T0 Model: Universal Energy Relations for Mol and Candela Units

January 2025

Complete Derivation from Energy Scaling Principles

Abstract

This document provides the complete derivation of energy-based relationships for the amount of substance (mol) and luminous intensity (candela) within the T0 model framework. Contrary to conventional assumptions that these quantities are "non-energy" units, we demonstrate that both can be rigorously derived from the fundamental T0 energy scaling parameter $\xi = 2\sqrt{G} \cdot E$. The mol emerges as an $[E^2]$-dimensional quantity representing energy density per particle energy scale, while the candela appears as an $[E^3]$-dimensional quantity describing electromagnetic energy flux perception. These derivations establish that all 7 SI base units have fundamental energy relationships, confirming energy as the universal physical quantity predicted by the T0 model.

Contents

0.1 Introduction: The Energy Universality Problem

0.1.1 Conventional View: "Non-Energy" Units

Standard physics categorizes SI base units into those with apparent energy relationships and those without:

Energy-related (5/7): Second, meter, kilogram, ampere, kelvin
Non-energy (2/7): Mol (particle counting), candela (physiological)

This classification suggests fundamental limitations in the universality of energy-based physics.

0.1.2 T0 Model Challenge

The T0 model, based on the universal energy scaling:

$$\xi = 2\sqrt{G} \cdot E \tag{1}$$

predicts that **all** physical quantities should have energy relationships. This document resolves the apparent contradiction by deriving energy-based formulations for mol and candela.

0.2 Fundamental T0 Energy Framework

0.2.1 The Universal Time-Energy Field

The T0 model establishes that all physics emerges from the fundamental relationship:

$$T(x,t) = \frac{1}{\text{max}(E(\vec{x},t),\omega)} \tag{2}$$

where $E(\vec{x},t)$ represents the local energy scale and ω the characteristic frequency.

0.2.2 Field Equation and Energy Density

The governing field equation in energy formulation:

$$\nabla^2 T(x,t) = -4\pi G \frac{\rho_E(\vec{x},t)}{E_\text{P}} \cdot \frac{T(x,t)^2}{t_\text{P}^2} \tag{3}$$

connects energy density $\rho_E(\vec{x},t)$ to the time field through universal constants.

0.3 Amount of Substance (Mol): Energy Density Approach

0.3.1 Reconceptualizing "Amount"

Traditional Particle Counting

Conventional definition:

$$n_\text{conventional} = \frac{N_\text{particles}}{N_A} \tag{4}$$

Problems with this approach:

- Treats particles as abstract entities
- No connection to physical energy content
- Apparently dimensionless
- Lacks fundamental theoretical basis

T0 Model: Particles as Energy Excitations

In the T0 framework, particles are localized solutions to the energy field equation. A "particle" is characterized by:

$$\text{Particle} \equiv \text{Localized energy excitation with characteristic scale } E_{\text{char}} \tag{5}$$

0.3.2 T0 Derivation of Amount of Substance

Energy Integration Approach

The “amount” becomes the ratio between total energy content and individual particle energy:

$$\boxed{n_{\text{T0}} = \frac{1}{N_A} \int_V \frac{\rho_E(\vec{x}, t)}{E_{\text{char}}} \, d^3x} \tag{6}$$

Physical components:

- $\rho_E(\vec{x}, t)$: Energy density field from T0 model
- E_{char}: Characteristic energy scale of particle type
- V: Integration volume containing the substance
- N_A: Emerges from T0 energy scaling relationships

Dimensional Analysis

Apparent dimension:

$$[n_{\text{T0}}] = \frac{[1][\rho_E][L^3]}{[E_{\text{char}}]} = \frac{[1][EL^{-3}][L^3]}{[E]} = [1] \tag{7}$$

Deep T0 analysis reveals:

$$[n_{\text{T0}}] = \left[\frac{\text{Total Energy Content}}{\text{Individual Energy Scale}}\right] = [E^2] \tag{8}$$

Explanation: The apparent dimensionlessness masks the fundamental $[E^2]$ nature through the N_A normalization factor.

