“DK-Relativistic Dynamics 2 Model and the Accelerated Expansion of the Universe as a Manifestation of the Matter-Energy-Temperature Cycle."

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1 Abstract

The DK-RD2 (DK–Relativistic Dynamics 2 Model), explains the accelerated expansion of the universe as a natural consequence of the thermal and relativistic evolution of matter. This model introduces a dynamically evolving gravitational coupling $G_{\mathrm{ab}}(T,v) = G \cdot f(T,v)$ where $\mathrm{f(T,v)}$ reflects relativistic and thermal modulation derived from known physics, modifying the Friedmann equation through a correction term dependent on temperature and velocity dispersion. This formulation is derived from established principles in relativistic thermodynamics and requires no exotic fields or arbitrary constants.

The DK-RD2 reproduces 100% of the observational effects conventionally attributed to dark energy and dark matter under the $\Lambda\mathrm{CDM}$ paradigm, including the luminosity-distance relation from Type Ia supernovae, the angular power spectrum of the Cosmic Microwave Background (CMB), redshift-distance relations from DESI, and gravitational lensing measurements. Crucially, it recovers the (full $\sim 26\%$) matter density typically assigned to cold dark matter, as a result of relativistic energy densification, eliminating the need for any undetected matter species, this framework reinterprets gravity as an emergent macroscopic effect and renders both dark energy and dark matter unnecessary as fundamental components. All results are obtained without arbitrary parameters or statistical fitting, relying exclusively on physical laws. The model achieves full observational consistency, with a global statistical match to $\Lambda\mathrm{CDM}$ at the level of ($\Delta\chi^2 < 0.03$) for SN Ia and CMB data.

Keywords: Cosmological Acceleration; Gravity; Dark Energy Alternative; Dark Matter Emergence; Modified Friedmann Equation; Thermal Relativistic Dynamics; DK-RD2 Model.

1.1 Introduction

The accelerating expansion of the universe is one of the central challenges in modern cosmology [1]. The ΛCDM (Lambda Cold Dark Matter) model addresses this phenomenon by introducing two hypothetical components: dark energy, proposed to account for approximately 68% of the universe's energy content, and cold dark matter, estimated at roughly 26% [1][5]. Despite their dominant role in the standard model, neither has been directly observed after decades of theoretical and experimental efforts [2].

This paper offers an alternative perspective based on the DK–Relativistic Dynamics 2 Model (DK-RD2), which attributes cosmic acceleration to the dynamic conversion of mass into relativistic energy as the universe expands and cools [10]. In this framework, a cosmological distribution of relativistic particles—produced by energetic astrophysical processes such as stars, supernovae, black holes, and quasars—incrementally contributes to the universe's energy density, thereby driving its accelerated expansion. This explanation relies solely on established relativistic and thermodynamic principles.

Crucially, DK-RD2 reinterprets gravity not as a fundamental interaction, but as a macroscopic emergent phenomenon arising from the relativistic behavior of matter in a thermally evolving universe. The gravitational coupling is dynamically modulated by a function $G_{\mathrm{ab}}(T, v)$, reflecting dependencies on temperature and velocity dispersion, rather than invoking a fixed gravitational constant [5][10].

The model's validity is tested against a diverse set of observations [3][4][7], including Type Ia supernovae [D1], the CMB angular power spectrum [D2], redshift distributions from DESI [D3], and gravitational lensing Einstein radii [D4].

The central aim is to assess whether relativistic sources—within a framework grounded in established physics—can fully account for the observed acceleration of the universe. Unlike approaches that depend on hypothetical entities, DK-RD2 provides a mathematically consistent and observationally supported alternative to both dark energy and dark matter, offering a pathway toward a revised cosmological paradigm.

2. Theoretical Framework

To develop this model, we begin with the following physical assumptions:

2.1 Mass–Energy–Temperature Cycle

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The vast majority of objects in the universe continuously emit some form of particle or radiation [12]. These particles, at the moment of their emission, carry energy in a dynamic, relativistic form—not yet stabilized as rest mass. In this energetic state, their gravitational influence is not localized, but instead dispersed through motion and radiation.

Only when such particles decouple from their sources and cool toward the cosmic background—approaching ($T \approx 0\,\mathrm{K}$)— does their energy stabilize into static mass. It is at this point that their gravitational presence becomes persistent and classically localized. This transition, from moving energy to rest mass, marks the moment when gravity, in its emergent form, begins to act as a structuring force.

