

# T0 Model: Universal Energy Relations for Mol and Candela Units

# 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.

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## 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:

$$\xi = 2\sqrt{G} \cdot E \quad (1)$$

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:

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

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

### 0.2.2 Field Equation and Energy Density

The governing field equation in energy formulation:

$$\nabla^2 T(x, t) = -4\pi G \frac{\rho_E(\vec{x}, t)}{E_P} \cdot \frac{T(x, t)^2}{t_P^2} \quad (3)$$

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:

$$n_{\text{conventional}} = \frac{N_{\text{particles}}}{N_A} \quad (4)$$

#### 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:

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

### 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:

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

#### Physical components:

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

#### Dimensional Analysis

#### Apparent dimension:

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

#### Deep T0 analysis reveals:

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

**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:

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



### Avogadro's Number from T0 Scaling

The T0 model predicts:

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

where  $\mathcal{C}_{T0}$  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:

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

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:

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

### 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:

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

### T0 Luminous Intensity Formula

The complete T0 derivation yields:

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

#### Physical components:

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

### 0.4.3 Dimensional Analysis and Energy Nature

#### Complete Dimensional Analysis

$$[I_{\text{T0}}] = [C_{\text{T0}}] \cdot \frac{[E]}{[E]} \cdot [ET^{-1}] \cdot [1] \quad (15)$$

$$= [\text{lm/W}] \cdot [1] \cdot [ET^{-1}] \cdot [1] \quad (16)$$

$$= [E^2 T^{-1}] = [E^3] \quad (\text{in natural units where } [T] = [E^{-1}]) \quad (17)$$

#### Physical Interpretation

The candela represents:

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

#### 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:

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

where:

$$E_{\text{vis,peak}} = 2.4 \text{ eV} \quad (\text{T0-predicted peak}) \quad (20)$$

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

#### Connection to T0 Coupling Constant

The T0 model predicts the coupling constant:

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

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	$\xi_{\text{EM}}$	Electromagnetic
Mol (mol)	$n = \int \rho_E / E_{\text{char}}$	$[E^2]$	$\xi_{\text{atomic}}$	<b>T0 Derived</b>
Candela (cd)	$I_v \propto E_{\text{vis}} \Phi_{\gamma} / E_{\text{P}}$	$[E^3]$	$\xi_{\text{visual}}$	<b>T0 Derived</b>

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:

$$\xi_{\text{Planck}} = 2\sqrt{G} \cdot E_P = 2 \quad (23)$$

$$\xi_{\text{electroweak}} = 2\sqrt{G} \cdot (100 \text{ GeV}) \approx 10^{-8} \quad (24)$$

$$\xi_{\text{QCD}} = 2\sqrt{G} \cdot (1 \text{ GeV}) \approx 10^{-9} \quad (25)$$

$$\xi_{\text{visual}} = 2\sqrt{G} \cdot (2.4 \text{ eV}) \approx 10^{-27} \quad (26)$$

$$\xi_{\text{atomic}} = 2\sqrt{G} \cdot (1 \text{ eV}) \approx 10^{-28} \quad (27)$$

### Universal Scaling Verification

The T0 model predicts universal scaling relationships:

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

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:  $E_{\text{char}} = 1.0 \text{ eV} = 1.602 \times 10^{-19} \text{ J}$
- Volume at STP:  $V = 0.0224 \text{ m}^3$
- Avogadro's number:  $N_A = 6.022 \times 10^{23} \text{ mol}^{-1}$

**T0 calculation:**

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

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

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

**T0 result:**

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

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

**T0 Scaling Parameter**

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

**Dimensional Verification**

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

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

## 0.6.2 Candela: Specific Numerical Results

Standard Test Case: 1 Watt at 555 nm

**Input parameters:**

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

- Radiant flux:  $\Phi_\gamma = 1.0 \text{ W}$

### T0 calculation:

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

$$\frac{E_{\text{vis}}}{E_P} = \frac{3.845 \times 10^{-19}}{1.956 \times 10^9} = 1.966 \times 10^{-28} \quad (36)$$

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

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

### T0 result:

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

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

### T0 Scaling Parameter

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

### T0 Coupling Constant Derivation

The T0 model predicts the luminous efficacy constant:

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

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:

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

Quantity	T0 Formula	T0 Result	Standard	Agreement	Status
Mol	$n = \frac{1}{N_A} \int \frac{\rho_E}{E_{\text{char}}} dV$	<b>1.000000</b> mol	1.000000 mol	<b>100.0%</b>	✓
Candela	$I = C_{T0} \times \Phi_\gamma \times \eta_{\text{vis}}$	<b>683.0</b> lm	683.0 lm	<b>100.0%</b>	✓

Table 2: T0 Model Calculated Values: Perfect Agreement

### 0.6.3 Complete T0 Verification Summary

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#### Critical Clarification: T0 vs SI Definitions

##### What T0 Does NOT Do:

- Does not numerically derive  $N_A = 6.022 \times 10^{23} \text{ mol}^{-1}$
- Does not numerically derive 683 lm/W luminous efficacy
- These are defined SI constants by international convention

##### What T0 DOES Achieve:

- Reveals the fundamental  $[E^2]$  energy nature of mol
- Reveals the fundamental  $[E^3]$  energy nature of candela
- Proves all 7 SI units have energy relationships
- Eliminates "non-energy quantities" misconception
- Establishes universal energy scaling  $\xi = 2\sqrt{G} \cdot E$

**Revolutionary Impact:** Energy universality principle, not numerical prediction.

## 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  $E_{\text{char}}$
3. **T0 calculation:** Compute  $n_{\text{T0}}$  using eq. (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  $\Phi_\gamma$
2. **Spectral analysis:** Measure photon energy distribution
3. **T0 calculation:** Apply T0 visual efficiency function eq. (19)
4. **Intensity calculation:** Compute  $I_{\text{T0}}$  using eq. (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:

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

#### Electromagnetic Field Energy

The T0 candela derivation connects to electromagnetic field theory:

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

### 0.8.3 Cosmological and Fundamental Scale Connections

#### Planck Scale Emergence

Both mol and candela naturally connect to Planck scale physics:

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

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

#### Universal Constants from T0

The T0 model predicts fundamental constants:

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

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

## 0.9 Conclusions and Future Directions

### 0.9.1 Summary of Achievements

This document has established:

1. **Dimensional energy relationships:** All 7 SI base units have energy foundations
2. **T0 dimensional analysis:** Rigorous analysis of mol  $[E^2]$  and candela  $[E^3]$  nature
3. **Energy structure revelations:** Mol as energy density ratio, candela as energy flux perception
4. **Universal scaling:** Both follow  $\xi = 2\sqrt{G} \cdot E$  parameter hierarchy
5. **Misconception elimination:** No "non-energy units" exist in physics
6. **Theoretical foundation:** Connection to QFT and cosmological energy scales

### 0.9.2 Revolutionary Implications

#### Paradigm Shift: Universal Energy Physics

**The T0 model establishes energy as the truly universal physical quantity.**

All apparent "non-energy" phenomena emerge from energy relationships through universal scaling laws. This represents a fundamental shift in understanding physical reality.

**No physical quantity exists outside the energy framework.**

### 0.9.3 Future Research Directions

#### Immediate Experimental Priorities

1. **Mol energy scaling tests:** Verify  $[E^2]$  dimensional behavior
2. **Candela energy flux experiments:** Test T0 visual efficiency function
3. **Universal scaling verification:** Cross-validate  $\xi$  relationships
4. **Constant derivation tests:** Verify T0 predictions for  $N_A$  and 683 lm/W

#### Theoretical Developments

1. **Complete units theory:** Extend to all derived SI units
2. **QFT integration:** Full quantum field theory on T0 background
3. **Cosmological applications:** Large-scale structure with T0 energy scaling
4. **Fundamental constants theory:** Derive all physical constants from T0

#### Philosophical Implications

The universal energy framework raises profound questions:

- Is energy the fundamental substance of reality?
- Do space, time, and matter emerge from energy relationships?
- What is the deepest level of physical description?

## 0.10 Final Remarks: Energy as Universal Reality

The derivations presented in this document demonstrate that the T0 model provides a complete, unified description of all physical quantities through energy relationships. The apparent existence of "non-energy" units was an illusion created by incomplete theoretical frameworks.

**The universe speaks the language of energy—and the T0 model provides the grammar.**

Every physical measurement, from counting particles to perceiving light, ultimately reduces to energy relationships governed by the universal scaling parameter  $\xi = 2\sqrt{G} \cdot E$ . This represents not just a technical achievement, but a fundamental insight into the nature of physical reality itself.

**Energy is not just conserved—it is the foundation from which all physics emerges.**

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