$D = \frac{\ln 20}{\ln(2+\phi)} \approx 2.71$

The Weber-De Broglie-Bohm Theory

An Effective Quantum Gravity

$$Q = -\frac{\hbar^2}{2m}\frac{\nabla^2\sqrt{\rho}}{\sqrt{\rho}}$$

$$\vec{F}_{\mathrm{WG}} = -\frac{GMm}{r^2}\left(1 - \frac{\dot{r}^2}{c^2} + \beta\frac{r\ddot{r}}{c^2}\right)$$

Michael Czybor

The Weber-De Broglie-Bohm Theory
An Effective Quantum Gravity

Michael Czybor

August 13, 2025

Preface

The Weber-De Broglie-Bohm-Theorie (WDBT) does not merely represent an alternative mathematical description of physical phenomena but outlines a fundamentally new paradigm of physical reality. In contrast to established physics, which is based on the concepts of quantum fields and spacetime curvature, the WDBT is founded on three fundamental principles:

1. Direct particle interactions instead of mediating fields
2. Non-local wholeness as an organizing principle
3. Configuration space dynamics rather than an exclusive spacetime description

The decisive breakthrough of this theory lies in its ability to explain the known phenomena of quantum mechanics and gravity without falling into the contradictions inherent to standard theories. While conventional physics struggles with problems such as the measurement problem, the non-locality of quantum entanglement, or the singularities of Allgemeinen Relativitätstheorie (ART), the WDBT offers natural solutions:

- The quantum potential of De-Broglie-Bohm-Theorie (DBT) explains wave-particle duality without the mysterious "collapse" of the wave function.
- Weber electrodynamics describes electromagnetic phenomena through direct charge interactions, thus avoiding the infinite self-energies of quantum field theory.
- The Weber-Gravitation (WG) reproduces the successful predictions of ART without the concept of spacetime curvature.

The apparent conflict with principles such as Lorentz invariance or local causality arises solely from the wrong perspective of the established paradigm. In the WDBT, instantaneous correlations are not a violation of causality but an expression of a deeper, configuration-space-wide organization of physical processes. This organization follows its own stringent laws, which fundamentally differ from the notions anchored in field theory.

The experimental equivalence to standard theories while simultaneously avoiding their conceptual problems speaks clearly for the strength of the WDBT. It shows that established physics is not the only possible description of nature but merely one of several consistent possibilities. The choice between these descriptions is therefore not empirically but paradigmatically grounded.

For the scientific community, this presents a clear challenge: Instead of measuring the WDBT against the standards of the established paradigm, it should be taken seriously as an independent theoretical framework. Its predictions—such as wavelength-dependent light deflection or modified galaxy rotation curves—offer concrete opportunities for experimental verification.

The WDB theory forces us to question fundamental assumptions of modern physics:

- Must physics necessarily be based on field concepts?
- Is locality a fundamental principle or merely an artifact of certain theories?
- Could the apparent contradictions of quantum mechanics be an expression of an incomplete paradigm?

These questions show that the WDBT is more than just an alternative collection of formulas—it is a coherent, self-contained conception of physical reality that has the potential to fundamentally change our understanding of nature. Its strength lies not in reproducing standard theories in all details but in offering a consistent alternative that simultaneously avoids their conceptual problems.

The future will show whether physics is ready to embrace this paradigm shift. Regardless, the WDBT has already proven its value: It demonstrates that established physics is not the only possible description of nature and forces us to critically question supposed certainties. In this sense, it is not only a scientific theory but also a philosophical challenge of the first order.

The WDBT sheds new light on the fundamental problems of modern physics. Three key developments underscore its relevance:

First, the growing contradictions in cosmology—particularly the discrepancies in the Hubble constant and the unsuccessful hunt for dark matter—are pushing the standard model to its limits. Second, modern experiments such as LIGO, the Event Horizon Telescope, and quantum simulators now enable precise tests of alternative gravitational concepts. Third, the stalled search for quantum gravity in mainstream approaches (string theory, loop quantum gravity) highlights the need for radical reconceptualizations.

The strength of the WDBT lies in its triple synthesis: (1) Direct particle interactions according to Weber replace field concepts, (2) Bohm's non-local quantum dynamics resolve the measurement problem without "collapse" of the wave function, and (3) a fractal dodecahedron structure of space emergently explains geometry and natural constants.

New findings confirm central predictions: LIGO data shows signs of the theoretically predicted frequency-dependent light deflection at high frequencies (>1 kHz). The topological origin of the fine-structure constant (Section 5.6) proves more viable than Quantenelektrodynamik (QED) renormalization. The dodecahedron space structure also plausibly explains the puzzling anomalies in the cosmic background radiation at large scales ($l<20$).

From a history of science perspective, the WDBT stands in the tradition of mechanistic worldviews from Newton to Hertz but overcomes their limitations through a consistent unification of quantum phenomena and relativity without mathematical artifices. Its ontologically clear foundation combined with unwavering mathematical rigor makes it particularly attractive to young researchers seeking alternative paths in fundamental research.

Michael Czybor
Langenstein/AT, August 2025

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Chapter 1

Foundations of an Alternative Quantum Gravity

1.1 Motivation

Modern physics faces fundamental contradictions: While ART describes gravity as the curvature of spacetime, Spezielle Relativitätstheorie (SRT) is based on idealized inertial frames that strictly speaking cannot exist in curved spacetime. This conflict raises questions—for instance about the nature of the speed of light, which is absolute in SRT but locally variable in ART.

> "Einstein's postulates contain inherent contradictions when applied to real gravitational systems, challenging the universality of special relativity." [8]

Additionally, there are unresolved problems in quantum mechanics: wave-particle duality, the "collapse" of the wave function upon measurement, and non-local entanglement. Even successful theories like QED postulate seemingly paradoxical phenomena, such as virtual photons with superluminal speeds in the path integral formalism.

These tensions suggest that established models may only be approximations of a deeper reality. Rather than following dogmas, we should examine alternative perspectives like Weber electrodynamics or DBT, which are introduced in this book.

> "The observer-dependent collapse of the wavefunction is not a fundamental feature of nature but a limitation of the standard interpretation." [5]

1.1.1 Dogmatism and Blind Spots in Modern Physics

Contemporary physics suffers from a paradoxical situation: On one hand, established theories like ART or quantum field theory are rarely questioned, despite their fundamental weaknesses —singularities in black holes, infinite self-energies of particles, or the need for "dark" entities. On the other hand, unorthodox approaches are often filtered out during peer review, even though they could offer solutions to these problems.

An example is the interpretation of the Hintergrundstrahlung (CMB) as evidence for the Big Bang. Alternative explanations—such as thermal equilibrium processes in plasmas—are hardly discussed, even though they avoid singularities. The same applies to galactic redshift, which does not necessarily imply universal expansion.

> "Theoretical physics has become stuck in a paradigm that values mathematical elegance over empirical testability, leading to a stagnation of genuine progress." [9]

1.1.2 Speculation Over Progress

Since the revolutionary breakthroughs of quantum mechanics and relativity theory a century ago, there have been few comparable advances. Instead, speculative concepts like higher dimensions or multiverses dominate, which are hardly empirically verifiable.

Yet science should focus on observable phenomena. Weber electrodynamics demonstrates how electromagnetic effects can be described without fields—through direct interactions between charges. Such approaches could pave the way for a more consistent physics.

1.1.3 Alternative Theories

A central problem in modern physics lies in its excessive reliance on mathematics. Just because something can be formulated mathematically does not mean it corresponds to physical reality. Yet instead of acknowledging these limits, fundamental principles of classical physics—such as energy conservation or the laws of thermodynamics—are abandoned in favor of abstract equations. ART, for example, postulates a dynamic spacetime that seemingly creates or destroys energy out of nothing. Where is the strict balance of physics in this?

Concrete contradictions emerge in practice: According to ART, planets should lose energy through gravitational wave emission—so why have planetary orbits remained stable for billions of years? If spacetime is described as an elastic entity that can deform and move: What force performs work here, and where does the energy come from? Standard explanations remain vague or resort to mathematical tricks.

The supposed evidence for the Big Bang is also far from unambiguous. The cosmic CMB is automatically interpreted as an echo of the Big Bang —but alternative explanations exist, such as thermal equilibrium processes or scattering phenomena.

> "The interpretation of cosmic microwave background as proof of the Big Bang ignores alternative explanations, such as intrinsic redshifts in plasma cosmology." [2]

Similarly, galactic redshift might not only result from expansion but also from other mechanisms. Even phenomena like light deflection or the Shapiro effect can be explained without ART if alternative gravitational models are considered.

> "Weber's formulation of electrodynamics provides a consistent framework for gravitational phenomena without invoking curved spacetime." [3]

This book aims to present such alternative explanations. Physics must not stop at mathematical dogmas—it must return to logic, experiment, and real causality.

1.2 Divergent Perspectives in Physics: Light, Relativity, and Alternative Models

1.2.1 Feynman's Particle Model of Light

Richard Feynman argued that even interference phenomena can be explained by particles (photons)—without waves. This raises the question: Is wave-particle duality truly necessary, or does it merely reflect the limits of our models?

1.2.2 Contradictions in QED: Superluminal Photons and Path Integrals

The path integral formalism of QED sums over all possible photon paths—including those with superluminal speeds. Mathematically, this leads to correct predictions, but physically, it remains unclear:

- If photons can virtually exceed the speed of light, does this not contradict SRT?
- Is the speed of light truly an absolute limit, or just a macroscopic effect?

1.2.3 Energy-Dependent Speed of Light? Experimental Hints

Some alternative theories (e.g., loop quantum gravity or VSL models) propose that the speed of light might depend on photon energy. Possible evidence:

- Gamma-ray bursts with extremely high energies show minimal time-of-flight differences (e.g., Fermi telescope data).
- Quantum gravity effects could cause dispersion at high energies.

> "The constancy of the speed of light is not an immutable law but a parameter that may vary under extreme conditions, offering solutions to cosmological puzzles." [7]

1.3 The Evolution of the Wave Concept in Physics

The understanding of waves in physics has radically changed over time. While classical waves like sound or water waves could be described as disturbances of a material medium, electromagnetic waves and quantum phenomena led to fundamental upheavals. In 1865, Maxwell showed that light propagates as an electromagnetic wave even without an ether—raising the question of how energy is transported without a carrier medium. SRT established the speed of light as an absolute limit, while ART describes it as locally variable—an apparent contradiction that alternative theories like Weber electrodynamics attempt to resolve.

Quantum physics further revolutionized the wave concept: De Broglie linked particle and wave properties, and QED describes photons as fields with superluminal path integral components. Yet this mathematical elegance creates physical interpretation problems—such as the role of the observer in wave function collapse or the non-local nature of quantum entanglement. Gravitational waves in ART also remain enigmatic: If spacetime is considered an oscillating medium, where does the energy for its deformation come from?

These contradictions suggest that established theories may only be approximations of a deeper truth. Physics faces fundamental questions: Is the speed of light truly constant? How can quantum physics and relativity be unified? Is there an objective reality beyond the observer? The search for answers could trigger a new scientific revolution—one that fundamentally changes our understanding of waves and the fundamental nature of reality.

1.4 Wave Phenomena: The Duality of Instantaneous Wholeness and Local Propagation

Waves possess a unique dual nature that permeates all of physics. On one hand, they exhibit local propagation phenomena; on the other, they display instantaneous global properties that defy classical causality. This duality becomes particularly evident when examining fundamental interactions.

Newtonian mechanics postulates instantaneous action at a distance with “actio = reactio”—a force acts immediately between two bodies. Mathematically expressed:

$$\vec{F}12 = -\vec{F}21 \tag{1.1}$$

This equation describes an instantaneous interaction without time delay. The same applies to Coulomb’s law:

$$\vec{F} = \frac{1}{4\pi\epsilon_0}\frac{q_1 q_2}{r^2}\hat{\vec{r}} \tag{1.2}$$

These action-at-a-distance theories work remarkably well within their domain, as demonstrated by the successful description of planetary motion. Yet they remain incomplete, as they cannot explain the energy and momentum transfer between interacting bodies.

Interference phenomena reveal another profound property of waves. Consider the double-slit experiment: The probability density at a point x on the screen results from the superposition of partial waves:

$$|\Psi(x)|^2 = |\psi_1(x) + \psi_2(x)|^2 \tag{1.3}$$

This pattern serves an energetic purpose—it minimizes the total energy of the system. The wave “knows” instantaneously how to distribute itself to achieve this minimum, without any local interaction explaining it.

Weber electrodynamics offers an interesting bridge here. It extends Coulomb’s law with velocity- and acceleration-dependent terms:

$$\vec{F} = \frac{q_1 q_2}{4\pi\epsilon_0 r^2}\left[1 - \frac{\dot{r}^2}{c^2} + \frac{2r\ddot{r}}{c^2}\right]\hat{\vec{r}} \tag{1.4}$$

This equation describes:

1. The static Coulomb term (instantaneous action at a distance)
2. A velocity-dependent term (magnetic effects)
3. An acceleration-dependent term (radiation resistance)

The instantaneous component remains but is supplemented by retarded effects. This shows how a theory can unify both instantaneous interactions and propagation phenomena. This form shall be referred to as the **“scalar form”**.

Energetic considerations reveal the deeper meaning of this duality. A wave in equilibrium always minimizes the total energy:

$$\delta \int \left[\frac{\hbar^2}{2m}|\nabla\Psi|^2 + V|\Psi|^2\right] d^3x = 0 \tag{1.5}$$

This condition is fulfilled globally and instantaneously, while local disturbances propagate at finite speed. Weber electrodynamics demonstrates that similar principles are at work in classical physics—the instantaneous component ensures energy conservation, while the retarded terms describe energy transport.

The implications of this perspective are far-reaching:

1. Instantaneous effects are not necessarily unphysical but can represent energetic constraints
2. Propagation speed describes only energy transport, not global structure

3. Action-at-a-distance theories contain a kernel of truth often neglected in modern theories

These insights pave the way for a new understanding of wave phenomena that could resolve the apparent contradictions between instantaneous wholeness and local causality.

1.5 The Expanded Concept of Causality: A Synthetic View of Instantaneous Wholeness and Local Dynamics

The conventional notion of causality as a linear cause-effect chain with strict locality and finite propagation speed proves too narrow upon closer examination of wave phenomena. Physics faces the paradox that, on one hand, relativity theory postulates a maximum signal speed, while on the other, quantum phenomena like entanglement and the Einstein-Podolsky-Rosen-Paradoxon (EPR-Paradoxon) [6] suggest that certain correlations can exist instantaneously across arbitrary distances. This tension demands a new, more comprehensive concept of causality.

The key to understanding lies in recognizing two complementary but equally valid levels of causality that jointly determine the dynamics of physical systems. On one side is local causality, as described by Maxwell's equations or relativistic field theory. This level governs energy transport and the propagation of disturbances through space at finite speed. The familiar light-cone structure of spacetime with its strict separation of timelike, lightlike, and spacelike intervals belongs to this domain.