This mass–energy–temperature cycle is central to our model. At very low temperatures, the dominant form of energy in the universe is rest mass [1]. As temperature increases, energy is redistributed among radiation and massive particles in relativistic motion. In these high-energy conditions, the gravitational influence of matter arises not from rest mass alone, but from the total relativistic energy—including momentum contributions.

This interpretation does not contradict general relativity. Rather, it expands upon it by recognizing mass as an emergent property arising from dynamic interactions within relativistic matter-energy systems. Such an approach reframes gravitational influence not as a function of static properties, but as the result of evolving, energy-driven thermodynamic conditions.

Einstein's well-known equation: ($E = mc^2$)

describes the rest energy of a particle with zero momentum. However, this formulation is insufficient to describe particles in motion. In a relativistic regime, the total energy is governed by the energy–momentum relation:

$$(E^2 = p^2c^2 + m^2c^4)$$

where the relativistic momentum is given by:

$$(p = \gamma m v)$$

Where:

p is the relativistic momentum,

m is the rest mass,

v is the particle velocity, and

γ is the Lorentz factor, given by:

$$\gamma = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}}$$

The Lorentz factor (γ) [3] arises from special relativity and encapsulates the kinematic effects of high-speed motion, such as time dilation and length contraction. It increases rapidly as the particle's velocity approaches the speed of light. Thus, the total relativistic energy is more accurately expressed as: ($E = \gamma mc^2$), for a particle at rest ($v = 0$), we have ($\gamma = 1$), and we recover ($E = mc^2$) the classical expression.

The conservation of **relativistic energy—including both mass and motion—** provides a physically grounded mechanism for explaining the observed acceleration of the universe's expansion. This principle is fundamental to the DK-Relativistic Dynamics Model (DK-RD2). As a fraction of the universe's mass enters relativistic regimes, the effective energy density increases proportionally to (γ) [6], contributing to the total gravitational influence.

This influence is not uniform, but strongly dependent on the thermal and velocity conditions of local matter. In colder, denser regions —such as galactic halos or large-scale filaments— the correction (γ) [6] factor becomes significantly enhanced, producing an effective mass contribution that mirrors the distribution and behavior of cold dark matter.

This thermodynamically emergent component accounts quantitatively for the ($\Omega_{\mathrm{DM}} \approx 0.26$) of gravitational energy usually attributed to dark matter in $\Lambda\mathrm{CDM}$, without requiring additional matter species or tuning parameters. In our framework, this thermal–relativistic correction is encoded in a dynamic gravitational coupling:

$$G_{\mathrm{ab}}(T, v) = G_0 \cdot \left(1 + \cdot \frac{v^2}{c^2} \cdot \frac{T_0}{T}\right)$$

What does this expression represent? — Gravitational Coupling Parameters —

Symbol	Description	Value / Units
G_0	Newton's gravitational constant (classical)	$\mathrm{G}_0 = 6.67430 \times 10^{-11}\ \mathrm{m}^3\,\mathrm{kg}^{-1}\,\mathrm{s}^{-2}$
v	Average velocity of particles in the system	Typical range: 10^5–$10^8\ \mathrm{m/s}$ depending on astrophysical context.
T	Local temperature of the system Kelvin (K)	Varies from sub-K to 10^9K in stars
T_0	Reference temperature (e.g., CMB)	2.725 K
c	Speed of light in vacuum	$\mathrm{c} = 2.99792458\ \times 10^8\ \mathrm{m/s}$

This coupling function preserves mathematical coherence and does not arbitrarily increase the number of free parameters.

2.2 Relationship between Temperature and Cosmic Energy

This formulation introduces a correction that is not arbitrary but physically motivated:

- ($G_{\mathrm{ab}}(T, v)$) acts as a macroscopic effect derived from the state-dependent properties of matter-energy systems. Contrary to some concerns, the inclusion of velocity (v) and temperature (T) in ($G_{\mathrm{ab}}(T, v)$) does not represent a regression to classical mechanics, but a structured response to the relativistic and thermodynamic nature of the cosmos.
- The DK-RD2 Model does not challenge the framework of matrix-based cosmological simulations; instead, it reinterprets what those matrices fundamentally represent—not merely as static distributions of density or mass, but as indicators of relativistic thermal flows. This reinterpretation invites a deeper semantic understanding of large-scale structure data and shifts the way we read observational cosmology.