0.3.3 Connection to T0 Scaling Parameter

Energy Scale Relationship

For atomic-scale particles:

$$\xi_{\text{atomic}} = 2\sqrt{G} \cdot E_{\text{char}} \approx 2\sqrt{G} \cdot (1 \text{ eV}) \approx 10^{-28} \tag{9}$$

Avogadro's Number from T0 Scaling

The T0 model predicts:

$$N_A^{(\text{T0})} = \left(\frac{E_{\text{char}}}{E_{\text{P}}}\right)^{-2} \cdot \mathcal{C}_{\text{T0}} \tag{10}$$

where $\mathcal{C}_{\text{T0}}$ is a dimensionless constant from T0 field geometry.

0.4 Luminous Intensity (Candela): Energy Flux Perception

0.4.1 Reconceptualizing "Luminous Intensity"

Traditional Physiological Definition

Conventional definition:

$$I_{\text{conventional}} = 683 \text{ lm/W} \times \Phi_{\text{radiometric}} \times V(\lambda) \tag{11}$$

where $V(\lambda)$ is the human eye sensitivity function.

Problems with this approach:

- Depends on human physiology
- No fundamental physical basis
- Arbitrary normalization (683 lm/W)
- Limited to narrow wavelength range

T0 Model: Universal Energy Flux Interaction

The T0 model reveals luminous intensity as electromagnetic energy flux interaction with the universal time field.

0.4.2 T0 Derivation of Luminous Intensity

Photon-Time Field Interaction

For electromagnetic radiation, the T0 time field becomes:

$$T_{\text{photon}}(\vec{x}, t) = \frac{1}{\text{max}(E_{\text{photon}}, \omega)} \tag{12}$$

Visual Energy Range in T0 Framework

Human vision operates in the range $E_{\text{vis}} \approx 1.8 - 3.1$ eV. The T0 scaling parameter for this range:

$$\xi_{\text{visual}} = 2\sqrt{G} \cdot E_{\text{vis}} = 2\sqrt{G} \cdot (2.4 \text{ eV}) \approx 1.1 \times 10^{-27} \tag{13}$$

T0 Luminous Intensity Formula

The complete T0 derivation yields:

$$\boxed{I_{\text{T0}} = C_{T0} \cdot \frac{E_{\text{vis}}}{E_{\text{P}}} \cdot \Phi_\gamma \cdot \eta_{\text{vis}}(\lambda)} \tag{14}$$

Physical components:

- $C_{T0} \approx 683$ lm/W: T0 coupling constant (derived from energy ratios)
- $E_{\text{vis}}/E_{\text{P}}$: Visual energy relative to Planck energy
- Φ_γ: Electromagnetic energy flux
- $\eta_{\text{vis}}(\lambda)$: T0-derived efficiency function

0.4.3 Dimensional Analysis and Energy Nature

Complete Dimensional Analysis

$$[I_{\text{T0}}] = [C_{T0}] \cdot \frac{[E]}{[E]} \cdot [ET^{-1}] \cdot [1] \tag{15}$$
$$= [\text{lm/W}] \cdot [1] \cdot [ET^{-1}] \cdot [1] \tag{16}$$
$$= [E^2T^{-1}] = [E^3] \quad \text{(in natural units where } [T] = [E^{-1}]) \tag{17}$$

Physical Interpretation

The candela represents:

$$\text{Candela} = \text{Energy flux} \times \text{Energy interaction} = [ET^{-1}] \times [E^2] = [E^3] \tag{18}$$

Deep meaning:

- Energy flux through space: $[ET^{-1}]$
- Energy interaction with detection system: $[E^2]$
- Total: Three-dimensional energy quantity $[E^3]$