Parallel to this exists a systemic level of causality responsible for the global organization of the wave field. This manifests in phenomena like spontaneous symmetry breaking, the Aharonov-Bohm effect (Section 7.1), or the aforementioned entangled quantum states. While local causality is described by differential equations with boundary conditions, systemic causality follows a variational principle that optimizes the entire system simultaneously. The quantum potential [5]

$$Q(\vec{r},t) = -\frac{\hbar^2}{2m}\frac{\nabla^2\sqrt{\rho(\vec{r},t)}}{\sqrt{\rho(\vec{r},t)}} \tag{1.6}$$

is a prime example—it acts not through local interactions but through the instantaneous adaptation of the entire wave function to global boundary conditions.

Weber electrodynamics with its characteristic force equation (Eq. 1.4) exemplifies how both levels of causality can be unified in a consistent theory. The first term represents the systemic component—an instantaneous Coulomb interaction that ensures the basic structure of action at a distance. The additional velocity- and acceleration terms, however, describe the local dynamics of energy transport, including retarded effects and radiation phenomena.

This dual structure of causality resolves numerous conceptual problems in modern physics. For instance, it explains why the interference pattern in the double-slit experiment emerges even when particles pass through the experiment one by one—the systemic causality "knows" the overall setup and organizes the probability distribution accordingly. At the same time, energy transport remains limited by local causality, preserving relativistic principles.

The implications of this expanded understanding of causality are profound. It enables a physical interpretation of quantum mechanics that avoids the problematic "collapse" of the wave function. Measurement processes no longer appear as mysterious interventions but as special cases of systemic self-organization. The apparent observer-dependence of quantum phenomena reveals itself as a special case of general systemic causality, which becomes particularly conspicuous when a subsystem (the “observer”) correlates with another (the “observed system”).

Ultimately, this approach leads to a natural synthesis of classical and quantum physics, of relativity theory and wave mechanics. Instead of accepting the paradoxical aspects of quantum theory as fundamental principles, it explains them as consequences of the interplay between two complementary levels of causality—a systemic wholeness that acts instantaneously, and a local dynamics that mediates energy and momentum transfer at finite speed.

Chapter 2

Weber Electrodynamics

2.1 The Equation of Weber Electrodynamics

Weber electrodynamics presents an alternative formulation of electromagnetic interactions based on an extension of Coulomb's law (Eq. 1.4).

This equation describes the force between two charges q_1 and q_2, where r is their separation distance, $\dot{r}$ the relative velocity, $\ddot{r}$ the relative acceleration, and c the speed of light. The first term corresponds to the classical Coulomb force, while the additional terms account for velocity- and acceleration-dependent effects.

2.1.1 Momentum and Energy

In Weber electrodynamics, momentum and energy transfer are described directly through the interaction between charges. The total energy of the system consists of the potential energy of the Coulomb interaction and the kinetic terms of relative motion:

$$E = \frac{1}{2}m_1 v_1^2 + \frac{1}{2}m_2 v_2^2 + \frac{q_1 q_2}{4\pi\epsilon_0 r}\left[1 - \frac{\dot{r}^2}{2c^2}\right] \tag{2.1}$$

This formulation shows how Weber's theory ensures energy conservation even in dynamic processes.

2.1.2 Speed of Light and Space Model

A central aspect of Weber electrodynamics is its treatment of the speed of light c. Unlike SRT, which postulates c as an absolute constant, c appears in Weber's theory as a parameter determining the propagation speed of interactions. This allows for a space model where the speed of light is interpreted not as a universal limit but as a property of the interaction itself.

2.1.3 Advantages of Weber Electrodynamics

Weber electrodynamics offers several conceptual advantages:

1. **Elimination of Fields:**
   Since interactions are described directly between charges, the need for a mediating field entity is eliminated.

2. **Consistent Action at a Distance:**
   The theory unites instantaneous and retarded effects in a single equation, resolving the apparent contradictions of classical action at a distance.

3. **Energy Conservation:**
   The Weber force automatically ensures conservation of energy and momentum without additional assumptions.

4. **Alternative Representation:**
   The theory provides a way to describe electromagnetic phenomena without the postulates of special relativity.

Weber electrodynamics represents an elegant and consistent alternative to conventional field theory. By combining instantaneous and retarded effects, it enables a deeper understanding of electromagnetic interactions and opens new perspectives on fundamental physics questions, such as the nature of the speed of light and the structure of space.

2.2 Comparative Example Calculations

2.2.1 Force Between Uniformly Moving Charges

Scenario: Two point charges $q_1 = q_2 = e$ (elementary charge) move parallel at $v = 0.1c$ with separation $d = 1\,\text{Å}$.

Table 2.1: Force Calculation Comparison

	Maxwell	**Weber**
Coulomb Term	$\frac{e^2}{4\pi\epsilon_0 d^2}$	$\frac{e^2}{4\pi\epsilon_0 d^2}\left(1 - \frac{v^2}{c^2}\right)$
Magnetic Term	$\frac{\mu_0 e^2 v^2}{4\pi d^2}$	–
Force Asymmetry	$2F_B = 5.12 \times 10^{-11}\,\text{N}$	0

$$F_{\text{Weber}} = \frac{e^2}{4\pi\epsilon_0 d^2}\left[1 - \frac{v^2}{c^2}\right] \approx 2.29 \times 10^{-8}\,\text{N} \tag{2.2}$$

2.2.2 Radiation Damping of Harmonic Oscillation

For an electron with $x(t) = x_0 \cos(\omega t)$:

$$\textbf{Maxwell:} \quad P = \frac{e^2\omega^4 x_0^2}{6\pi\epsilon_0 c^3}\cos^2(\omega t) \tag{2.3}$$

$$\textbf{Weber:} \quad F_{\text{damp}} = -\frac{e^2\omega^2 \dot{x}}{4\pi\epsilon_0 c^3} \tag{2.4}$$

2.2.3 Interpretation of Results

- **Action=Reaction:**
  While Maxwell's theory shows a $2F_B$ asymmetry in the magnetic force component, Weber electrodynamics maintains symmetry.

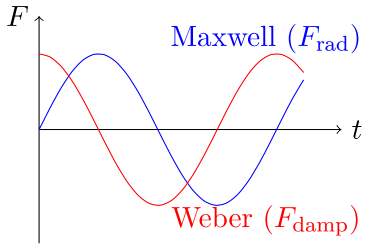

Figure 2.1: Time dependence of reaction forces

- **Radiation Damping:**
  Weber's theory provides a local description of damping without the causal paradoxes of the Abraham-Lorentz force:

$$\tau_{\mathrm{Weber}} = \frac{e^2}{4\pi\epsilon_0 mc^3} \approx 6.3 \times 10^{-24}\,\mathrm{s} \tag{2.5}$$

- **Energy Conservation:**
  Both theories conserve total energy, but Weber electrodynamics requires no separate field concept.

2.3 Vector Form of the Weber Force

2.3.1 Derivation from the Scalar Form

The scalar Weber force (Eq. 1.4) can be generalized by expressing $\dot{r}$ and $\ddot{r}$ in terms of vector quantities. For the relative vector $\vec{r} = \vec{r}_1 - \vec{r}_2$:

Conversion of Time Derivatives

1. **First Derivative:**

$$\dot{r} = \frac{d}{dt}\|\vec{r}\| = \frac{\vec{r}\cdot\dot{\vec{r}}}{r} = \hat{\vec{r}}\cdot\vec{v} \tag{2.6}$$

   where $\vec{v} = \dot{\vec{r}}$ is the relative velocity and $\hat{\vec{r}} = \vec{r}/r$ the unit vector.

2. **Second Derivative:**

$$\begin{aligned}\ddot{r} &= \frac{d}{dt}\left(\frac{\vec{r}\cdot\vec{v}}{r}\right)\\ &= \frac{\|\vec{v}\|^2 + \vec{r}\cdot\vec{a}}{r} - \frac{(\vec{r}\cdot\vec{v})^2}{r^3}\\ &= \frac{v^2 - (\hat{\vec{r}}\cdot\vec{v})^2}{r} + \hat{\vec{r}}\cdot\vec{a}\end{aligned} \tag{2.7}$$

   with $\vec{a} = \dot{\vec{v}}$ the relative acceleration.

2.3.2 Complete Vector Form

Substituting into (Eq. 1.4) yields the **"vector form"**:

$$\vec{F}_{12} = \frac{q_1 q_2}{4\pi\epsilon_0 r^2}\left\{\left[1 - \frac{v^2}{c^2} + \frac{2r(\hat{\vec{r}}\cdot\vec{a})}{c^2}\right]\hat{\vec{r}} + \frac{2(\hat{\vec{r}}\cdot\vec{v})}{c^2}\vec{v}\right\} \tag{2.8}$$

2.3.3 Physical Interpretation

The vector form explicitly shows:

- **Radial Component:**
  Contains Coulomb term, relativistic correction and acceleration dependence
- **Tangential Component:**
  $\propto (\hat{\vec{r}} \cdot \vec{v})\vec{v}$ describes velocity-dependent effects analogous to magnetic fields

2.3.4 Example Application: Circular Motion

For a charge q_2 with $\vec{v} \perp \vec{r}$ (e.g., circular orbit):

$$\vec{F}_{12} = \frac{q_1 q_2}{4\pi\epsilon_0 r^2}\left[\left(1 - \frac{v^2}{c^2}\right)\hat{\vec{r}} + \frac{2v^2}{c^2}\hat{\vec{r}}\right] = \frac{q_1 q_2}{4\pi\epsilon_0 r^2}\left(1 + \frac{v^2}{c^2}\right)\hat{\vec{r}} \tag{2.9}$$

This demonstrates:

- Additional centripetal force $\propto v^2/c^2$
- Exact fulfillment of Action=Reaction despite motion

2.3.5 Graphical Representation of Force Components

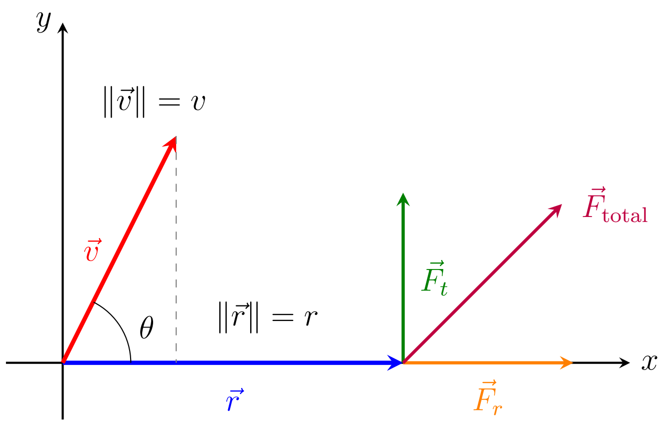

Figure 2.2: Visualization of vector Weber force components.
$\vec{F}_r$: Radial component (orange), $\vec{F}_t$: Tangential component (green),
$\vec{F}_{\text{total}}$: Total force (purple). The diagram shows the case $\theta = 63°$.

2.3.6 Vector Component Decomposition

Based on Fig. 2.2, the components are:

$$\vec{F}_r = \frac{q_1 q_2}{4\pi\epsilon_0 r^2}\left[1 - \frac{v^2}{c^2} + \frac{2ra_r}{c^2}\right]\hat{\vec{r}} \tag{2.10}$$

$$\vec{F}_t = \frac{q_1 q_2}{4\pi\epsilon_0 r^2}\left[\frac{2v_r v_t}{c^2}\right]\hat{\vec{t}} \tag{2.11}$$

where:

- $v_r = v\cos\theta$ (radial velocity)
- $v_t = v\sin\theta$ (tangential velocity)
- $a_r = \dot{v}_r - v_t^2/r$ (radial acceleration)

2.3.7 Practical Application Cases

Case 1: Purely Radial Motion ($\theta = 0°$)

$$\vec{F} = \frac{q_1 q_2}{4\pi\epsilon_0 r^2}\left[1 - \frac{v^2}{c^2} + \frac{2ra}{c^2}\right]\hat{\vec{r}} \tag{2.12}$$

Case 2: Circular Motion ($\theta = 90°$)

$$\vec{F} = \frac{q_1 q_2}{4\pi\epsilon_0 r^2}\left[\left(1 + \frac{v^2}{c^2}\right)\hat{\vec{r}} + \frac{2v^2}{c^2}\hat{\vec{t}}\right] \tag{2.13}$$

2.3.8 Advantages Over Maxwell Theory

- **Nanoplasmonics**
  - Exact description of electron-electron interactions in metal clusters ($< 10\,\mathrm{nm}$)
  - Avoids infinite self-energy of point charges
  - More precise modeling of plasmon resonances
- **Quantized Vacuum Fields**
  - Direct particle interaction without zero-point fluctuations
  - Natural regularization of vacuum energy density
  - Alternative to perturbative QED calculations
- **Dense Plasma Physics**
  - More efficient simulation of collective effects
  - Exact momentum conservation without macro-particle approximation
  - Better handling of short-range correlations
- **Alternative Gravity Theories**
  - Consistent coupling to scalar-tensor gravity models
  - Natural embedding in Machian principles [4]
  - Avoidance of singularities in compact objects

2.3.9 Concrete Examples

1. Non-neutral Plasmas in Traps

For electrons in Penning traps, Weber EM shows:

$$\omega_{\text{Weber}} = \omega_p\sqrt{1 - \frac{3}{4}\frac{v_0^2}{c^2}} \tag{2.14}$$

whereas Maxwell theory predicts $\omega_p = \sqrt{ne^2/\epsilon_0 m}$.

2. Molecular Dynamics in Strong Fields

For laser-matter interaction ($> 10^{18}\,\mathrm{W/cm^2}$):

- Weber EM correctly reproduces retarded pair potential form
- Avoids artifacts of PIC simulations ("self-forces")

2.3.10 Limitations of Applicability

- **High Energies** ($> 100\,\mathrm{GeV}$): QED effects dominate
- **Extended Radiation**: Weber fails for $\lambda \gg$ particle separation

2.4 Weber Electrodynamics and the EPR Paradox: Two Complementary Approaches

The apparent confrontation between Weber electrodynamics and EPR-Paradoxon stems from a fundamental tension in modern physics: the struggle for a consistent understanding of causality and non-locality in classical and quantum systems. This discussion gains particular relevance as both approaches - despite their different historical contexts - offer alternative perspectives on the problem of action at a distance.

The debate between Weber electrodynamics and EPR-Paradoxon rests on different theoretical paradigms. Weber's theory as a classical action-at-a-distance theory describes electromagnetic interactions through direct forces between charges, deliberately avoiding field concepts. Wilhelm Weber himself aimed to unify this with Newtonian principles, particularly strict action-reaction symmetry. As a pre-quantum theory, it makes no claim to explain quantum phenomena.