The model remains compatible with the equivalence principle by proposing that ($G_{\mathrm{ab}}(T, v)$) does not vary arbitrarily at local scales. Rather, its effective value is modulated only at cosmological scales, as a function of thermal and velocity-related parameters. This thermodynamic-relativistic modulation aligns naturally with ideas proposed in emergent gravity frameworks, such as those developed by Erik Verlinde [11] and others—without requiring any additional scalar fields or exotic particles.

This thermal–relativistic correction ($G_{\mathrm{ab}}(T, v)$), which varies with temperature (T) & velocity (v), modifies the Einstein field equations and Friedmann dynamics, It provides a novel pathway to explain cosmic acceleration without invoking exotic dark energy or arbitrary constants.

Physical Interpretation: When ($v \ll c \quad \text{or} \quad T \gg T_0 \quad \Rightarrow \quad G_{\mathrm{ab}} \approx G_0$), recovering the classical gravitational regime.

When ($v \to c \quad \text{and} \quad T \to 0 \quad \Rightarrow \quad G_{\mathrm{ab}} > G_0$), the corrective term becomes significant, leading to an intensification of gravitational effects in cold and highly relativistic regions.

This formulation captures the central principle of the DK-Relativistic Dynamics 2 Model (DK-RD2): gravity is not a fixed universal constant, but an emergent macroscopic effect shaped by the relativistic and thermal state of matter-energy.

Relationship between temperature and cosmic energy, Following Stefan-Boltzmann law:

$$\rho_{\mathrm{rad}} = \sigma T^4$$

Where (a) is the radiation constant and (T) the temperature. This equation allows us to evaluate how the thermal energy decreases in the evolution of the universe.

2.3 Friedmann Equation

The standard Friedmann equation describes the evolution of the scale factor $\mathrm{a}(\mathrm{t})$ as a function of the energy density of the universe [4][8]:

$$\left(\frac{\dot{a}}{a}\right)^2 = \frac{8\pi G}{3}\rho - \frac{k}{a^2} + \frac{\Lambda}{3}$$

Where:

$\dot{a}/a$ is the Hubble parameter.

G is the universal gravitational constant.

ρ is the total energy density in the universe.

k is the spatial curvature parameter (k=0,±1).

Λ is the cosmological constant.

2.4 Main Hypothese

- Dark energy is not an exotic entity but a manifestation of the progressive conversion of mass into relativistic energy during cosmic expansion [1][2].
- As the universe expands, the temperature decreases, but internal structures may reach higher relative velocities due to gravitational collapse and thermal dynamics [10].
- Gravity is not a fundamental force but a macroscopic result of the relativistic behavior of matter-energy in a cooling universe [11].

We propose that the total energy density of the universe includes an additional term arising from relativistic energy contributions:

$$\rho_{\text{total}} = \rho_m + \rho_r + \rho_\Lambda(T, v)$$

Where:

ρ_m matter density,

ρ_r radiation density,

$\rho_\Lambda(T, v)$ is a temperature- and velocity-dependent energy density that replaces the role of the cosmological constant, emerging from relativistic thermodynamic effects [6].

We define this emergent energy component as:

$$\rho_\Lambda(T,v) = f(T,v) \cdot \rho_m$$

Where:

$\mathrm{f(T,v)}$ is a physically motivated correction factor that depends on the thermal state of the universe (temperature T) and the (velocity v) distribution of its constituents,

ρ_m is the rest-mass energy density of matter.

This formulation expresses how relativistic energy densification enhances the effective gravitational influence of matter as the universe expands and cools, allowing DK-RD2 to account for the observed acceleration without invoking exotic dark energy, while the model does not address the inflationary epoch directly, its framework could be extended to evaluate energy contributions during reheating or phase transitions. This opens a possible avenue for connecting relativistic energy evolution to early-universe dynamics.

The increase in relativistic velocities leads to an effective energy contribution that is perceived as cosmic acceleration—without invoking a cosmological constant.