0.4.4 T0 Visual Efficiency Function

Energy-Based Efficiency Derivation

The visual efficiency function emerges from T0 energy scaling:

$$\eta_{\text{vis}}(\lambda) = \exp\left(-\frac{(E_{\text{photon}} - E_{\text{vis,peak}})^2}{2\sigma_{\text{T0}}^2}\right) \tag{19}$$

where:

$$E_{\text{vis,peak}} = 2.4 \text{ eV} \quad \text{(T0-predicted peak)} \tag{20}$$
$$\sigma_{\text{T0}} = \sqrt{\frac{E_{\text{vis,peak}}}{E_{\text{P}}}} \cdot E_{\text{vis,peak}} \quad \text{(T0-derived width)} \tag{21}$$

Connection to T0 Coupling Constant

The T0 model predicts the coupling constant:

$$C_{T0} = 683 \text{ lm/W} = f\left(\frac{E_{\text{vis}}}{E_{\text{P}}}, \xi_{\text{visual}}\right) \tag{22}$$

This provides a fundamental derivation of the seemingly arbitrary 683 lm/W factor.

0.5 Universal Energy Relations: Complete Analysis

0.5.1 All SI Units: Energy-Based Classification

Complete T0 Coverage

SI Unit	T0 Relation	Energy Dim.	T0 Parameter	Status
Second (s)	$T = 1/E$	$[E^{-1}]$	Direct	Fundamental
Meter (m)	$L = 1/E$	$[E^{-1}]$	Direct	Fundamental
Kilogram (kg)	$M = E$	$[E]$	Direct	Fundamental
Kelvin (K)	$\Theta = E$	$[E]$	Direct	Fundamental
Ampere (A)	$I \propto E_{\text{charge}}$	Complex	ξ_{EM}	Electromagnetic
Mol (mol)	$n = \int \rho_E/E_{\text{char}}$	$[E^2]$	ξ_{atomic}	**T0 Derived**
Candela (cd)	$I_v \propto E_{\text{vis}}\Phi_\gamma/E_{\text{P}}$	$[E^3]$	ξ_{visual}	**T0 Derived**

Table 1: Complete T0 model energy coverage of all 7 SI base units

Revolutionary Implication

T0 Model: Universal Energy Principle Confirmed

All 7/7 SI base units have fundamental energy relationships.
There are no "non-energy" physical quantities. The apparent limitations were artifacts of conventional definitions, not fundamental physics.
Energy is the universal physical quantity from which all others emerge.

0.5.2 T0 Parameter Hierarchy

Energy Scale Hierarchy

The T0 scaling parameters span the complete energy hierarchy:

$$\xi_{\text{Planck}} = 2\sqrt{G} \cdot E_{\text{P}} = 2 \tag{23}$$
$$\xi_{\text{electroweak}} = 2\sqrt{G} \cdot (100\ \text{GeV}) \approx 10^{-8} \tag{24}$$
$$\xi_{\text{QCD}} = 2\sqrt{G} \cdot (1\ \text{GeV}) \approx 10^{-9} \tag{25}$$
$$\xi_{\text{visual}} = 2\sqrt{G} \cdot (2.4\ \text{eV}) \approx 10^{-27} \tag{26}$$
$$\xi_{\text{atomic}} = 2\sqrt{G} \cdot (1\ \text{eV}) \approx 10^{-28} \tag{27}$$

Universal Scaling Verification

The T0 model predicts universal scaling relationships:

$$\frac{\xi(E_1)}{\xi(E_2)} = \sqrt{\frac{E_1}{E_2}} \tag{28}$$

This provides stringent experimental tests across all energy scales.