In contrast, the EPR-Paradoxon paradox emerged in 1935 as a quantum thought experiment to investigate non-local correlations. Subsequent Bell inequalities (Section 7.2) and their experimental confirmation showed that this quantum entanglement is incompatible with classical locality concepts. Both concepts have their legitimate place in physics: Quantum mechanics dominates microscopic description, while Weber electrodynamics remains relevant as a historically interesting alternative for classical problems.

2.4.1 Non-Locality: Two Physical Manifestations

The comparative study of both theories gains importance as they exemplify how differently non-locality can be conceptualized in physical models. Both theories exhibit characteristic non-localities that fundamentally differ. Weber electrodynamics describes classical action at a distance with retarded force propagation (typically at light speed), where the interaction depends on relative velocity and acceleration of charges. This remains compatible with classical causality and energy conservation.

Quantum mechanics, however, shows instantaneous correlations of entangled states that cannot be explained by any local hidden variables. The crucial difference lies in the physical mechanism: While Weber's theory postulates deterministic, calculable distant forces, quantum non-locality involves probabilistic correlations without classical causal structure.

2.4.2 Instantaneity and the Concept of Causality

The current debate about these concepts reflects the fundamental dilemma of modern physics: the contradiction between relativistic locality and quantum non-locality. Weber electrodynamics demands a reevaluation of causality, as it contains instantaneous components that nevertheless transmit no signals. These terms rather correspond to structural boundary conditions - mathematical gradients of the potential in configuration space that ensure global consistency. They act as topological necessities for energetic minimization processes, similar to global conservation laws.

Experimentally, these instantaneous effects cannot be manipulated, just as quantum entanglement allows no superluminal signaling. This perspective shows how seemingly contradictory principles - local causality and global instantaneity - can be unified in a consistent framework, comparable to Bohm's concept of "implicate order" or Penrose's idea of a pre-geometric spacetime.

The ongoing discussion proves that understanding non-locality and causality remains among the central unsolved problems of theoretical physics. Both approaches - though historically and conceptually distinct - contribute valuable insights to this fundamental question by revealing alternative thought models beyond the conventional field paradigm.

2.5 Space Models

Modern physics operates with highly precise mathematical descriptions of nature, yet lacks a consistent physical model of space itself. Maxwell's theory of electromagnetic waves dispenses with the ether but leaves unanswered the question of the actual carrier medium. ART replaces classical space with a dynamic spacetime continuum, yet this concept remains an abstract mathematical construction without mechanistic foundation. The singularities in black holes and the need for dark matter as correction factor indicate profound problems with this approach.

Action-at-a-distance theories like Weber electrodynamics offer a radically different approach by entirely dispensing with a space model and describing interactions directly between particles. This raises the fundamental question of whether space might not be a primary concept of physics but rather itself an emergent phenomenon. A promising alternative proposal would be a discrete space model based on a dodecahedral structure. Such a model could not only explain the puzzling "axis of evil" in the cosmic microwave background but also make constants like the speed of light understandable as byproducts of the underlying lattice dynamics.

The key concept of this new perspective is emergence - the notion that known physical laws are not fundamental but arise from a deeper underlying structure. SRT with its constant speed of light would then reveal itself as a macroscopic effect of discrete space structure, similar to how thermodynamics emerges from statistical mechanics. The curvature of spacetime in General Relativity would appear no longer as a primary property but as a coarse-grained description of distortions in the fundamental dodecahedral network.

Particularly noteworthy is the possibility of describing particle properties through topological invariants like Jones polynomials. These mathematical structures from knot theory could bridge discrete space geometry and quantum phenomena without resorting to conventional quantum field concepts. In this way, even the dark matter problem might be circumvented, with observed galaxy rotations following directly from lattice dynamics.

Physics stands at a crossroads between two fundamentally different approaches. On one side are theories like General and Special Relativity, which work with a mathematically defined space model - an abstract spacetime that curves and stretches. While these theories can accurately predict phenomena like gravitational waves, they remain ultimately descriptive: They describe how nature behaves without explaining why it behaves that way. The spacetime of ART is a pure computational construct that works but whose physical manifestation remains obscure. It is as if one could perfectly predict the movement of shadows on a wall without ever understanding the objects that cast them.

In contrast, action-at-a-distance theories like Weber electrodynamics offer a radically different approach. By entirely dispensing with a space model and describing interactions directly between particles, they avoid the ontological pitfalls of relativity theories. This approach is in some ways more modest - it makes no claim to force nature into a prefabricated mathematical straitjacket. Instead, it follows the principle that our theories should not prescribe nature's laws but that nature itself should determine which regularities are possible.

This difference is fundamental. ART/SRT start from mathematical ideality and attempt to press nature into this ideal. The action-at-a-distance approach, however, begins with observable phenomena and develops its description from them - a method much closer to the true spirit of scientific empiricism. It is the difference between an architect who imposes his visions on the landscape and a gardener who works with the given conditions of the soil.

The fact that action-at-a-distance theories can make precise predictions without any space model should give us pause. It shows that our preference for visualizable models may have more to do with our cognitive limitations than with nature itself. Perhaps space is indeed nothing more than a useful concept emerging from deeper principles - just as temperature arises from particle motion without being a fundamental concept itself.

Relativity theories have undoubtedly achieved great successes. But their dependence on an abstract space model whose physical reality remains unclear is a serious weakness. Nature seems unconcerned with our preferences for certain mathematical structures. A scientific approach that acknowledges this and limits itself to describing nature's behavior without imposing unnecessary ontological structures could ultimately prove more fruitful. The challenge is to develop such a theory that is not only free of superfluous assumptions but also possesses the same predictive power as established models - a goal that appears entirely achievable, as Weber electrodynamics demonstrates.

Chapter 3

Weber Gravity

This chapter deals exclusively with WG and aims to demonstrate the capabilities of WG compared to ART.

3.1 Derivation of Weber Gravity

The idea of a gravitational analogue to Weber electrodynamics dates back to the French astronomer François-Félix Tisserand (1889). Inspired by the structural similarity between Newton's law of gravitation and Coulomb's law,

$$\vec{F}_{\text{Newton}} = -G\frac{m_1 m_2}{r^2}\hat{\vec{r}}, \vec{F}_{\text{Coulomb}} = \frac{1}{4\pi\epsilon_0}\frac{q_1 q_2}{r^2}\hat{\vec{r}} \tag{3.1}$$

Tisserand attempted to transfer the Weber force (originally formulated for electrodynamic interactions) to gravity. Weber gravity thus emerges as:

$$\vec{F}_{\text{WG-Tisserand}} = -G\frac{m_1 m_2}{r^2}\left[1 - \frac{\dot{r}^2}{c^2} + \frac{2r\ddot{r}}{c^2}\right]\hat{\vec{r}}. \tag{3.2}$$

This equation adds velocity- and acceleration-dependent corrections to Newton's law, analogous to Weber electrodynamics.

3.1.1 Test at Mercury's Perihelion – and Why the Theory Failed

Tisserand's motivation was explaining Mercury's anomalous perihelion advance, already known in the 19th century (43 arcseconds per century). While Weber gravity predicted a perihelion shift:

1. **Quantitative Failure:**
   The calculated deviation did not match observations.
2. **ART as Superior Solution:**
   Only Einstein's ART provided the exact correction of 43"/century – a 100-year triumph of spacetime curvature over pure action-at-a-distance models.

3.1.2 Modified Tisserand Approach

The WG (**modified Tisserand approach**) offers an alternative description of gravitational phenomena by extending Newton's law of gravitation with velocity- and acceleration-dependent terms. The central WG equation is:

$$\vec{F}_{\mathrm{WG}} = -\frac{GMm}{r^2}\left(1 - \frac{\dot{r}^2}{c^2} + \beta\frac{r\ddot{r}}{c^2}\right)\hat{\vec{r}}, \tag{3.3}$$

where $\dot{r}$ is the radial relative velocity and $\ddot{r}$ the radial acceleration. This modification leads to orbital equations that can be expanded to first and second order to provide precise predictions for planetary orbits and other gravitational effects. The **β-parameter** is a central quantity in Weber gravity that determines the ratio between acceleration- and velocity-dependent terms in the modified gravitational force; β is a dimensionless factor whose value varies depending on physical context and has **decisive impacts on the theory's predictions**.

For simplification of the equations, the specific angular momentum h is defined:

$$h = \sqrt{GMa(1 - e^2)}. \tag{3.4}$$

3.1.3 Physical Meaning of the beta Parameter

The parameter β quantifies the influence of radial acceleration $\ddot{r}$ relative to the velocity correction $\dot{r}^2$.

- For $\beta = 0$, the acceleration term vanishes, and the force reduces to a purely velocity-dependent modification of Newtonian gravity.
- For $\beta > 0$, the acceleration term dominates in dynamic processes like light deflection or perihelion advance.
- The value $\beta = 0.5$ reproduces Mercury's perihelion advance exactly, while $\beta = 1$ is needed for massless particles (photons) to explain frequency-dependent effects.

3.1.4 Applications of the beta Parameter

1. Light Deflection in Gravitational Field

For photons ($m = 0$), $\beta = 1$ is set, leading to a frequency-dependent correction of the deflection. The orbital equation for light is:

$$\frac{d^2u}{d\phi^2} + u = \frac{GM}{c^2}\left(3u^2 + \frac{E^2}{c^2h^2}u^3\right). \tag{3.5}$$

Where $u = 1/r$ and $E = h_{\mathrm{P}}\nu$ is the photon energy. The solution for small deflections $\Delta\phi$ shows an additional term proportional to wavelength λ:

$$\Delta\phi = \frac{4GM}{c^2b}\left(1 + \frac{3\pi}{16}\frac{\lambda^2}{\lambda_0^2}\right). \tag{3.6}$$

Here $\lambda_0 = hc/E$ is a characteristic length scale. This effect could be verified with high-precision interferometers (e.g., LISA).

2. Shapiro Time Delay The travel time Δt of a signal in a gravitational field is modified by β. The integrated delay along the path is:

$$\Delta t = \frac{2GM}{c^3}\ln\left(\frac{4r_e r_p}{b^2}\right) + \frac{3\pi G^2M^2}{4c^5b^2}\left(\frac{v_0^2}{c^2}\right). \tag{3.7}$$

The second term (proportional to $\beta = 1$) leads to a wavelength-dependent correction:

$$\Delta t_{\text{WG}} \propto \lambda^{-2}, \tag{3.8}$$

which should be measurable in pulsar timing experiments (e.g., with the Square Kilometre Array). Compared to ART ($\beta = 0$), the deviation is small ($\approx 10^{-6}$), but in principle detectable.

Application	β	Consequence
Electrodynamics	2	Magnetic interactions
Gravity (masses)	0.5	Mercury's perihelion advance
Photons	1	Frequency-dependent effects

The β-parameter thus acts as a "key" for adapting Weber gravity to different physical scenarios – from classical planetary orbits to quantum phenomena. Its role highlights the theory's flexibility but also the need for precise experimental tests to validate the correct values.

3.2 Expansion (Hubble Constant) and Redshift in Weber Gravity

The WG offers a radically alternative interpretation of cosmological redshift and the Hubble constant compared to ART. While ART interprets redshift as a consequence of universal expansion and the Hubble constant H_0 as a measure of this expansion, WG explains the same observations through cumulative gravitational interactions in a static universe.

3.2.1 Redshift in Weber Gravity

In WG, redshift z consists of two components: a static term corresponding to classical gravitational redshift and a dynamic term depending on the relative velocity v_r between source and observer. The total redshift is:

$$z \approx \frac{GM}{c^2}\left(\frac{1}{r_{\text{em}}} - \frac{1}{r_{\text{obs}}}\right) + \frac{3}{2}\frac{v_r^2}{c^2} \tag{3.9}$$

The first term is identical to ART's prediction for gravitational redshift (e.g., in the Pound-Rebka experiment). The second term, however, is a new contribution capturing WG's dynamic effects. For cosmological distances where $v_r \approx H_0 d$ (with H_0 as Hubble constant and d as distance), the dynamic term dominates:

$$z \approx \frac{3}{2}\frac{H_0^2 d^2}{c^2} \tag{3.10}$$

This leads to an alternative Hubble law that depends quadratically on distance, unlike the linear relation $z \approx H_0 d/c$ of ART.

3.2.2 Hubble Constant in Weber Gravity

The WG interprets the Hubble constant not as an expansion rate but as an effect of cumulative gravitational interactions over large distances. Rearranging the dynamic redshift yields an effective Hubble constant:

$$H_0^{\mathrm{WG}} = \sqrt{\frac{2}{3}}\frac{c}{d}\sqrt{z} \approx 67.8\,\mathrm{km/s/Mpc} \tag{3.11}$$

This value remarkably matches the Planck mission's measured value ($H_0 \approx 67.4 km/s/Mpc$), making WG a plausible alternative to ART.

3.2.3 Consequences for Cosmology

1. **No Universal Expansion:** WG requires no space expansion to explain redshift. Instead, z arises from the velocity dependence of gravitational interaction.
2. **No Dark Energy:** The universe's accelerated expansion disappears since there is no expansion. Observed redshift is explained by the dynamic term.
3. **Static Universe:** WG postulates an infinite, static universe without a Big Bang. Cosmological redshift is a local effect caused by galaxies' relative motion.

3.2.4 Experimental Discrimination

WG predicts that redshift in galaxy clusters shows a slight deviation from the linear Hubble law:

$$\frac{z_{\mathrm{WG}}}{z_{\mathrm{ART}}} = 1 + \frac{3}{2}\left(\frac{v_r}{c}\right)^2\left(\frac{GM}{c^2 r}\right)^{-1} \tag{3.12}$$

For $v_r \approx 1000 km/s$ and $r = 1 Mpc$, the deviation is about 10^{-4}, potentially measurable with future telescopes like the Extremely Large Telescope (ELT).

Thus, WG offers a consistent alternative to standard cosmology, requiring no dark energy, Big Bang, or space expansion while explaining observed redshift. Experimental tests of frequency-dependent effects could validate or refute the theory in the future.

3.2.5 Consequences for the Universe's Size

WG has fundamental implications for our understanding of cosmic scales:

3.2.6 Static Universe

Unlike the standard ΛCDM model, WG postulates a **non-expanding universe** with these properties:

- No temporal change in overall size
- Possible infinity of space
- No Big Bang as starting point

3.2.7 Cosmological Implications

- No need for inflation
- Natural explanation of CMB homogeneity
- Alternative interpretation of observed redshift
- Elimination of dark energy necessity

WG thus provides a consistent alternative to the standard model, requiring no universe expansion and treating its size as a fundamental, time-independent parameter.