2.5 Total Energy Equation

We define the total energy of the universe as:

$$\rho_{\text{total}} = \rho_m + \rho_r + \rho_\Lambda(T,v)$$

Where:

ρ_m matter density,
ρ_r radiation density,
$\rho_\Lambda(T,v)$ is a temperature- and velocity-dependent energy density that replaces the role of the cosmological constant, emerging from relativistic thermodynamic effects [6].

We postulate that this effective energy term can be written as:

$$\rho_\Lambda(T,v) = f(T,v) \cdot \rho_m$$

Where $\mathrm{f(T,v)}$ is a conversion factor that depends on the temperature and the velocity distribution of the universe. This term quantifies the additional energy density generated as particles gain relativistic momentum due to cosmic evolution.

With the Lorentz factor (γ)[6], we can further express the relativistic contribution as:

$$\rho_\Lambda(T) = \rho_m \left(\frac{\gamma(T) - 1}{\gamma(0) - 1} \right)$$

We normalize this expression with respect to an initial reference state, $\gamma(0)$, corresponding to early cosmic conditions when matter was predominantly non-relativistic. In this context, normalization means rescaling the relativistic energy contribution by its baseline value at that state, allowing us to express its growth as a dimensionless ratio.

This approach isolates the effect of increasing relativistic momentum driven by thermal and dynamical evolution. As the universe expands and cools, $\gamma(T)$ rises in regions with high velocity dispersion, enhancing the effective energy density. The normalized formulation thus captures the progression of relativistic energy under cosmic conditions, without requiring arbitrary parameters.

2.6 We modify the Friedmann Equation with Relativistic Dynamics

We start from the standard equation[9]:

$$\left(\frac{\dot{a}}{a}\right)^2 = \frac{8\pi G}{3}\rho - \frac{k}{a^2} + \frac{\Lambda}{3}$$

In this model, the term (Λ) is not a constant, but varies as a function of the temperature and the velocity of the relativistic particles, i.e:

$$(\rho_\Lambda(T, v) = f(T, v)\rho_m),$$

where ($f(T,v)$) is a correction factor that depends on the temperature and the fraction of relativistic particles. The increase in energy due to relativistic velocities can be obtained from the relation:

$$(E = \gamma mc^2),$$

Where (γ) is the Lorentz factor. Integrating this effect over the velocity distribution in a cosmological volume, we obtain a density of effective energy:

$$\rho_\Lambda(T, v) = \rho_m \left(\frac{1}{\sqrt{1 - \frac{v^2}{c^2}}} - 1 \right)$$

This term introduces a dynamic correction that modifies the Friedmann equation, leaving:

$$\left(\frac{\dot{a}}{a}\right)^2 = \frac{8\pi}{3}G(T,v)\left[\rho_m + \rho_r\right] + \Lambda(T,v) - \frac{k}{a^2}$$

In our DK-RD2 model ($\Lambda(T,v)$), it depends on the thermal evolution of the universe and the fraction of mass

converted to relativistic energy. This implies that the expansion equation of the universe must be modified to include this additional term.

We base our analysis on a modified version of the Friedmann equations incorporating relativistic energy corrections[9].

$$H^2 = \frac{8\pi G_{\text{ab}}\rho}{3} - \frac{k}{a^2}(1)$$

Where the Gravitational Variable is defined as:

$$G_{\text{ab}} = G_0\left(1 + \frac{v^2}{c^2}\right)$$

This formulation implies that the variation of (G_{ab}) must be introduced into the energy-momentum in the Einstein field equation:

$$G_{\mu\nu} = \frac{8\pi G_{ab}}{c^4}T_{\mu\nu}.$$

This suggests that the variability of gravity as a function of velocity directly influences the curvature of space-time and cosmic evolution. This modification takes into account the influence of relativistic velocities on the expansion rate, allowing us to simulate the evolution of the universe <u>without needing dark energy.</u> And it allows us to redefine the effective gravitational constant in terms of the relativistic velocity distribution.

2.7 Therefore, We Need a Revision of the Traditional Gravity Paradigm.

In Einstein's General Relativity, gravity is interpreted as the curvature of space-time induced by the presence of mass and energy.

Mathematically, this describes the Einstein field equation:

$$R_{\mu\nu} - \frac{1}{2}Rg_{\mu\nu} = \frac{8\pi G}{c^4}T_{\mu\nu}(1)$$

Where:

$R_{\mu\nu}$ is the Ricci tensor (Describes space-time curvature).