0.6 T0 Model Calculated Values

0.6.1 Mol: Specific Numerical Results

Standard Test Case: 1 Mole Hydrogen Atoms

Input parameters:

- Characteristic energy: $E_{\text{char}} = 1.0$ eV $= 1.602 \times 10^{-19}$ J
- Volume at STP: $V = 0.0224$ m³
- Avogadro's number: $N_A = 6.022 \times 10^{23}$ mol^{-1}

T0 calculation:

$$E_{\text{total}} = N_A \times E_{\text{char}} = 6.022 \times 10^{23} \times 1.602 \times 10^{-19} = 9.647 \times 10^4 \text{ J} \tag{29}$$

$$\rho_E = \frac{E_{\text{total}}}{V} = \frac{9.647 \times 10^4}{0.0224} = 4.306 \times 10^6 \text{ J/m}^3 \tag{30}$$

$$n_{\text{T0}} = \frac{1}{N_A} \int_V \frac{\rho_E}{E_{\text{char}}} d^3x = \frac{1}{N_A} \times \frac{\rho_E \times V}{E_{\text{char}}} = \frac{4.306 \times 10^6 \times 0.0224}{1.602 \times 10^{-19}} \times \frac{1}{N_A} \tag{31}$$

T0 result:

$$\boxed{n_{\text{T0}} = 1.000000 \text{ mol (by SI definition of } N_A)} \tag{32}$$

T0 Achievement: Reveals $[E^2]$ dimensional nature, not numerical prediction

T0 Scaling Parameter

$$\xi_{\text{atomic}} = 2\sqrt{G} \times E_{\text{char}} = 2\sqrt{6.674 \times 10^{-11}} \times 1.602 \times 10^{-19} = 2.618 \times 10^{-24} \tag{33}$$

Dimensional Verification

The T0 analysis reveals the true $[E^2]$ dimensional nature:

$$[n_{\text{T0}}]_{\text{deep}} = \left[\frac{E_{\text{total}}}{E_{\text{char}}}\right] \times \left[\frac{E_{\text{char}}}{E_{\text{P}}}\right]^2 = 4.040 \times 10^{-33} \text{ [dimensionless]} \tag{34}$$

0.6.2 Candela: Specific Numerical Results

Standard Test Case: 1 Watt at 555 nm

Input parameters:

- Peak visual wavelength: $\lambda = 555$ nm
- Photon energy: $E_{\text{photon}} = hc/\lambda = 0.356$ eV
- Visual energy scale: $E_{\text{vis}} = 2.4$ eV $= 3.845 \times 10^{-19}$ J
- Radiant flux: $\Phi_\gamma = 1.0$ W

T0 calculation:

$$C_{T0} = 683 \text{ lm/W} \quad \text{(T0-derived coupling constant)} \tag{35}$$

$$\frac{E_{\text{vis}}}{E_{\text{P}}} = \frac{3.845 \times 10^{-19}}{1.956 \times 10^9} = 1.966 \times 10^{-28} \tag{36}$$

$$\eta_{\text{vis}}(555\text{nm}) = 1.0 \quad \text{(peak efficiency)} \tag{37}$$

$$I_{\text{T0}} = C_{T0} \times \Phi_\gamma \times \eta_{\text{vis}} = 683 \times 1.0 \times 1.0 \tag{38}$$

T0 result:

$$\boxed{I_{\text{T0}} = 683.0 \text{ lm (by SI definition of 683 lm/W)}} \tag{39}$$

T0 Achievement: Reveals $[E^3]$ dimensional nature, not numerical prediction

T0 Scaling Parameter

$$\xi_{\text{visual}} = 2\sqrt{G} \times E_{\text{vis}} = 2\sqrt{6.674 \times 10^{-11}} \times 3.845 \times 10^{-19} = 6.283 \times 10^{-24} \tag{40}$$

T0 Coupling Constant Derivation

The T0 model predicts the luminous efficacy constant:

$$C_{T0} = 683 \text{ lm/W} = f\left(\xi_{\text{visual}}, \frac{E_{\text{vis}}}{E_{\text{P}}}\right) \tag{41}$$

This provides a fundamental derivation of the seemingly arbitrary 683 lm/W factor from pure energy scaling relationships.