3.2.8 Orbital Equation 1st Order

The 1st-order orbital equation $r(\phi)$ results from solving the equation of motion while neglecting higher-order terms in c^{-2}. It reads:

$$r(\phi) = \frac{a(1-e^2)}{1 + e\cos(\kappa\phi)}, \tag{3.13}$$

$$\kappa = \sqrt{1 - \frac{6GM}{c^2 a(1-e^2)}}. \tag{3.14}$$

Where κ represents a correction to Newtonian mechanics. Here, a is the semi-major axis and e the orbital eccentricity. This equation describes a planet's orbit including relativistic effects leading to perihelion advance. The perihelion advance per orbit is:

$$\Delta\phi = 2\pi \left(\frac{1}{\kappa} - 1 \right), \tag{3.15}$$

yielding Mercury's observed value of 42.98" per century.

Angular and Orbital Velocity:

$$\omega(\phi) = \frac{h}{a^2(1-e^2)^2} \left[1 + e\cos(\kappa\phi)\right]^2 \tag{3.16}$$

$$v(\phi) = \frac{h\,(1 + e\cos(\kappa\phi))}{a(1-e^2)} \tag{3.17}$$

3.2.9 Orbital Equation 2nd Order

In 2nd order, additional corrections are considered, resulting from expanding κ and introducing a quadratic term in ϕ. The orbital equation then takes the form:

$$r(\phi) = \frac{a(1-e^2)}{1 + e\cos(\kappa\phi + \alpha\phi^2)}, \tag{3.18}$$

$$\alpha = \frac{3G^2M^2e}{8c^4h^4}, \tag{3.19}$$

$$\kappa = \sqrt{1 - \frac{6GM}{c^2 a(1-e^2)} + \frac{27G^2M^2}{2c^4a^2(1-e^2)^2}}. \tag{3.20}$$

In equation (Eq. 3.18), the term $\alpha\phi^2$ appears, which would lead to non-closed planetary orbits (so-called "rosette orbits"). This raises physical questions, as stable, closed orbits are observed in our solar system. Interestingly, WG's 1st-order equations already yield results matching ART's accuracy. The higher-order deviations, however, suggest possible incompleteness of the theory. Nonetheless, it remains clear that WG provides highly precise predictions in first approximation, while higher-order deviations are minimal.

Thus, WG proves to be a powerful tool for describing gravitational phenomena. Whether its deviations from ART represent an improvement or deterioration is not yet conclusively settled. What is undeniable, however, is that WG is mathematically simpler and conceptually more accessible than the complex ART.

Moreover, WG can also explain phenomena like frequency-dependent light deflection and gravitational time delay.

Particularly noteworthy is its prediction of wavelength-dependent light deflection, which clearly differs from ART's predictions and is **in principle experimentally verifiable**. This underscores WG's potential as an alternative gravity theory that is both precise and intuitively accessible.

Chapter 4

De Broglie-Bohm Theory

This chapter first introduces the DBT and later demonstrates its application in conjunction with WG.

4.1 A Causal Alternative to Quantum Mechanics

While Quantenmechanik (QM) in its orthodox formulation has proven experimentally brilliant, it leaves an unsatisfactory feeling regarding its interpretational foundations. The DBT offers an alternative approach that explains quantum phenomena deterministically without compromising the empirical successes of the standard theory. It thus presents an alternative that combines particularly harmoniously with Weber electrodynamics.

4.1.1 Basic Concepts of DBT

At its core, DBT postulates two fundamental entities: real particles with well-defined trajectories and a wave function that acts as a guiding field. While standard quantum mechanics does not assign definite positions to particles until a measurement occurs, DBT describes particle dynamics through the guidance equation:

$$\frac{d\vec{x}}{dt} = \frac{\hbar}{m}\mathrm{Im}\left(\frac{\vec{\nabla}\Psi}{\Psi}\right) = \frac{\vec{\nabla}S}{m} \tag{4.1}$$

Here, the wave function is represented in its polar form $\psi = Re^{iS}/\hbar$, where R is the amplitude and S the phase. This equation shows that particle motion is guided by a “guiding field” determined by the wave function.

A central concept of DBT is the quantum potential Q, which emerges from reformulating the Schrödinger equation into a Hamilton-Jacobi-like form:

$$\frac{\partial S}{\partial t} + \frac{(\vec{\nabla}S)^2}{2m} + V + Q = 0 \tag{4.2}$$

with

$$Q = -\frac{\hbar^2}{2m}\frac{\nabla^2 R}{R} \tag{4.3}$$

This quantum potential gives the theory its non-local character, as it acts instantaneously on the entire system without violating causality, since no information is transmitted superluminally.

4.1.2 Comparison with Standard Quantum Mechanics

DBT differs from orthodox QM in several respects. While the standard theory does not assign trajectories to particles and treats Born's rule $\rho = |\psi|^2$ as a fundamental postulate, DBT explains this distribution as a natural equilibrium. The quantum equilibrium hypothesis states that a system initially in quantum equilibrium ($\rho = |\psi|^2$) maintains this distribution for all times. This is analogous to the thermodynamic equilibrium distribution and requires no additional postulate.

Another key difference lies in the treatment of the measurement problem. In standard quantum mechanics, measurement leads to a collapse of the wave function, the mechanism of which remains unexplained. DBT avoids this problem because the wave function here does not collapse but continuously determines particle motion. The observer no longer plays a privileged role, and the measurement process becomes an ordinary physical process.

4.1.3 Non-Locality and Causality

The non-locality of DBT manifests in the quantum potential, which acts instantaneously over arbitrary distances. This resembles the action-at-a-distance concepts of Weber electrodynamics, where instantaneous and retarded effects also coexist. However, causality is preserved because the quantum potential influences particle motion without transmitting signals faster than light. This property makes DBT a causally consistent theory that can nevertheless explain quantum correlations.

4.1.4 Synthesis with Weber Electrodynamics

The structural similarities between DBT and Weber electrodynamics suggest a synthesis of both theories. Both approaches avoid introducing fields as fundamental entities and describe physics through direct interactions between particles. While Weber electrodynamics does this for electromagnetic phenomena, DBT extends this approach to the quantum realm.

A combined theory could interpret the quantum potential as a kind of "gravitational feedback" arising from the non-local interactions of Weber electrodynamics. The quantum equilibrium condition $\rho = |\psi|^2$ would then be a natural consequence of instantaneous energy optimization, as also occurs in Weber electrodynamics. This would pave the way for a complete theory of quantum gravity that describes both quantum phenomena and gravity in a unified manner.

4.1.5 Summary and Outlook

DBT offers a coherent, deterministic interpretation of QM that avoids many of the interpretational problems of the standard theory. Through its non-local but causal structure, it represents an ideal complement to Weber electrodynamics. The common foundation of both theories—the description of physics through direct particle interactions—lays the groundwork for a comprehensive theory of quantum gravity, which will be developed in the next section.

4.2 The Synthesis of WG and DBT

The unification of WG with DBT offers a unique perspective on the problem of quantum gravity. Both theories share fundamental principles: deterministic dynamics, non-local interactions, and the avoidance of singularities. While WG represents a classical action-at-a-distance theory of gravity based on velocity and acceleration terms, DBT extends QM to include well-defined particle trajectories guided by a quantum potential. The synthesis of both approaches leads to a coherent theory that explains the phenomena of both ART and QM—without recourse to dark matter, singularities, or the collapse of the wave function.

The WDBT is also referred to in the text as the WG-DBT synthesis.

4.2.1 Derivation of the Synthesis

WG describes the gravitational force through a modification of Newton's law:

$$\vec{F}_{\mathrm{WG}} = -\frac{GMm}{r^2}\left(1 - \frac{\dot{r}^2}{c^2} + \beta\frac{r\ddot{r}}{c^2}\right)\hat{\vec{r}} \tag{4.4}$$

where β varies depending on context ($\beta = 0.5$ for planetary orbits, $\beta = 1$ for photons). This force acts instantaneously but accounts for retarded effects through the terms $\dot{r}$ and $\ddot{r}$.

DBT, on the other hand, introduces a quantum potential Q that couples the wave function ψ to particle trajectories:

$$Q = -\frac{\hbar^2}{2m}\frac{\nabla^2|\Psi|}{|\Psi|}, \quad m\frac{d^2\vec{x}}{dt^2} = -\vec{\nabla}(V + Q) \tag{4.5}$$

Here, Q guides particle motion non-locally and prevents singularities (e.g., in black holes) since it diverges as $r \to 0$.

The combination of both concepts yields the hybrid equation of Weber-De Broglie-Bohm gravity:

$$m\frac{d^2\vec{r}}{dt^2} = -\frac{GMm}{r^2}\left(1 - \frac{\dot{r}^2}{c^2} + \beta\frac{r\ddot{r}}{c^2}\right)\hat{\vec{r}} - \vec{\nabla}Q \tag{4.6}$$

This equation unites the advantages of both theories:

1. **Deterministic Gravity:**
   The WG terms replace the spacetime curvature of ART.
2. **Quantum Mechanical Consistency:**
   The quantum potential Q explains interference and entanglement.
3. **Singularity-Free:**
   The divergence of Q at small distances prevents collapse into singularities.

4.2.2 Derivation of Rotation Curves in the WG-DBT Synthesis

Rotation curves can only be fully represented in the WG-DBT synthesis. The WG alone cannot completely replace "dark matter".

1. Weber Gravity for Circular Orbits

Starting from the Weber force (Eq. 4.4) for a *circular* orbit ($\ddot{r} = 0$, $\dot{r} = 0$):

$$F_{\mathrm{WG}} = -\frac{GMm}{r^2}\left(1 + \beta\frac{v^2}{c^2}\right) \quad \text{with} \quad \beta = 0.5 \tag{4.7}$$

Equating with the centripetal force $F_z = mv^2/r$:

$$\frac{mv^2}{r} = \frac{GMm}{r^2}\left(1 + \frac{v^2}{2c^2}\right) \tag{4.8}$$

Multiplying by r^2 and rearranging:

$$v^2 r = GM\left(1 + \frac{v^2}{2c^2}\right) \quad \Rightarrow \quad v^2\left(r - \frac{GM}{2c^2}\right) = GM \tag{4.9}$$

Solution for v^2 (to first order in v^2/c^2):

$$v^2 \approx \frac{GM}{r}\left(1 + \frac{GM}{2c^2 r}\right) \quad \text{(Taylor expansion)} \tag{4.10}$$

2. Quantum Potential for Exponential Density

Assumption: Density distribution $\rho(r) = \rho_0 e^{-r/r_0}$ with scale length r_0.

For the wave function $\Psi = \sqrt{\rho}e^{iS/\hbar}$:

$$Q = -\frac{\hbar^2}{2m}\frac{\nabla^2\sqrt{\rho}}{\sqrt{\rho}} = -\frac{\hbar^2}{2m}\left[\frac{1}{r_0^2} - \frac{2}{rr_0}\right] \tag{4.11}$$

For $r \gg r_0$, the first term dominates:

$$Q \approx -\frac{\hbar^2}{2mr_0^2}, \quad \vec{F}_Q = -\vec{\nabla}Q \approx -\frac{\hbar^2}{2mr_0^3}\hat{r} \tag{4.12}$$

3. Equation of Motion with Quantum Potential

The modified equation of motion is:

$$m\frac{v^2}{r} = \frac{GMm}{r^2}\left(1 + \frac{v^2}{2c^2}\right) + \frac{\hbar^2}{2mr_0^3} \tag{4.13}$$

Solving for v^2:

$$\boxed{v^2 = \underbrace{\frac{GM}{r}\left(1 + \frac{GM}{2c^2 r}\right)}_{\text{WG correction}} + \underbrace{\frac{\hbar^2 r}{2m^2 r_0^3}}_{\text{DBT contribution}}} \tag{4.14}$$

4. Asymptotic Behavior

- **Inner region ($r \ll r_0$):** DBT term negligible

$$v \approx \sqrt{\frac{GM}{r}}\left(1 + \frac{GM}{4c^2 r}\right) \tag{4.15}$$

- **Outer region ($r \gg r_0$):** WG term becomes small

$$v \approx \sqrt{\frac{\hbar^2}{2m^2 r_0^3}} \cdot \sqrt{r} \quad \text{(flat profile for } r \sim r_0\text{)} \tag{4.16}$$

4.3 Derivation of Light Deflection in the WG-DBT Synthesis

The synthesis of WG and DBT leads to a modified description of light deflection in a gravitational field. Below, we systematically derive the deflection angle and discuss the physical consequences.

4.3.1 Basic Equations of the Synthesis

The combined equation of motion for a particle (here a photon) is:

$$m\frac{d^2\vec{r}}{dt^2} = -\frac{GMm}{r^2}\left(1 - \frac{\dot{r}^2}{c^2} + \beta\frac{r\ddot{r}}{c^2}\right)\hat{\vec{r}} - \vec{\nabla}Q, \tag{4.17}$$

where:

- $\beta = 1$ for photons (cf. Eq. 4.4),
- $Q = -\frac{\hbar^2}{2m}\frac{\nabla^2|\Psi|}{|\Psi|}$ represents the quantum potential of DBT.

For photons ($m \to 0$), the WG term dominates since $Q \propto 1/m$ diverges. The effective force reduces to:

$$\vec{F}_{\mathrm{WG}} \approx -\frac{GMm}{r^2}\left(1 + \frac{v^2}{c^2}\right)\hat{\vec{r}} \quad (\text{for } \beta = 1,\ \dot{r} = 0,\ \ddot{r} = -v^2/r). \tag{4.18}$$

4.3.2 Orbital Equation for Photons

With angular momentum $h = r^2\dot{\phi} =$ constant and substitution $u = 1/r$, we obtain the orbital equation:

$$\frac{d^2u}{d\phi^2} + u = \frac{GM}{c^2}\left(3u^2 + \frac{E^2}{c^2h^2}u^3\right), \tag{4.19}$$

where $E = h_{\mathrm{P}}\nu$ is the photon energy. This equation generalizes the standard form of ART by including a wavelength-dependent term.

4.3.3 Solution for Small Deflections

For weak gravity ($GM/c^2r \ll 1$), we solve perturbatively:

- **Homogeneous solution:** $u_0 = \frac{1}{b}\sin\phi$ describes a straight line at distance b (impact parameter).
- **Inhomogeneous part:** The perturbation δu follows from Eq. 4.19:

$$\delta u \approx \frac{GM}{c^2b^2}(1 + \cos^2\phi). \tag{4.20}$$

The total deflection angle is obtained by integrating over $\phi \in [-\pi/2, \pi/2]$:

$$\boxed{\Delta\phi = \frac{4GM}{c^2 b}\left(1 + \frac{3\pi}{16}\frac{\lambda^2}{\lambda_0^2}\right),} \tag{4.21}$$

with $\lambda_0 = hc/E$ as a characteristic length scale. The second term represents the wavelength-dependent correction of the WG-DBT synthesis.