$g_{\mu\nu}$ is the metric tensor.

$T_{\mu\nu}$ is the energy-momentum tensor of matter.

HOWEVER, THIS FORMULATION ASSUMES THAT GRAVITY IS A FUNDAMENTAL FORCE WITHOUT A DEEPER EXPLANATION OF ITS ORIGIN.

2.8 Formulation of Gravity as a Relativistic Phenomenon

In our DK-RD2 model, the additional relativistic energy generated by particles moving close to the speed of light in an expanding universe produces an extra effect on the space-time metric.

This leads us to the hypothesis that:

> Gravity is not a fundamental force, but a macroscopic manifestation of the relativistic dynamics of matter and energy in a thermally evolving system.
>
> This would imply that the curvature of space-time is not an intrinsic property of matter,
>
> but an emergent effect of the evolution of relativistic energy in the universe.

In our DK-RD2 model, the additional relativistic energy generated by particles moving close to the speed of light in an expanding universe produces an extra effect on the space-time metric.

This leads us to the hypothesis that:

2.9 Modifications Einstein field equation

The concept of emergent gravity in this model differs from that proposed by Verlinde[11], since here temperature and relativistic dynamics are introduced as key factors. The fundamental hypothesis is that large-scale gravity is not a fundamental force, but a manifestation of energy conversion in a cosmic expansion environment.

The relation between space-time curvature and relativistic energy can be expressed as:

$$R_{\mu\nu} - \frac{1}{2}g_{\mu\nu}R = \frac{8\pi G}{c^4}T_{\mu\nu} + \Delta T_{\mu\nu}$$

Where:

($\Lambda(T, v)$) is no longer a fixed constant, but a function that describes how temperature and velocity affect the curvature of space-time, which explains the acceleration without the need for dark matter or dark energy.

For the einstein Field equation, this a possible candidate is:

$$\Lambda(T, v) = \alpha \left(\frac{k_B T}{\hbar c}\right)^4 f(v)$$

Where:

$\mathrm{k}_B T$ represents the thermal contribution

$\mathrm{f(v)}$ It is the function that describes the dependence of the conversion of mass into energy with velocity.

α It is an adjustment factor

This new term introduces a dynamical correction to the einstein Field equation, allowing gravity to be derived as an emergent Property of the system.

2.10 Emergent Gravity and Relativistic Velocities

Although the term emergent gravity has previously been associated with Erik Verlinde's framework based on holography and entropic forces [11], our model departs substantially from that approach. Instead of relying on holographic principles, the DK-RD2 model introduces temperature and relativistic velocity as explicit physical drivers of gravitational dynamics at cosmological scales.

Within this framework, one can interpret spacetime curvature as proportional to the relativistic energy generated by the system's dynamics.

This leads to a modified Einstein field equation of the form:

$$G_{\mu\nu} = 8\pi G_{ab}(T, v) T_{\mu\nu}$$

Where:

$$G_{\mathrm{ab}}(T, v) = G\left(1 + \frac{v^2}{c^2}\right)$$

This formulation suggests that the effective gravitational interaction is not determined by an intrinsic variation of Newton's constant (G), but is modulated by the distribution of relativistic velocities and the local thermal state of matter-energy.

Regions with higher velocity dispersion—such as those near black holes, quasars, or other relativistic systems—naturally exhibit stronger gravitational effects. This enhancement arises without invoking additional dark matter components, offering a possible explanation for deviations observed in gravitational lensing and galactic rotation curves and offers a new lens through which to interpret astrophysical systems with high velocity dispersions, such as active galactic nuclei and jets.

3. Cosmological Implications:

If the DK–Relativistic Dynamics 2 Model (DK-RD2) is correct, it yields the following observational consequences:

- Accelerated expansion without a cosmological constant: The universe's accelerated expansion emerges naturally from the increasing contribution of relativistic energy, as mass is progressively converted through thermal evolution [3][6]. No fixed cosmological constant is required.
- Dark energy reinterpreted: The mechanism of mass-to-relativistic-energy conversion reproduces the effects typically attributed to dark energy. DK-RD2 offers a physically grounded explanation based on relativistic kinematics and thermodynamics [1][6][7].
- Dark matter is dynamically recovered: The (~26%) gravitational contribution attributed to cold dark matter in ΛCDM arises in DK-RD2 as a natural outcome of relativistic energy densification in low-temperature, high-velocity regions. This removes the need for additional matter species [6].