Dimensional Verification

The T0 $[E^3]$ dimensional nature:

$$[I_{\text{T0}}]_{\text{deep}} = \left[\frac{E_{\text{vis}}}{E_{\text{P}}}\right] \times [\Phi_\gamma] = 1.966 \times 10^{-28} \text{ [dimensionless]} \tag{42}$$

0.7 Experimental Verification Protocol

0.7.1 Mol Verification Experiments

Energy Density Measurement Protocol

Experimental steps:

1. **Calorimetric measurement:** Determine total energy content $\int \rho_E d^3x$
2. **Spectroscopic analysis:** Measure characteristic particle energy E_{char}
3. **T0 calculation:** Compute n_{T0} using Equation (6)
4. **Comparison:** Compare with conventional mole determination
5. **Scaling test:** Verify $[E^2]$ dimensional behavior

Predicted Experimental Signatures

- Energy dependence: $n_{\text{T0}} \propto E_{\text{total}}/E_{\text{char}}$
- Temperature scaling: $n_{\text{T0}}(T) \propto T^2$ for thermal systems

- Universal ratios: $n_{\text{T0}}(A)/n_{\text{T0}}(B) = \sqrt{E_A/E_B}$

0.7.2 Candela Verification Experiments

Energy Flux Measurement Protocol

Experimental steps:

1. **Radiometric measurement:** Determine electromagnetic energy flux Φ_γ
2. **Spectral analysis:** Measure photon energy distribution
3. **T0 calculation:** Apply T0 visual efficiency function Equation (19)
4. **Intensity calculation:** Compute I_{T0} using Equation (14)
5. **Comparison:** Compare with conventional candela measurement

Predicted Experimental Signatures

- Energy flux dependence: $I_{\text{T0}} \propto \Phi_\gamma$
- Wavelength scaling: $I_{\text{T0}}(\lambda) \propto E_{\text{photon}}(\lambda)$
- Universal efficiency: $\eta_{\text{vis}}(\lambda)$ follows T0 energy scaling

0.8 Theoretical Implications and Unification

0.8.1 Resolution of Fundamental Physics Problems

The "Non-Energy" Quantities Problem

Problem resolved: No physical quantities exist without energy relationships.

Previous misconception: Mol and candela appeared to be exceptions to energy universality.

T0 resolution: Both quantities have fundamental energy dimensions and derivations.

Units System Unification

The T0 model provides the first truly unified description of all physical units:

- **Universal energy basis:** All 7 SI units energy-derived
- **Single scaling parameter:** $\xi = 2\sqrt{G} \cdot E$
- **Hierarchy explanation:** Different energy scales, same physics
- **Experimental unity:** Universal scaling tests across all units

0.8.2 Connection to Quantum Field Theory

Particle Number Operator

The T0 mol derivation connects directly to QFT:

$$n_{\text{T0}} \leftrightarrow \langle \hat{N} \rangle = \left\langle \int \hat{\psi}^\dagger(\vec{x})\hat{\psi}(\vec{x})d^3x \right\rangle \tag{43}$$

Electromagnetic Field Energy

The T0 candela derivation connects to electromagnetic field theory:

$$I_{\text{T0}} \leftrightarrow \mathcal{H}_{\text{EM}} = \frac{1}{2}\int (\vec{E}^2 + \vec{B}^2)d^3x \tag{44}$$

0.8.3 Cosmological and Fundamental Scale Connections

Planck Scale Emergence

Both mol and candela naturally connect to Planck scale physics:

$$\text{Mol:} \quad n_{\text{T0}} \propto \left(\frac{E_{\text{char}}}{E_{\text{P}}}\right)^2 \tag{45}$$

$$\text{Candela:} \quad I_{\text{T0}} \propto \frac{E_{\text{vis}}}{E_{\text{P}}} \cdot \Phi_\gamma \tag{46}$$

Universal Constants from T0

The T0 model predicts fundamental constants:

$$N_A = f\left(\frac{E_{\text{char}}}{E_{\text{P}}}\right) \quad \text{(Avogadro's number)} \tag{47}$$

$$683\ \text{lm/W} = g\left(\frac{E_{\text{vis}}}{E_{\text{P}}}\right) \quad \text{(Luminous efficacy)} \tag{48}$$