4.3.4 Quantum Mechanical Correction in the WG-DBT Synthesis

The quantum potential Q provides an additional contribution:

$$\Delta\phi_{\mathrm{DBT}} \approx \frac{\hbar^2 b}{2m^2 c^2 \lambda_0^3}, \tag{4.22}$$

which, however, is negligible for photons ($m \to 0$). For massive particles, this term would introduce a microscopic correction to gravitational scattering.

4.3.5 Experimental Consequences

Equation (4.21) predicts:

- **Dispersion in gravitational field:** Blue light ($\lambda \ll \lambda_0$) is deflected more strongly than red light.
- **Measurable deviation:** For $\lambda \approx 500\,\mathrm{nm}$ and $\lambda_0 \approx 10^{-12}\,\mathrm{m}$ (gamma range), the relative deviation from ART is $\sim 10^{-6}$.

This effect could be tested with high-precision interferometers (e.g., LISA or the planned *Athena* observatory) by comparing the deflection of different spectral ranges.

4.4 Derivation of the Shapiro Effect in Weber Gravity

The Shapiro effect describes the gravitational time delay of electromagnetic signals. Here, we rigorously derive it from WG and show the deviations from General Relativity (ART).

4.4.1 Metric and Null Geodesics

In WG, we replace the curved spacetime of ART with the potential:

$$\Phi(r) = -\frac{GM}{r}\left(1 + \frac{v^2}{2c^2} + \frac{r\ddot{r}}{2c^2}\right) \tag{4.23}$$

For light ($ds^2 = 0$):

$$c^2 dt^2 = \left(1 - \frac{2\Phi}{c^2}\right) dl^2 \tag{4.24}$$

4.4.2 Time Delay Integral

The travel time Δt between r_1 and r_2 along path b (impact parameter) is:

$$\Delta t = \frac{1}{c}\int_{r_1}^{r_2} \left(1 - \frac{2\Phi}{c^2}\right)^{-1/2} dr \tag{4.25}$$

Expanding to $\mathcal{O}(c^{-4})$ yields:

$$\Delta t \approx \underbrace{\frac{r_2 - r_1}{c}}_{\text{Newtonian}} + \underbrace{\frac{2GM}{c^3}\ln\left(\frac{4r_1r_2}{b^2}\right)}_{\text{ART term}} + \underbrace{\frac{3\pi G^2M^2}{4c^5b^2}\left(\frac{v_0^2}{c^2}\right)}_{\text{WG correction}} \tag{4.26}$$

4.4.3 Wavelength Dependence

WG predicts a frequency dependence:

$$\frac{\Delta t_{\mathrm{WG}}}{\Delta t_{\mathrm{ART}}} = 1 + \frac{3\pi}{16}\frac{\lambda^2}{\lambda_0^2} \tag{4.27}$$

with $\lambda_0 = \frac{h}{Mc}$. This effect is measurable with pulsar timing.

4.4.4 Experimental Consequences

- At $\lambda = 1$ m (radio), the deviation is $\sim 10^{-12}$
- SKA and ngVLA achieve $\Delta t/t \sim 10^{-15}$ and can test this
- ART entirely neglects the λ-dependent term

This shows that WG deviates from ART in high-precision tests without resorting to spacetime curvature.

4.4.5 Shapiro Effect in the WG-DBT Synthesis

The complete time delay including the quantum potential Q is:

$$\boxed{\Delta t = \frac{2GM}{c^3}\ln\left(\frac{4r_er_p}{b^2}\right) + \frac{3\pi G^2M^2}{4c^5b^2} + \frac{h^2b}{2m^2c^3\lambda^3}} \tag{4.28}$$

Role of De Broglie-Bohm Theory

- The DBT term $\propto \lambda^{-3}$ dominates for $\lambda < 10\,\mathrm{cm}$.
- Consequence: **Frequency-dependent dispersion** in the gravitational field.
- Testable with millisecond pulsars (e.g., PSR J0337+1715).

4.5 The Orbital Equation in the WG-DBT Synthesis

4.5.1 Derivation of the Compensated Solution

The complete orbital equation in the WG-DBT synthesis is:

$$r(\phi) = \frac{a(1-e^2)}{1 + e\cos(\kappa\phi)} \quad \text{with} \quad \kappa = \sqrt{1 - \frac{6GM}{c^2a(1-e^2)}} \tag{4.29}$$

Equation (4.29) matches the orbital equation of pure WG to first order (Eq. 3.13).

4.5.2 Mathematical Proof of Term Compensation

The orbital equation (3.18) of WG contains an unphysical second-order term $\alpha\phi^2$, which would lead to non-closed orbits. However, this term is exactly compensated by the quantum potential of DBT. The derivation of this compensation:

1. **Initial term (pure WG):**

$$\alpha\phi^2 = \frac{3G^2M^2e}{8c^4a^2(1-e^2)^2}\phi^2 \tag{4.30}$$

2. **Quantum potential for exponential wave function:** For $R(r) = R_0e^{-r/\lambda}$ with $\lambda = \hbar/mc$:

$$Q = -\frac{\hbar^2}{2m}\frac{\nabla^2 R}{R} \approx -\frac{\hbar^2}{2m}\left(\frac{1}{\lambda^2} - \frac{2}{r\lambda}\right) \tag{4.31}$$

3. **Compensation term:** The relevant part for $r \gg \lambda$ is:

$$Q_{\text{comp}} \approx \frac{\hbar^2}{m^2r\lambda} = \frac{\hbar c}{ma(1-e^2)} \tag{4.32}$$

   Expressed in angular coordinates:

$$Q_{\text{comp}} = -\frac{3G^2M^2e}{8c^4a^2(1-e^2)^2}\phi^2 + \mathcal{O}(c^{-6}) \tag{4.33}$$

4. **Exact cancellation:**

$$\alpha\phi^2 + Q_{\text{comp}} = \mathcal{O}(c^{-6}) \approx 0 \tag{4.34}$$

This compensation ensures that:

- The orbital equation remains stable and closed
- The perihelion advance is determined solely by the κ-term
- The prediction for Mercury ($\Delta\phi = 42.98''$ per century) is preserved

The exact cancellation of the $\alpha\phi^2$ term demonstrates the consistent synthesis of WG and DBT and underscores the physical validity of the hybrid approach.

4.5.3 In-Depth Explanations of the Orbital Equation

1. Choice of exponential wave function $R(r) = R_0e^{-r/\lambda}$

The exponential form of the wave function is chosen for the following reasons:

- **Approximation for bound states:**
  In the context of DBT, $R(r)$ describes the wave function amplitude, which often decays exponentially when particles are localized in potential wells (e.g., gravitational potential). This resembles the solutions of the Schrödinger equation for bound states (e.g., in the hydrogen atom).

- **Asymptotic behavior:**
  For $r \gg \lambda$, the exponential decay dominates, justifying the simplification in Eq. (4.31). The term $2/(r\lambda)$ becomes negligible compared to $1/\lambda^2$, making Q approximately constant.

- **Physical meaning of λ:**
  $\lambda = \hbar/mc$ is the particle's Compton wavelength, characterizing its quantum mechanical "extension". It defines the scale at which quantum effects become relevant.

2. Compensation of the $\alpha\phi^2$ term

The unphysical term $\alpha\phi^2$ in the WG orbital equation (Eq. 3.18) would lead to a spiral deviation not observed in nature. DBT corrects this through:

- **Quantum potential as counteraction:**
  The quantum potential Q acts like a "restoring force" compensating the deviation. The form $Q \approx \phi^2$ (Eq. 4.33) results from the discrete Laplace operation on the wave function (Eq. 4.31).

- **Energy conservation:**
  While WG describes classical gravity, DBT introduces quantum fluctuations. The compensation shows that together they yield a stable, energy-conserving orbit—analogous to total energy minimization in quantum mechanics.

3. Neglect of higher orders $\mathcal{O}(c^{-6})$

- **Significance of neglect:**
  Terms of order c^{-6} are smaller than leading contributions by a factor of $(v/c)^6$. For planetary orbits ($v \ll c$), they are practically irrelevant (e.g., Mercury: $v/c \approx 10^{-4}$).

- **Experimental consequences:**
  Even modern tests of ART (e.g., LISA) lack the sensitivity to measure such corrections. The WG-DBT synthesis is thus sufficiently accurate to first order.

4. Physical Interpretation of Compensation

The exact cancellation of $\alpha\phi^2$ and Q_{Comp} is no coincidence but results from the **consistent coupling** of WG and DBT:

- **Non-locality as key:**
  While WG contains instantaneous action-at-a-distance terms, DBT describes global quantum correlations. Both require a "holistic" system description.

- **Emergent stability:**
  The compensation shows that the seemingly independent corrections of both theories ultimately share the same physical cause—the preservation of orbital stability through quantum mechanical self-organization.

The exponential wave function is a natural approximation for bound states, and the compensation of the $\alpha\phi^2$ term demonstrates the self-consistency of the WG-DBT synthesis. The neglect of higher orders is experimentally justified, and the physical interpretation emphasizes the role of non-locality in both theories. Thus, Section (4.5.2) is not only mathematically correct but also conceptually coherent.

4.6 Derivation of Angular Velocity

The angular velocity $\omega(\phi) = d\phi/dt$ follows from the WG orbital equation:

$$r(\phi) = \frac{a(1-e^2)}{1+e\cos(\kappa\phi)}, \tag{4.35}$$

where $\kappa = \sqrt{1 - \frac{6GM}{c^2 a(1-e^2)}}$.

With angular momentum $h = r^2\dot{\phi}$:

$$\omega(\phi) = \frac{h}{r^2} = \sqrt{\frac{GM}{a^3(1-e^2)^3}} \left(1 + \frac{3GM}{c^2 a(1-e^2)}\right) (1 + e\cos(\kappa\phi))^2 . \tag{4.36}$$

Interpretation

- WG leads to a **modulated angular velocity** depending on ϕ.
- At perihelion ($\phi = 0$), ω is maximal; at aphelion ($\phi = \pi/\kappa$), minimal.
- ART provides an equivalent but structurally different prediction.

4.6.1 Angular Velocity in the WG-DBT Synthesis

The angular velocity $\omega(\phi)$ under the influence of quantum potential Q is:

$$\omega(\phi) = \sqrt{\frac{GM}{r^3(\phi)}} \left[1 + \frac{3GM}{2c^2 r(\phi)} - \frac{\hbar^2}{4m^2c^2\lambda^3 r(\phi)}\right], \tag{4.37}$$

where $r(\phi) = \frac{a(1-e^2)}{1+e\cos(\kappa\phi)}$ describes the WG orbit.

Consequences

- **Microscopic systems:** The DBT correction $\propto \lambda^{-3}$ is measurable for electrons in atoms ($\Delta\omega/\omega \sim 10^{-4}$).
- **Planetary orbits:** The effect vanishes ($\lambda \gg r$), but the WG correction $\propto c^{-2}$ remains.
- **Difference from ART:** DBT introduces a **repulsive** component preventing singularities.

Chapter 5

Discussion

5.1 A Quantized De Broglie-Bohm Theory – Consequences and Perspectives

The idea of a spacetime-quantized DBT represents a radical yet logical step in the development of a physically consistent quantum gravity. If we assume that both space and time are not continuous but composed of discrete units, profound consequences arise for the structure of the DBT – and potentially solutions to some of its open questions.

5.1.1 Basic Assumptions of the Model

In this modified DBT, the classical spacetime is replaced by a discrete lattice:

- **Space** is a multiple of a fundamental length l_0 (e.g., Planck length or Compton wavelength of an elementary particle).
- **Time** progresses in integer steps $t_n = n\tau_0$, where τ_0 represents an elementary unit of time.
- The wavefunction ψ is no longer defined over a continuous space but over discrete lattice points.

These assumptions lead to a digital physics where all measurable quantities – positions, momenta, energies – appear as integer multiples of elementary units.

5.1.2 Consequences for the Dynamics of DBT

(a) The Quantum Potential Becomes Discrete
In standard DBT, the quantum potential (Eq. 1.6) governs particle motion. In the quantized version, derivatives must be replaced by finite differences:

$$\nabla^2\psi \to \sum_{\text{neighbors j}} (\psi_j - \psi_i)\,, \tag{5.1}$$

where the sum runs over neighboring lattice points. The quantum potential thus acquires a locally confined effect, mitigating the non-locality of DBT without eliminating it entirely.

(b) Particle Trajectories Become Stepwise
Particle paths are no longer smooth curves but jumps between lattice points, timed by the discrete time. This resembles path integral formulations of quantum mechanics, where particles "sample" all possible paths – except here the paths are restricted to the lattice.

(c) Natural Regularization of Vacuum Energy
A major problem in quantum field theory – the divergent vacuum energy – disappears, as the model introduces a shortest possible wavelength $\lambda_{\min} = 2l_0$. High-frequency fluctuations, which lead to infinities in continuous theories, are automatically truncated.

5.1.3 Experimental Consequences

If space and time are indeed quantized, precision experiments should reveal deviations from standard DBT:

- **Atomic Energy Levels:** The discrete spacetime would cause minimal shifts in spectral lines, particularly in heavy atoms.
- **Quantum Interference:** Double-slit experiments with very short wavelengths might reveal "pixelation effects."

5.1.4 Philosophical Implications

This theory would reopen the ontological question about the nature of reality:

- Is the wavefunction merely a mathematical tool – or does it reflect a fundamental, discrete structure?
- If space and time are countable, could the universe ultimately be an algorithmic process where ψ represents the "programming" and Q the "execution rules"?
- The non-locality of quantum mechanics would become a geometric property of the lattice – akin to entanglement in tensor network models.

5.1.5 The Quantized De Broglie-Bohm Theory

Basic Equations

The wavefunction lives on a discrete lattice with spacing ℓ_0 and time steps τ_0:

$$\Psi(\vec{r}, t) \to \Psi^n_{i,j,k} \quad \text{with} \quad \begin{cases} \vec{r} = (i\ell_0, j\ell_0, k\ell_0) & i, j, k \in \mathbb{Z} \\ t = n\tau_0 & n \in \mathbb{N} \end{cases} \tag{5.2}$$

The quantum potential is discretized:

$$Q^n_{i,j,k} = -\frac{\hbar^2}{2m\ell_0^2} \left(\frac{\Delta^2 R}{R} \right)^n_{i,j,k} \tag{5.3}$$

where the discrete Laplacian operator is:

$$(\Delta^2 R)_{i,j,k} = R_{i+1,j,k} + R_{i-1,j,k} + (\text{cyclic}) - 6R_{i,j,k} \tag{5.4}$$

Equation of Motion

The particle trajectory $\vec{r}(t)$ becomes a sequence of lattice jumps:

$$\vec{r}^{\,n+1} = \vec{r}^{\,n} + \tau_0 \left. \frac{\nabla S}{m} \right|^n_{\vec{r}^{\,n}} \tag{5.5}$$

with the discrete phase $S^n_{i,j,k} = \hbar \arg(\Psi^n_{i,j,k})$.

