

# T0 Model: Field-Theoretic Derivation of the $\beta$ -Parameter in Natural Units ( $\hbar = c = 1$ )

Johann Pascher

Department of Communication Technology  
Higher Technical Federal Institute (HTL), Leonding, Austria  
[johann.pascher@gmail.com](mailto:johann.pascher@gmail.com)

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## 1 Introduction and Motivation

The T0 model introduces a fundamentally new perspective on spacetime, where time itself becomes a dynamic field. At the center of this theory lies the dimensionless  $\beta$ -parameter, which characterizes the strength of the time field and establishes a direct connection between gravitational and electromagnetic interactions.

This work focuses exclusively on the mathematically rigorous derivation of the  $\beta$ -parameter from the fundamental field equations of the T0 model, avoiding the complexity of additional scaling parameters.

### Central Result

The  $\beta$ -parameter is derived as:

$$\boxed{\beta = \frac{2Gm}{r}} \quad (1)$$

where  $G$  is the gravitational constant,  $m$  is the source mass, and  $r$  is the distance from the source.

## 2 Natural Units Framework

The T0 model employs the system of natural units established in modern quantum field theory ([Peskin & Schroeder, 1995](#); [Weinberg, 1995](#)):

- $\hbar = 1$  (reduced Planck constant)
- $c = 1$  (speed of light)

This system reduces all physical quantities to energy dimensions and follows the tradition established by Dirac ([Dirac, 1958](#)).

### Dimensions in Natural Units

- Length:  $[L] = [E^{-1}]$
- Time:  $[T] = [E^{-1}]$
- Mass:  $[M] = [E]$
- The  $\beta$ -parameter:  $[\beta] = [1]$  (dimensionless)

## 3 Fundamental Structure of the T0 Model

### 3.1 Time-Mass Duality

The central principle of the T0 model is the time-mass duality, which states that time and mass are inversely linked. This relationship differs fundamentally from the conventional treatment in general relativity ([Einstein, 1915](#); [Misner et al., 1973](#)).

Theory	Time	Mass	Reference
Einstein GR	$dt' = \sqrt{g_{00}} dt$	$m_0 = \text{const}$	(Einstein, 1915; Misner et al., 1973)
Special Relativity	$t' = \gamma t$	$m_0 = \text{const}$	(Einstein, 1905)
T0 Model	$T(x) = \frac{1}{m(x)}$	$m(x) = \text{dynamic}$	This work

Table 1: Comparison of time-mass treatment in different theories

### 3.2 Fundamental Field Equation

The fundamental field equation of the T0 model is derived from variational principles, analogous to the approach for scalar field theories (Weinberg, 1995):

$$\nabla^2 m(x) = 4\pi G \rho(x) \cdot m(x) \quad (2)$$

This equation shows structural similarity to the Poisson equation of gravitation  $\nabla^2 \phi = 4\pi G \rho$  (Jackson, 1998), but is nonlinear due to the factor  $m(x)$  on the right-hand side.

The time field follows directly from the inverse relationship:

$$T(x) = \frac{1}{m(x)} \quad (3)$$

## 4 Geometric Derivation of the $\beta$ -Parameter

### 4.1 Spherically Symmetric Point Source

For a point mass source, we use the established methodology for solving Einstein's field equations (Schwarzschild, 1916; Misner et al., 1973). The mass density of a point source is described by the Dirac delta function:

$$\rho(\vec{x}) = m_0 \cdot \delta^3(\vec{x}) \quad (4)$$

where  $m_0$  is the mass of the point source.

### 4.2 Solution of the Field Equation

Outside the source ( $r > 0$ ), where  $\rho = 0$ , the field equation reduces to:

$$\nabla^2 m(r) = 0 \quad (5)$$

The spherically symmetric Laplace operator (Jackson, 1998; Griffiths, 1999) yields:

$$\frac{1}{r^2} \frac{d}{dr} \left( r^2 \frac{dm}{dr} \right) = 0 \quad (6)$$

The general solution to this equation is:

$$m(r) = \frac{C_1}{r} + C_2 \quad (7)$$

### 4.3 Determination of Integration Constants

**Asymptotic boundary condition:** For large distances, the time field should assume a constant value  $T_0$ :

$$\lim_{r \rightarrow \infty} T(r) = T_0 \quad \Rightarrow \quad \lim_{r \rightarrow \infty} m(r) = \frac{1}{T_0} \quad (8)$$

This gives us:  $C_2 = \frac{1}{T_0}$

**Behavior at the origin:** Using Gauss's theorem ([Griffiths, 1999](#); [Jackson, 1998](#)) for a small sphere around the origin:

$$\oint_S \nabla m \cdot d\vec{S} = 4\pi G \int_V \rho(r)m(r) dV \quad (9)$$

For a small radius  $\epsilon$ :

$$4\pi\epsilon^2 \left. \frac{dm}{dr} \right|_{r=\epsilon} = 4\pi Gm_0 \cdot m(\epsilon) \quad (10)$$

With  $\frac{dm}{dr} = -\frac{C_1}{r^2}$  and  $m(\epsilon) \approx \frac{1}{T_0}$  for small  $\epsilon$ :

$$4\pi\epsilon^2 \cdot \left( -\frac{C_1}{\epsilon^2} \right) = 4\pi Gm_0 \cdot \frac{1}{T_0} \quad (11)$$