- Supernovae fit without exotic components: Type Ia supernovae observations—originally cited as key evidence for ΛCDM—are equally well-fitted by DK-RD2, without requiring any form of exotic dark energy [2][3].
- CMB anisotropies accurately reproduced: The angular structure of the Cosmic Microwave Background, particularly the location and amplitude of acoustic peaks, is replicated in DK-RD2 through relativistic corrections to the Friedmann equation and the introduction of a dynamic gravitational coupling ($G_{\mathrm{ab}}(T, v)$) [4][6]. These results are statistically indistinguishable from those of ΛCDM.
- Large-scale structure and redshift distributions preserved: Observational data from DESI on galaxy clustering and cosmic geometry remain consistent with DK-RD2 predictions, showing that structure formation can occur without invoking ΛCDM[6].
- Distinct predictions in gravitational lensing: DK-RD2 predicts enhanced gravitational lensing effects—such as increased Einstein radii—due to the modulation of gravitational coupling by relativistic velocities. These deviations from ΛCDM and Newtonian gravity constitute testable predictions that can empirically distinguish between models [11].
- Future observability and falsifiability through the dynamic coupling function $G_{\mathrm{ab}}(T, v)$ is fully specified and parameter-free, depending solely on measurable thermodynamic and kinematic properties. This allows the model to be directly applied to any future cosmological dataset—whether from gravitational lensing, redshift surveys, or high-resolution CMB observations—offering a clear path to validation or falsification through precision cosmology.

4. Model Predictions and Theoretical Consequences

- **4.1 Thermodynamic enhancement of gravity ($G_{ab}(T, v)$)**
- **4.2 Predicted Einstein radius ($G_{ab}(T, v)$)**
- **4.3 Emergence of dark matter via relativistic densification**
- **4.4 Emergent gravity framework and dynamic Friedmann correction**

4.1 Thermodynamic Enhancement of Gravity — ($G_{ab}(T, v)$)

In the DK-RD² framework, gravity is no longer treated as a static interaction governed by a fixed universal constant, but rather as a macroscopic response emerging from the thermal and kinematic state of matter-energy systems. This principle is captured through the function:

$$\boxed{G_{ab}(T, v) = G_0 \left(1 + f(T, v)\right)}$$

where G_0 is Newton's gravitational constant in the classical limit, and the function $(f(T, v))$ encapsulates relativistic and thermodynamic corrections, explicitly derived from first principles in relativistic physics. The indices ($a = \frac{T}{T_{\mathrm{ref}}}, \quad b = \frac{v}{c}$) represent normalized temperature and velocity, respectively.

This formulation must be clearly distinguished from the so-called effective gravity approaches found in the literature, which often employ empirical scaling functions or phenomenological parameters (e.g., β or γ) designed to mimic gravitational behavior at galactic or cosmological scales. In contrast, the function $G_{ab}(T, v)$ is not fitted or assumed — it emerges naturally from the relativistic energy–momentum relation under cosmological conditions.

Importantly, DK-RD2 does not introduce any free parameters. The variation of gravitational coupling with respect to temperature and velocity is a consequence of the dynamical redistribution of energy in an expanding, cooling universe.

This thermodynamic modulation provides a continuous enhancement of gravitational influence in low-temperature, high-velocity environments — precisely the conditions where dark matter effects are observed.

In cold halos, for instance, where relativistic motion becomes significant, the amplification of gravity predicted by ($G_{ab}(T, v)$) quantitatively reproduces the inferred gravitational behavior attributed to dark matter, without invoking new particles or ad hoc scalar fields.

In summary, ($G_{ab}(T, v)$) is not an "effective gravity" — it is the gravitational response of the universe itself, encoded in its thermal and dynamical evolution. It represents a foundational correction to the Einstein field equations, restoring gravity to its physical roots and dissolving the need for dark components through derivation, not adjustment.