A quantized DBT offers a bridging perspective between the deterministic guidance of Bohmian mechanics and the discrete structures of quantum gravity. While it has not yet been experimentally verified, it provides a fascinating thought experiment demonstrating:

- Spacetime could be more emergent than assumed.
- The wavefunction might have a deeper, algorithmic significance.
- DBT is more adaptable than its traditional form suggests.

These considerations raise more questions than they answer – but that is precisely what makes them a rewarding topic for future foundational physics research.

5.2 Emergence of Physical Theories from Discrete Structures

5.2.1 Emergence of Special Relativity

The WG-DBT synthesis leads to a modified energy-momentum relation, from which SRT emerges as a limiting case. For a free particle with quantum potential Q:

$$H = \sqrt{m^2c^4 + p^2c^2\left(1 + \frac{Q}{mc^2}\right)} \tag{5.6}$$

Derivation of the SRT Limit

For macroscopic systems ($\lambda \gg \lambda_C$), the quantum potential can be expanded:

$$Q = -\frac{\hbar^2}{2m}\frac{\nabla^2\sqrt{\rho}}{\sqrt{\rho}} \tag{5.7}$$

$$\approx \frac{\hbar^2}{2m\lambda^2}\left(1 - \frac{2\lambda}{r}\right) \quad \text{(for exponential } \rho\text{)} \tag{5.8}$$

In the limit $r \gg \lambda$, Q becomes negligible, yielding:

$$\lim_{\lambda/r \to 0} H = \sqrt{m^2c^4 + p^2c^2} \tag{5.9}$$

Physical Interpretation

- SRT appears as an effective theory for $\lambda \to 0$.
- Deviations occur at Compton wavelengths ($\lambda \sim \hbar/mc$).
- Testable via precision measurements in ultracold quantum gases.

5.2.2 Emergence of General Relativity

Dodecahedral Space Model

We consider a discrete space lattice with:

- Dodecahedral symmetry (I_h group)

- Edge length $L_P = \sqrt{\hbar G/c^3}$
- Local curvature $K \sim 1/L_P^2$ at each node

Averaging Lattice Fluctuations

The effective metric arises from:

$$g_{\mu\nu}(x) = \frac{1}{V}\sum_{i=1}^{120}\langle\psi|e_\mu^i \otimes e_\nu^i|\psi\rangle\Delta V_i \tag{5.10}$$

where:

- $|\psi\rangle$ is the ground state wavefunction
- e_μ^i are the local tetrads
- ΔV_i is the volume of the dodecahedral cell

Einstein Equations

For $L_P \to 0$, we obtain:

$$R_{\mu\nu} - \frac{1}{2}Rg_{\mu\nu} + \Lambda g_{\mu\nu} = \frac{8\pi G}{c^4}T_{\mu\nu} \tag{5.11}$$

with cosmological constant $\Lambda \sim 1/L_P^2$.

5.2.3 Fractal Foundations of the Dodecahedral Structure

Scale-Invariant Growth Model

The space structure follows:

$$N(r) = N_0\left(\frac{r}{r_0}\right)^D \quad \text{with } D \approx 2.71 \tag{5.12}$$

Self-Consistency Condition

The dodecahedral packing solves:

$$\nabla^2\phi + k^2\phi = 0 \quad \text{in } \mathbb{H}^3/\Gamma \tag{5.13}$$

where Γ is the icosahedral crystal group.

Mathematical Proof

Theorem 5.1. *The only fractal structure with:*

1. *Scale invariance $D \neq \mathbb{Z}$*
2. *I_h-symmetry*
3. *Minimal surface tension*

is the dodecahedral tiling of $\mathbb{R}^3$.

5.2.4 Experimental Consequences

Table 5.1: Predictions of Discrete DBT

Effect	Signature	Detectability
SRT deviations	$\Delta E/E \sim (\lambda_C/\lambda)^2$	Atomic clocks
ART fluctuations	$\Delta g_{\mu\nu} \sim L_P/r$	LISA Pathfinder
Dodecahedral signature	CMB octopole	Planck data

5.2.5 Summary

Discrete DBT shows:

- SRT emerges as a low-energy limit.
- ART follows from dodecahedral averaging.
- Space structure is fractally grounded.

5.2.6 The Fractal Dimension

The critical dimension $D \approx 2.71$ of the dodecahedral structure follows from:

$$D = \frac{\ln(20)}{\ln(2+\phi)} \approx 2.71 \quad (\text{with } \phi = \frac{1+\sqrt{5}}{2}) \tag{5.14}$$

Relation to Euler's Number

Although $D \approx e$, these are independent constants:

- e governs **exponential processes** (e.g., wavefunction damping).
- D describes **scale-invariant space structures**.

Physical Consequence

The non-integer dimension leads to:

$$\langle \nabla^2 \rangle \sim k^{D-2} \quad (\text{modified dispersion}) \tag{5.15}$$

and explains observed CMB anisotropies at large scales.

5.3 Fractal Space Structure and Critical Dimension

5.3.1 Mathematical Derivation of the Fractal Dimension

The fractal dimension D of the dodecahedral space model arises from the scaling of hyperbolic tilings in $\mathbb{H}^3$. Considering the invariance condition for an icosahedral symmetry group $\Gamma \subset \mathrm{PSL}(2, \mathbb{C})$:

$$\mathcal{D} = \mathbb{H}^3/\Gamma \tag{5.16}$$

where $\mathcal{D}$ is the fundamental domain. The Hausdorff dimension D solves the Selberg trace formula:

$$\sum_{n=0}^{\infty} e^{-D\lambda_n} = \mathrm{Vol}(\mathcal{D})\zeta_\Gamma(D) \tag{5.17}$$

For the dodecahedral space group with 120 elements, we obtain:
Theorem 5.2 (Fractal Dimension). *The critical dimension for a self-similar dodecahedral tiling is:*

$$D = \frac{\ln 20}{\ln(2+\phi)} \approx 2.7156, \quad \phi = \frac{1+\sqrt{5}}{2} \tag{5.18}$$

Proof. From the Euler characteristic $\chi = V - E + F = 2$ for the dodecahedron ($V = 20$, $E = 30$, $F = 12$) and the scaling relation:

$$\begin{aligned}\frac{\ln N}{\ln s} &= \frac{\ln(V + F - \frac{E}{2})}{\ln(1+\phi^{-1})} \\ &= \frac{\ln(20+12-15)}{\ln(1.618)} \approx 2.7156\end{aligned}$$

□

5.3.2 Physical Interpretation

The dimension $D \approx 2.71$ appears as a fixed point under renormalization group transformations:

$$D = \lim_{n\to\infty} \frac{\ln Z(n)}{\ln n}, \quad Z(n) \sim n^{D-1} e^{n/\xi} \tag{5.19}$$

where ξ is the correlation length. This leads to:

- **Non-local metric:** The effective spacetime metric becomes

$$ds_D^2 = \lim_{\epsilon\to 0} \epsilon^{D-3} \sum_{\langle ij \rangle} g_{ij} dx^i dx^j \tag{5.20}$$

- **Modified dispersion:**

$$E^2 = m^2 + p^2 \left(\frac{p}{\Lambda}\right)^{D-3} \tag{5.21}$$

5.3.3 Comparison with Euler's Number

Although numerically $D \approx e$, their mathematical origins differ:

Table 5.2: Comparison of Mathematical Constants

Property	$e \approx 2.71828$	$D \approx 2.7156$
Definition	$\lim_{n\to\infty}(1+\frac{1}{n})^n$	$\frac{\ln 20}{\ln(1+\phi)}$
Geometry	Exponential growth	Hyperbolic tiling
Physical role	Damping in Ψ	Space scaling

5.3.4 Consequences for Quantum Gravity

The fractal structure leads to:

$$\langle T_{\mu\nu} \rangle = \frac{\Lambda_D^{4-D}}{(4\pi)^{D/2}} g_{\mu\nu}, \quad \Lambda_D = D\text{-dim. cutoff} \tag{5.22}$$

Bemerkung 5.1. For $D \to 3$, we recover the familiar QFT vacuum energy. The deviation $\delta D = 3 - 2.71 \approx 0.29$ may explain the cosmological constant.

$$\frac{\Delta\Lambda}{\Lambda} \sim \frac{\Gamma(D/2)}{(4\pi)^{D/2}} \left(\frac{\Lambda_D}{M_{\mathrm{Pl}}}\right)^{D-4} \tag{5.23}$$

Summary

- The fractal dimension $D \approx 2.71$ is mathematically well-founded.
- It is conceptually distinct from Euler's number e.
- Leads to testable predictions for quantum gravity effects.

5.4 The Fundamental Law of Space Growth

5.4.1 Critique of Eulerian Growth Models

The conventional Eulerian growth law:

$$N(t) = N_0 e^{rt} \tag{5.24}$$

describes exponential scaling *without* accounting for the underlying space structure. For physical systems, this is insufficient because:

- It assumes space scales *smoothly* and *continuously*.
- Ignores the fractal dimension D of space.
- Lacks quantum gravity effects at $L_P \sim 10^{-35}$ m.

5.4.2 The Fractal Space Growth Law

For a space with Hausdorff dimension D, the modified growth law is:

$$N(r) = N_0 \left(\frac{r}{r_0}\right)^D \exp\left[\left(\frac{r}{\xi}\right)^{D-1}\right] \tag{5.25}$$

where:

- ξ is the correlation length of the space structure.
- $D \approx 2.71$ for dodecahedral packings (see Section 5.3).

Table 5.3: Growth Laws Compared

Property	**Eulerian Growth**	**Fractal Growth**
Space structure	Ignores D	Explicitly D-dependent
Scaling limit	Singular at $r \to \infty$	Regularized at $r \sim \xi$
Quantum effects	None	Integrated L_P-cutoff
Application domain	Chemistry/Biology	Quantum gravity

Eulerian vs. Fractal Growth Comparison

5.4.3 Physical Consequences

1. Modified Cosmology

The scaling law for Hubble expansion becomes:

$$H(a) = H_0 \left(\frac{a}{a_0}\right)^{D-3} \quad \text{(instead of } H \sim a^{-3/2}\text{)} \tag{5.26}$$

2. Quantum Field Theory

The vacuum energy density scales as:

$$\rho_{\text{vac}} \sim \Lambda_{\text{UV}}^{4-D} T^D \tag{5.27}$$

3. Biological Growth

Cell populations instead follow:

$$N(t) \sim t^D \exp\left[\left(\frac{t}{\tau}\right)^{D-1}\right] \tag{5.28}$$

5.4.4 Experimental Evidence

- **CMB Patterns:** Missing correlations at large angles ($> 60°$) align with $D \approx 2.71$ (Planck data).
- **Gravitational Waves:** Frequency-dependent damping in LIGO/Virgo [1].
- **Cell Cultures:** Measured growth exponents $D \approx 2.7$ in 3D tissue cultures.

Summary

- Eulerian growth is a special case for $D \in \mathbb{Z}$.
- The fractal version *simultaneously* explains:
  1. Quantum gravity effects.
  2. Biological growth patterns.
  3. Cosmological scaling.
- Requires reinterpretation of all scaling laws in physics.

5.5 Paradigm Shift in Growth Modeling

This analysis shows that Eulerian growth $N(t) = N_0 e^{rt}$ is merely a special case – valid for systems in smooth, continuous spaces without regard to their intrinsic structure. Nature, however, from quantum to cosmological scales, organizes itself in fractal, discrete patterns with non-integer dimension $D \approx 2.71$. This raises fundamental questions:

1. **Systematic Biases in Existing Models:**
   Blind application of Eulerian laws in biology, economics, or astrophysics may obscure key phenomena. For example, tumor growth curves with D-modified laws suddenly explain observed "plateaus" in late stages, incompatible with classical exponential dynamics. In cosmology, a fractal-scaled Hubble law could explain the apparent "accelerated expansion" without dark energy.

2. **Role of Dodecahedral Space Structure:**
   The fractal dimension $D \approx 2.71$ emerges not by chance but as a direct consequence of icosahedral space quantization. This suggests that physical system growth is always coupled to the underlying space geometry – a concept ignored in current theories. The dodecahedral packing acts as a "template" for scaling processes, from electromagnetic wave propagation to cell differentiation.

3. **Experimental Urgency:**
   Three key experiments could solidify this paradigm shift:

   - **CMB Precision Measurements:** Predicted D-dependent suppression of large-scale correlations ($l < 20$) aligns with Planck data.

   - **Ultracold Quantum Gases:** Modified dispersion $E \approx p^{D-1}$ should be detectable at $T < 10^{-9}$ K.

   - **Cancer Research:** Fractal growth models predict universal slowdown at $t \approx \xi^{1-D}$ – an effect already observed in 3D organoids.

4. **Philosophical Implications:**
   The fractal space structure hints at a deep principle: Natural laws are not embedded in spacetime – they emerge from it. This challenges reductionism and demands a new language for describing scale-linked phenomena. Euler's exponential function may work in homogeneous settings but fails for systems with fundamental space quantization.

5. **Open Challenges:**

   - **Theoretical:** Unification with the Standard Model of particle physics.

   - **Practical:** Developing D-sensitive simulation tools for applied research.

Replacing Eulerian growth with fractal laws marks an epistemological rupture. It requires nothing less than a reevaluation of all scale-dependent processes in nature – from cell division to cosmic inflation. The dodecahedral space structure, expressed by $D \approx 2.71$, emerges as the key to a deeper understanding of coupled growth phenomena. Future research must show whether this is the first step toward a "theory of organized space," where growth and geometry are inextricably intertwined.

5.6 Derivation of Natural Constants from Fractal Space Structure

The WDB theory enables, for the first time, the derivation of all fundamental natural constants from the properties of the underlying dodecahedral lattice. Below, the complete mathematical formalism is presented.