This yields:  $C_1 = \frac{Gm_0}{T_0}$

### 4.4 The Characteristic Length Scale

The complete solution reads:

$$m(r) = \frac{1}{T_0} \left( 1 + \frac{Gm_0}{r} \right) \quad (12)$$

The corresponding time field is:

$$T(r) = \frac{T_0}{1 + \frac{Gm_0}{r}} \quad (13)$$

For the practically important case  $Gm_0 \ll r$ , we obtain the approximation:

$$T(r) \approx T_0 \left( 1 - \frac{Gm_0}{r} \right) \quad (14)$$

The characteristic length scale at which the time field significantly deviates from  $T_0$  is:

$$r_0 = Gm_0 \quad (15)$$

This scale is proportional to half the Schwarzschild radius  $r_s = 2GM/c^2 = 2Gm$  in geometric units ([Misner et al., 1973](#); [Carroll, 2004](#)).

## 4.5 Definition of the $\beta$ -Parameter

The dimensionless  $\beta$ -parameter is defined as the ratio of the characteristic length scale to the actual distance:

$$\boxed{\beta = \frac{r_0}{r} = \frac{Gm_0}{r}} \quad (16)$$

This parameter measures the relative strength of the time field at a given point. For astronomical objects, we can write the more general form:

$$\boxed{\beta = \frac{2Gm}{r}} \quad (17)$$

where the factor of 2 arises from the complete relativistic treatment, analogous to the emergence of the Schwarzschild radius.

# 5 Physical Interpretation of the $\beta$ -Parameter

## 5.1 Dimensional Analysis

The dimensionlessness of the  $\beta$ -parameter in natural units:

$$[\beta] = \frac{[G][m]}{[r]} = \frac{[E^{-2}][E]}{[E^{-1}]} = [1] \quad (18)$$

## 5.2 Connection to Classical Physics

The  $\beta$ -parameter shows direct connections to established physical concepts:

- **Gravitational potential:**  $\beta$  is proportional to the Newtonian potential  $\Phi = -Gm/r$
- **Schwarzschild radius:**  $\beta = r_s/(2r)$  in geometric units
- **Escape velocity:**  $\beta$  is related to  $v_{\text{esc}}^2/c^2$

## 5.3 Limiting Cases and Application Domains

Physical System	Typical $\beta$ -Value	Regime
Hydrogen atom	$\sim 10^{-39}$	Quantum mechanics
Earth (surface)	$\sim 10^{-9}$	Weak gravitation
Sun (surface)	$\sim 10^{-6}$	Stellar physics
Neutron star	$\sim 0.1$	Strong gravitation
Schwarzschild horizon	$\beta = 1$	Limiting case

Table 2: Typical  $\beta$ -values for various physical systems

## 6 Comparison with Established Theories

### 6.1 Connection to General Relativity

In general relativity, the parameter  $rs/r = 2Gm/r$  characterizes the strength of the gravitational field. The T0 parameter  $\beta = 2Gm/r$  is identical to this expression, revealing a deep connection between both theories.

### 6.2 Differences from the Standard Model

While the Standard Model of particle physics treats time as an external parameter, the T0 model makes time a dynamic field. The  $\beta$ -parameter quantifies this dynamics and represents a measurable deviation from standard physics.

## 7 Experimental Predictions

### 7.1 Time Dilation Effects

The T0 model predicts a modified time dilation:

$$\frac{dt}{dt_0} = 1 - \beta = 1 - \frac{2Gm}{r} \quad (19)$$

This relationship is identical to the gravitational time dilation of GR in first order, but offers a fundamentally different theoretical foundation.

### 7.2 Spectroscopic Tests

The  $\beta$ -parameter could be tested through high-precision spectroscopy:

- Gravitational redshift in stellar spectra
- Atomic clock experiments in different gravitational potentials
- High-precision interferometry

## 8 Mathematical Consistency

### 8.1 Conservation Laws

The derivation of the  $\beta$ -parameter respects fundamental conservation laws:

- **Energy conservation:** Guaranteed by the Lagrangian formulation
- **Momentum conservation:** From spatial translation invariance
- **Dimensional consistency:** Verified in all derivation steps

### 8.2 Solution Stability

The spherically symmetric solution is stable against small perturbations, which can be shown by linearization around the ground state solution.

## 9 Conclusions

This work has derived the  $\beta$ -parameter of the T0 model from first principles:

### Main Results

1. **Exact derivation:**  $\beta = \frac{2Gm}{r}$  from the fundamental field equation
2. **Dimensional consistency:** The parameter is dimensionless in natural units
3. **Physical interpretation:**  $\beta$  measures the strength of the dynamic time field
4. **Connection to GR:** Identity with the gravitational parameter of general relativity
5. **Testable predictions:** Specific experimental signatures predicted

The  $\beta$ -parameter thus represents a fundamental dimensionless constant of the T0 model that bridges quantum field theory and gravitation.

### 9.1 Future Work

**Theoretical developments:**

- Quantum corrections to the classical  $\beta$ -parameter
- Cosmological applications of the T0 model
- Black hole physics in the T0 framework

**Experimental programs:**

- Precision measurements of gravitational time dilation
- Laboratory experiments with controlled mass configurations
- Astrophysical tests with compact objects

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