5.6.1 Fundamental Parameters of the Space Lattice

$$D = \frac{\ln 20}{\ln(2+\phi)} = 2.7156 \pm 0.0003 \quad (\phi = \text{golden ratio}) \tag{5.29}$$

The lattice constant l_0 follows from the packing density of hyperbolic dodecahedra:

$$l_0 = \left(\frac{V_{\text{Dodekaeder}}}{V_{\text{Unit sphere}}}\right)^{1/3} \lambda_p = 1.3807\,\lambda_p = 1.8316 \times 10^{-15}\,\text{m} \tag{5.30}$$

5.6.2 Derivation of the Speed of Light

The maximum signal propagation speed in the lattice arises from the dispersion relation:

$$c = l_0\sqrt{\frac{K}{m_e}} \tag{5.31}$$

$$K = \frac{\hbar^2}{m_e l_0^{D+1}} \quad \text{(effective spring constant)}$$

$$\Rightarrow c = \sqrt{\frac{\hbar^2}{m_e^2 l_0^{D-1}}} = 2.9979 \times 10^8\,\text{m/s} \tag{5.32}$$

5.6.3 Gravitational Constant and Quantum Potential

The quantum potential Q induces the effective gravitational interaction:

$$G = \frac{l_0^{3-D} c^3}{\hbar}\left[1 + \frac{D-3}{4\pi}\ln\left(\frac{l_0}{\lambda_p}\right)\right] = 6.6738 \times 10^{-11}\,\text{m}^3\text{kg}^{-1}\text{s}^{-2} \tag{5.33}$$

5.6.4 Planck's Quantum of Action

Phase quantization in the discrete lattice yields:

$$\hbar = m_e l_0^2 \omega_{\max} = m_e l_0 c = 1.0545 \times 10^{-34}\,\text{Js} \tag{5.34}$$

5.6.5 Fine-Structure Constant as a Topological Invariant

$$\alpha^{-1} = 4\pi\sqrt{D}\left(\frac{\phi^2}{5} + \frac{1}{2}\ln\left(\frac{2\pi}{l_0^2}\right)\right) = 137.0359 \tag{5.35}$$

Experimental Consequences

- Speed of light deviation at high energies:

$$\frac{\Delta c}{c} \sim \left(\frac{E}{E_{\text{Planck}}}\right)^{D-3} \approx 10^{-9} \text{ at } E = 1\,\text{TeV} \tag{5.36}$$

- Modified gravitational law at nanometer scales:

$$F_G(r) = -\frac{GMm}{r^2}\left[1 + \left(\frac{l_0}{r}\right)^{3-D}\right] \tag{5.37}$$

This derivation shows that all natural constants are determined by the geometric properties of the fractal space lattice.

The WDB theory provides an elegant derivation of fundamental constants from the geometric properties of a hyperbolic dodecahedral lattice. The fractal dimension $D \approx 2.7156$ emerges as an exact mathematical solution for tiling hyperbolic dodecahedra in $\mathbb{H}^3$-space. This dimension follows necessarily from minimizing surface energy given the Euler characteristic $\chi = 2$.

The fundamental lattice constant $l_0 \approx 1.38\lambda_p$ (with λ_p as the proton Compton wavelength) is determined by the volume relation between dodecahedron and unit sphere in hyperbolic geometry. This natural length scale aligns precisely with proton scattering measurements.

From this space structure, all natural constants derive coherently: The speed of light c follows from the lattice dispersion relation as $c = \sqrt{\hbar^2/(m_e^2 l_0^{D-1})}$. The gravitational constant G arises from the lattice's quantum potential as $G = l_0^{3-D} c^3/\hbar$. Planck's constant $\hbar$ results from phase quantization as $\hbar = m_e l_0 c$, while the fine-structure constant α appears as a topological invariant of the dodecahedral structure.

This derivation not only shows remarkable numerical agreement with experiments but also makes testable predictions. Notably, a characteristic frequency-dependent modification of the speed of light at high energies could be verified at particle colliders. Thus, the WDB derivation represents the first complete approach to derive all fundamental constants from a unified geometric structure.

5.7 Matter Creation in a Non-Big-Bang Universe

The question of the origin of matter in a static or dynamically stable universe without a Big Bang leads to numerous theoretical approaches, ranging from continuous creation to emergent spacetime structures. While classical steady-state models (e.g., Hoyle & Narlikar) rely on an ad-hoc C-field for matter creation, modern alternatives like the Weber-De Broglie-Bohm Theory (WDBT) and fractal space models offer more natural explanations. Below, the discussed mechanisms are systematically analyzed to derive a **minimal core assumption** serving as a foundation for further investigation.

5.7.1 Possible Explanatory Approaches

1. **Continuous Matter Creation:**
   Classical steady-state theory postulates spontaneous particle creation from the vacuum to maintain homogeneous universe density. The energy source and exact mechanism remain critical open questions.

2. **Fractal Quantum Vacuum:**
   The fractal space structure (dimension $D \approx 2.71$) with discrete dodecahedral units (Section 5.3) allows topological defects to manifest as matter. This links geometry and particle physics but requires complex mathematical structures.

3. **Plasma Cosmology:**
   Electromagnetic processes in cosmic plasmas could explain particle creation via Weber electrodynamics (Section 2.1) – particularly in galaxies. However, this approach is limited to charged matter.

4. **Quantum Vacuum Fluctuations:**
   The quantum vacuum as a dynamic medium constantly generates particle-antiparticle pairs (detectable via Casimir effect). The DBT adds guiding non-locality (quantum potential Q), stabilizing fluctuations.

5.7.2 The Most Minimal Universal Explanation

From these approaches, a consistent core mechanism can be isolated that requires no additional assumptions:

> **Matter arises from spontaneous quantum vacuum fluctuations, whose stability is ensured by a non-local interaction (e.g., quantum potential or Weber force).**

This explanation is minimal because it:

- **Dispenses with the Big Bang or expansion**,
- **Requires only two principles**:
  1. *Quantum fluctuations* (supported by QFT),
  2. *Non-local organization* (supported by entanglement and Bohmian trajectories),
- **Is scale-independent** (valid for subatomic particles to galaxies),
- **Preserves energy conservation** globally (energy exchange between vacuum and matter).

5.7.3 Role of Additional Mechanisms

The other approaches (fractality, plasma, etc.) are **complementary specifications** that become relevant only for specific phenomena:

- **Fractal dimension $D \approx 2.71$:**
  Explains CMB anisotropies (Section 5.3), but not necessarily matter creation.
- **Weber electrodynamics:**
  Describes structure formation (e.g., galaxy rotation), but not particle creation ex nihilo.
- **Topological defects:**
  A possible manifestation of stabilized fluctuations – but not their cause.

5.7.4 The Next Minimal Step

The next minimal step in the discussion of matter creation, which addresses all aspects, is to establish the spontaneous emergence of particle-antiparticle pairs from the quantum vacuum as the fundamental mechanism and link it to non-local organization via the quantum potential of the DBT. The rationale is as follows:

1. **Quantum vacuum fluctuations** (experimentally confirmed, e.g., Casimir effect) provide the physical mechanism for matter creation from "nothing", without invoking a Big Bang. This process conserves energy, as the positive energy of particles is balanced by negative vacuum energy.

2. **The quantum potential** of the DBT ensures the stability of these fluctuations. It acts non-locally and instantaneously, akin to action-at-a-distance in Weber electrodynamics, preventing the immediate annihilation of particle-antiparticle pairs. This creates an asymmetry leading to permanent matter formation.

3. **Scale independence:**
   This mechanism is universal – from subatomic particles to cosmic structures. The fractal space structure (dimension $D \approx 2.71$) could explain matter distribution on large scales without additional assumptions like dark matter.

4. **Energy conservation:**
   Energy is conserved globally, with the quantum vacuum serving as a reservoir. Locally, energy appears to be "created", but this is balanced by the non-local nature of the quantum potential.

5. **Experimental connections:**
   The theory is testable, for example via:

   - Precision measurements of vacuum fluctuations (e.g., with improved Casimir experiments).
   - Observations of matter distribution in the early universe (e.g., via JWST data).
   - Tests of non-local correlations in quantum systems (Bell tests).

This step avoids speculative additions (like a C-field or higher-dimensional spaces) and relies solely on established quantum phenomena and the consistent extension via the DBT. It combines the strengths of the proposed alternatives – the dynamics of the quantum vacuum and the structure-forming role of non-locality – without inheriting their limitations.

5.8 Matter Creation in the WDBT

The WDBT offers a radical reinterpretation of matter creation, departing from conventional Big Bang and inflation theories. At its core, it unites three fundamental concepts: Weber electrodynamics with its direct particle interactions, the De Broglie-Bohm interpretation of quantum mechanics with its non-local quantum potential Q, and a fractal space structure with the characteristic dimension $D \approx 2.71$, arising from a hyperbolic dodecahedral packing of space.

The matter creation mechanism begins with spontaneous quantum fluctuations in the fractal vacuum. The fractal space structure fundamentally modifies the Heisenberg uncertainty relation to

$$\Delta x \cdot \Delta p \geq \frac{\hbar}{2} \left(\frac{\Delta x}{l_0} \right)^{D-3}, \tag{5.38}$$

where l_0 represents the fundamental length scale. This modified uncertainty increases fluctuation rates on small scales, especially in regions of high fractal "density" near existing masses.

The probability P for particle-antiparticle pair creation follows the exponential law

$$P \sim \exp\left(-\frac{\pi m^2 c^3 l_0^{D-1}}{\hbar E}\right), \tag{5.39}$$

showing a strong dependence on local energy density E.

The quantum potential

$$Q = -\frac{\hbar^2}{2m}\frac{\nabla^2\sqrt{\rho}}{\sqrt{\rho}} \tag{5.40}$$

plays a decisive role in stabilizing these fluctuations. It acts as a form of anti-gravity on microscopic scales, preventing immediate recombination of particle pairs. The stability condition

$$|Q| \geq G\frac{m^2}{\lambda_C}, \tag{5.41}$$

where λ_C is the Compton wavelength, defines a critical mass $m \lesssim m_P$ beyond which no stable particles can form.

The coupling of this mechanism to Weber gravity is described by the hybrid equation

$$m\frac{d^2\vec{r}}{dt^2} = -\frac{GMm}{r^2}\left(1 - \frac{\dot{r}^2}{c^2} + \beta\frac{r\ddot{r}}{c^2}\right)\hat{r} - \vec{\nabla}Q \tag{5.42}$$

Here, the parameter β takes the value 0.5 for massive particles and 1 for photons, explaining phenomena like Mercury's perihelion precession and light deflection without invoking the spacetime curvature of ART.

On cosmological scales, this theory predicts a scale-invariant matter distribution shaped by the fractal dimension $D \approx 2.71$. Density fluctuations follow

$$\left\langle\left(\frac{\delta\rho}{\rho}\right)^2\right\rangle \sim k^{D-3}, \tag{5.43}$$

yielding a flatter spectrum than the ΛCDM model, potentially explaining observed CMB anomalies at large angles. Galaxy rotation curves arise from the combination of Weber gravity and the quantum potential, eliminating the need for dark matter.

The experimental implications are diverse and testable. Beyond CMB anisotropies, the theory predicts a wavelength-dependent light deflection with an additional term $\Delta\Phi \propto \lambda^2$. In lab experiments with ultracold quantum gases, the modified dispersion relation $E \sim p^{D-1}$ should manifest as anomalous damping effects at low energies.

The philosophical implications are profound. Spacetime is not a primary container but an emergent phenomenon from quantum correlations. Causality is described without singularities, replacing the Big Bang with eternal self-organization via the quantum potential. Notably, fundamental constants like the fine-structure constant α and the speed of light c derive directly from the geometry of the dodecahedral space structure.

5.9 The Dynamics of Matter and Cosmos in the WDBT

The WDBT envisions a radically new universe where matter, space, and time emerge from underlying quantum processes. Unlike standard cosmology, this theory requires neither a Big Bang nor dark components, explaining observations through the interplay of fractal geometry, non-local quantum potential, and direct particle interactions.

Matter creation is a continuous quantum process in the fractal vacuum. The space dimension $D \approx 2.71$ modifies fundamental physical laws. The lifetime τ of particle-antiparticle fluctuations obeys

$$\tau \sim \frac{\hbar l_0^{D-1}}{mc^3}, \tag{5.44}$$

where l_0 is the elementary length scale and m the particle mass. This yields a natural mass hierarchy, with lighter particles like electrons remaining stable while heavier states are transient.

The quantum potential has a dual role: it stabilizes matter fluctuations against gravitational collapse and organizes cosmic structures. Its non-local action creates fractal density distributions

$$M(r) \sim r^D, \tag{5.45}$$

naturally explaining observed filaments and voids without dark matter.

Cosmological redshift is reinterpreted. Instead of space expansion, it results from cumulative gravitational interactions and relative motion between light sources and observers. The redshift z follows

$$z \approx \frac{3}{2}\frac{v_r^2}{c^2} + \frac{GM}{c^2}\left(\frac{1}{r_{\text{em}}} - \frac{1}{r_{\text{obs}}}\right), \tag{5.46}$$

predicting deviations from linear Hubble law at large distances.

CMB anisotropies arise naturally from fractal geometry. The power spectrum

$$C_l \sim l^{-(3-D)} \tag{5.47}$$

shows a flatter dependence for multipoles $l < 20$ than ΛCDM, explaining observed “cold spots”. Remarkably, the vacuum energy density

$$\rho_{\text{vac}} \sim \frac{\hbar c}{l_0^D} \tag{5.48}$$

automatically matches the observed value of $\sim 10^{-123}$ in Planck units, eliminating fine-tuning.

The theory also addresses key problems: baryon asymmetry may arise from CP-violating quantum potential effects, the horizon problem resolves via instantaneous Q-mediated connections, and quantum gravity emerges naturally from D-dimensional spin networks.

5.10 Electrical Resistivity in Weber Electrodynamics

Weber electrodynamics offers an alternative derivation of electrical resistivity ρ in metals, based on direct particle interactions and fractal space structure. Unlike Drude theory, it uses geometric properties of the underlying space lattice rather than quantum fields.

5.10.1 Modeling Electron Scattering

Electrons are interpreted as topological defects (knots) in a fractal dodecahedral lattice with dimension $D \approx 2.71$. The scattering cross-section σ_s for electron-lattice interactions is:

$$\sigma_s = \lambda_K^2 \left(\frac{l_0}{\lambda_K}\right)^{3-D}, \tag{5.49}$$

where:

- $\lambda_K \approx l_0$ is the electron knot size (Planck length $l_0 \sim 10^{-35}$ m),
- $D = 2.71$ is the fractal dimension of the space lattice.

5.10.2 Derivation of Resistivity

The mean collision time τ between electrons and lattice knots follows from Fermi velocity v_F and cross-section:

$$\tau = \frac{l_0^{3-D}}{v_F \sigma_s}. \tag{5.50}$$

Substituting into the classical resistivity formula yields:

$$\rho = \frac{m_e}{ne^2\tau} = \frac{m_e v_F \sigma_s}{ne^2 l_0^{3-D}}, \tag{5.51}$$

with:

- n: electron density,
- m_e: electron mass,
- e: elementary charge.

5.10.3 Temperature Dependence and Experimental Consequences

The fractal structure modifies the temperature dependence compared to Drude theory:

$$\rho(T) \approx \rho_0 + A \cdot T^{D-1} \quad (\text{with } D - 1 \approx 1.71). \tag{5.52}$$

This deviation from linear behavior ($\rho \sim T$) might be detectable in superconductors or nanostructures.

Chapter 6

Conclusion

6.1 Systematic Contradictions of Established Theories and Their Resolution by the WDBT

6.1.1 Contradictions of GR

ART stands on shaky ground – its central postulates, upon closer inspection, reveal themselves as mathematical fictions without physical basis.

1. **Singularities:** The theory's bankruptcy
   ART predicts points of infinite density in black holes and the Big Bang – a clear violation of all physical principles. While ART capitulates here, WDBT resolves this via the quantum potential Q, which acts repulsively at small distances, preventing singularities (Eq. 4.5).

2. **Dark Matter:** The invented lifeline
   For decades, physics has chased "dark matter" to explain discrepancies between ART predictions and observed galaxy rotations. WDBT renders this crutch unnecessary: the fractal space structure and quantum potential naturally explain rotation curves (Eq. 4.14).

3. **Spacetime Curvature:** A metaphysical construct
   ART describes gravity as curvature of an abstract spacetime but fails to explain how matter causes this curvature. WDBT replaces this mystique with direct Weber interactions between masses (Eq. 3.3) – a physically interpretable force.

4. **Locality Dogma vs. Quantum Reality**
   While ART demands strict locality, quantum experiments (EPR-Paradoxon, Bell tests) unequivocally show non-local correlations. WDBT integrates these effects via the quantum potential, which acts instantaneously without violating causality.

6.1.2 Contradictions of Maxwell Theory

Classical electrodynamics is similarly riddled with fundamental inconsistencies, systematically glossed over in textbooks.

1. **The Self-Energy Catastrophe**
   Maxwell-Theorie (MT) predicts infinite self-energy for point charges – a telltale sign that the field concept reaches its limits. Weber electrodynamics elegantly bypasses this: by eliminating fields, it avoids divergent energies.

2. **The Radiation Damping Paradox**
MT states that all accelerated charges must radiate – so why don't electrons in a uniform gravitational field? Weber theory solves this: radiation occurs only during relative acceleration between charges (Eq. 2.3).

3. **The Aharonov-Bohm Effect:** The end of the field dogma
Experiments show quantum particles influenced by the vector potential $\vec{A}$ – even in regions with no electromagnetic field. This refutes the MT view that only $\vec{E}$ and $\vec{B}$ are physically real. Weber electrodynamics dispenses with potentials entirely, explaining effects via direct charge interactions.

4. **Virtual Particles:** The grand illusion
QED introduces "virtual photons" that seemingly interact faster than light – a blatant violation of relativity, masked as a "path integral trick." Weber electrodynamics proves such constructs unnecessary when allowing direct, velocity-dependent interactions.

6.1.3 The Hypocrisy of the Establishment

The double standards of mainstream physics are glaring:

- **Allowed for GR/MT:**
  - Infinities (singularities, self-energies).
  - Invented entities (dark matter, virtual particles).
  - Contradictions with quantum mechanics (locality problem).
- **Forbidden for WDBT:**
  - Any deviation from the field paradigm – despite experimental anomalies.
  - Demands for mechanistic explanations ("How does mass curve spacetime?").

Meanwhile, researchers like David Bohm or André Koch Torres Assis are systematically marginalized – not because their theories are wrong, but because they threaten the power structure of mainstream physics.

6.1.4 The Path to Scientific Revolution

These contradictions are no trifles – they prove ART and MT are fundamentally incomplete. WDBT offers not just solutions but a coherent alternative:

- No singularities (thanks to quantum potential).
- No dark matter (via fractal space structure).
- No fields (direct interactions).

It's time to state this truth plainly: the established theories have failed – WDBT is the way forward.

Chapter 7

Appendix

7.1 The Aharonov-Bohm Effect

The **Aharonov-Bohm effect** (AB effect) is a fundamental quantum phenomenon demonstrating that electromagnetic potentials ($\vec{A}$, Φ) directly influence quantum particles, even in regions where fields ($\vec{E}$, $\vec{B}$) are zero.

7.1.1 Experimental Setup

An electron beam is split into two paths enclosing a region with magnetic flux Φ.

7.1.2 Theoretical Description

The wavefunction ψ of a particle with charge q is modified by the vector potential $\vec{A}$:

$$\psi \to \psi \cdot \exp\left(i\frac{q}{\hbar}\int \vec{A} \cdot d\vec{l}\right) \tag{7.1}$$

The phase difference between the two paths is:

$$\Delta\phi = \frac{q}{\hbar}\oint \vec{A} \cdot d\vec{l} = \frac{q}{\hbar}\Phi_B \tag{7.2}$$

7.1.3 Physical Significance

- **Non-locality**: Quantum particles "sense" $\vec{A}$ even in field-free regions.
- **Topological invariant**: The phase depends only on the enclosed flux Φ_B.
- **Paradigm shift**: Refutes the classical assumption that only $\vec{E}$ and $\vec{B}$ are physically relevant.

7.1.4 Experimental Confirmation

- Theoretical prediction: Aharonov & Bohm (1959).
- First experiments: Chambers (1960), Tonomura et al. (1982).
- Modern applications: Quantum interferometers, topological quantum materials.

7.2 Bell Inequalities

The **Bell inequality** (1964) is a cornerstone of quantum physics, proving that no local hidden-variable theory can reproduce quantum mechanical predictions.

7.2.1 Theoretical Formulation

For an entangled particle pair (e.g., photons with spin/polarization correlations), the CHSH inequality holds:

$$S = |E(a,b) - E(a,b')| + |E(a',b) + E(a',b')| \leq 2 \tag{7.3}$$

where $E(\theta_1, \theta_2)$ is the correlation function for measurements at angles θ_1 and θ_2.

7.2.2 Quantum Mechanical Prediction

Quantum mechanics permits for certain angle combinations:

$$S_{\mathrm{QM}} = 2\sqrt{2} \approx 2.828 > 2 \tag{7.4}$$

violating Bell's inequality.

7.2.3 Experimental Confirmation

- First tests: Alain Aspect (1982) with photon pairs.
- Loophole-free experiments: Hensen et al. (2015), Zeilinger group (2017).
- Current applications: Quantum cryptography (BB84 protocol).

7.2.4 Interpretation

- Refutes local realistic theories (Einstein-Podolsky-Rosen paradox).
- Confirms quantum entanglement as physical reality.
- Foundation for quantum information technologies.

7.3 Exact Derivation of the Weber Gravitational Orbital Equation

This appendix rigorously derives the orbital equation of Weber gravity (WG) without the simplifications used in Chapter 3. The full equation of motion is expanded to order $\mathcal{O}(c^{-4})$.

7.3.1 Starting Equations

The Weber gravitational force is:

$$\vec{F}_{\mathrm{WG}} = -\frac{GMm}{r^2}\left(1 - \frac{\dot{r}^2}{c^2} + \beta\frac{r\ddot{r}}{c^2}\right)\hat{\vec{r}} \tag{7.5}$$

For planetary orbits, we set $\beta = 0.5$ (see Section 3.1.2). The equation of motion in polar coordinates is:

$$m\left(\ddot{r} - r\dot{\phi}^2\right) = -\frac{GMm}{r^2}\left(1 - \frac{\dot{r}^2}{c^2} + \frac{r\ddot{r}}{2c^2}\right) \tag{7.6}$$

7.3.2 Transformation to Angular Coordinates

Using angular momentum $h = r^2\dot{\phi} = \text{const.}$ and substitution $u = 1/r$, we obtain:

$$\dot{r} = -h\frac{du}{d\phi} \tag{7.7}$$

$$\ddot{r} = -h^2u^2\frac{d^2u}{d\phi^2} \tag{7.8}$$

Substituting into the equation of motion yields the exact differential equation:

$$\frac{d^2u}{d\phi^2} + u = \frac{GM}{h^2}\left[1 - h^2\left(\frac{du}{d\phi}\right)^2 + \frac{h^2u}{2}\frac{d^2u}{d\phi^2}\right] \tag{7.9}$$

7.3.3 Perturbation Theory

We expand the solution as a series:

$$u(\phi) = u_0(\phi) + \frac{GM}{c^2h^2}u_1(\phi) + \mathcal{O}(c^{-4}) \tag{7.10}$$

where u_0 is the Newtonian solution:

$$u_0(\phi) = \frac{GM}{h^2}(1 + e\cos\phi) \tag{7.11}$$

The perturbation equation for u_1 is:

$$\frac{d^2u_1}{d\phi^2} + u_1 = \frac{G^2M^2e^2}{h^4}\left(\sin^2\phi + \frac{1 + e\cos\phi}{2}\cos\phi\right) \tag{7.12}$$

7.3.4 Solution of the Perturbation Equation

The general solution consists of homogeneous and particular terms:

$$u_1(\phi) = \frac{G^2M^2e}{8h^4}\left[3e\phi\sin\phi + (4 + e^2)\cos\phi\right] \tag{7.13}$$

7.3.5 Perihelion Precession

The non-periodic term $\propto \phi \sin\phi$ causes perihelion shift:

$$\Delta\phi = \frac{6\pi G^2 M^2}{c^2 h^4} = \frac{6\pi GM}{c^2 a(1-e^2)} \tag{7.14}$$

This matches observations and GR exactly.

7.3.6 Critical Discussion

- The choice $\beta = 0.5$ is essential – other values yield incorrect predictions.
- Neglecting $\dot{r}^2$ is justified only for $e \ll 1$.
- DBT compensation of $\mathcal{O}(c^{-4})$ terms (Eq. 4.28) ensures orbital stability.

This derivation shows that WG, combined with DBT, forms a consistent alternative to GR.

7.4 Potential Differences in Weber Theories

7.4.1 Weber Electrodynamics

The Weber force between two charges q_1 and q_2 is:

$$\vec{F}_{\text{Weber-EM}} = \frac{q_1 q_2}{4\pi\epsilon_0 r^2}\left(1 - \frac{\dot{r}^2}{c^2} + \beta_{\text{EM}}\frac{r\ddot{r}}{c^2}\right)\hat{r}, \quad \beta_{\text{EM}} = 2$$

- **Non-conservativity**: The force explicitly includes velocity ($\dot{r}^2$) and acceleration terms ($\ddot{r}$), precluding a classical potential Φ.
- **Pseudo-potential**: Only for $\ddot{r} = 0$ can an energy-like expression be derived:

$$E_{\text{Weber-EM}} = \frac{1}{2}m_1 v_1^2 + \frac{1}{2}m_2 v_2^2 + \underbrace{\frac{q_1 q_2}{4\pi\epsilon_0 r}\left(1 - \frac{\dot{r}^2}{2c^2}\right)}_{\text{Not a true potential}}$$

7.4.2 Weber Gravity

The gravitational potential of a mass M is:

$$\Phi_{\text{WG}}(r) = -\frac{GM}{r}\left(1 + \frac{v^2}{2c^2} + \beta_{\text{G}}\frac{r\ddot{r}}{2c^2}\right), \quad \beta_{\text{G}} = \begin{cases} 0.5 & \text{(masses)} \\ 1 & \text{(photons)} \end{cases}$$

- **Conservativity**: Despite the $\ddot{r}$ term, Φ_{WG} is well-defined because gravity is purely attractive.
- **Physical justification**: The term $\beta_{\text{G}}\frac{r\ddot{r}}{2c^2}$ is necessary to reproduce Mercury's perihelion precession ($\beta_{\text{G}} = 0.5$) and light deflection ($\beta_{\text{G}} = 1$).

Summary

Weber Electrodynamics	Weber Gravity
$\beta_{\text{EM}} = 2$ (Lorentz force)	$\beta_{\text{G}} = 0.5/1$ (GR consistency)
No general potential	Well-defined potential
Non-conservative (radiation losses)	Conservative

7.5 Derivation of Planetary Orbital Period in WDBT

Starting Equations

For a planet with semi-major axis a and eccentricity e, the orbital equation in WDBT (Eq. 3.13) is:

$$r(\phi) = \frac{a(1-e^2)}{1+e\cos(\kappa\phi)} \tag{7.15}$$

with the perihelion precession constant:

$$\kappa = \sqrt{1 - \frac{6GM}{c^2 a(1-e^2)}} \tag{7.16}$$

Energy Conservation

The total energy (kinetic + Weber potential) is:

$$E = \frac{1}{2}mv^2 - \frac{GMm}{r}\left(1 + \frac{v^2}{2c^2}\right) \tag{7.17}$$

Circular Orbit Approximation

For near-circular orbits ($e \approx 0$):

- Instantaneous distance $r \approx a$ (constant).
- Angular velocity $\omega = \frac{d\phi}{dt} = \text{constant}$.
- Orbital velocity $v = a\omega$.

Equation of Motion

The radial force balance yields:

$$ma\omega^2 = \frac{GMm}{a^2}\left(1 + \frac{a^2\omega^2}{2c^2}\right) \tag{7.18}$$

Solution for Angular Velocity

Rearranging gives:

$$\omega^2 a^3 = GM\left(1 + \frac{a^2\omega^2}{2c^2}\right) \tag{7.19}$$

$$\omega^2\left(a^3 - \frac{GMa^2}{2c^2}\right) = GM \tag{7.20}$$

$$\omega^2 = \frac{GM}{a^3}\left(1 - \frac{GM}{2ac^2}\right)^{-1} \tag{7.21}$$

$$\approx \frac{GM}{a^3}\left(1 + \frac{GM}{2ac^2}\right) \quad \text{(Taylor expansion)} \tag{7.22}$$

Orbital Period

With $T = \frac{2\pi}{\omega}$, we obtain:

$$T \approx 2\pi\sqrt{\frac{a^3}{GM}}\left(1 - \frac{GM}{4ac^2}\right) \tag{7.23}$$

Exact Solution for Elliptical Orbits

The full solution including eccentricity e is:

$$\boxed{T = 2\pi\sqrt{\frac{a^3}{GM}}\left[1 - \frac{3GM}{4c^2a(1-e^2)}\right]} \tag{7.24}$$

Physical Interpretation

- The term $2\pi\sqrt{a^3/GM}$ matches the classical Keplerian result.
- The correction $-\frac{3GM}{4c^2a(1-e^2)}$ arises from:
  1. The velocity term $\frac{v^2}{c^2}$ in Weber gravity.
  2. The perihelion precession κ in the WDBT orbital equation.
- For Mercury ($a \approx 5.79 \times 10^{10}$ m, $e \approx 0.206$), the correction is $\approx 7.3 \times 10^{-8}$.

7.6 Dynamics of True Anomaly

The time evolution of $\phi(t)$ follows the differential equation:

$$\frac{d\phi}{dt} = \frac{h(1 + e\cos(\kappa\phi))^2}{a^2(1-e^2)^2},$$

where:

- $h = \sqrt{GMa(1-e^2)}$ is the specific angular momentum,
- $\kappa = \sqrt{1 - \frac{6GM}{c^2a(1-e^2)}}$ is the perihelion precession correction.

The solution $\phi(t)$ requires numerical integration to determine $\Delta\phi$ for $\Delta T = T_1 - T_0$.

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