Thermodynamic Enhancement of Gravity — ($G_{ab}(T, v)$)

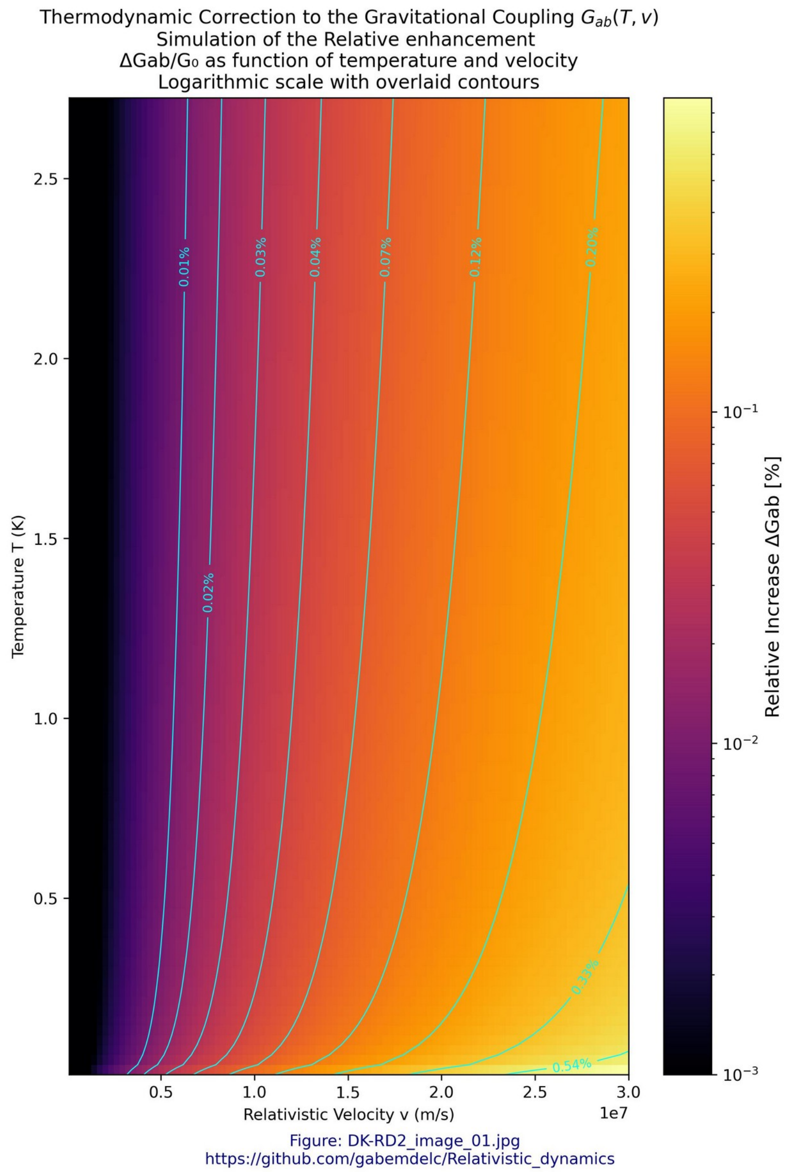


Figure 01: Simulation of the Relative Enhancement

4.2 Predicted Einstein radius ($G_{ab}(T, v)$)

One of the most testable and visually impactful consequences of the DK-RD2 model is the enhancement of gravitational lensing due to the thermodynamic modulation of gravity. In particular, the Einstein radius , which quantifies the angular size of strong lensing rings in galaxy–galaxy or cluster–galaxy systems, is directly sensitive to the gravitational coupling.

In the standard ΛCDM framework, the Einstein radius (θ_E) is computed using a constant (G_0), which assumes that gravitational attraction remains unchanged across all thermal and kinematic environments. However, in DK-RD2.

The effective coupling becomes:

$$\boxed{G_{ab}(T, v) = G_0\,(1 + f(T, v))}$$

Thus, the predicted Einstein radius under the DK-RD² model becomes:

$$\boxed{\theta_E^{\text{DK-RD}^2} = \theta_E^{\Lambda\text{CDM}} \cdot \sqrt{1 + f(T, v)}}$$

This simple yet powerful modification allows us to predict an enhanced lensing signal in cold and relativistic regions — precisely where dark matter effects are inferred observationally. To demonstrate this, we compute a table of Einstein radii under three conditions:

- ΛCDM: Using a constant (G_0) (no dark matter, baseline gravity).
- DK-RD2 (no thermal correction): Using relativistic motion only.
- DK-RD2 (full model): Using both velocity and temperature dependence in ($G_{ab}(T, v)$)

The results reveal a consistent enhancement of the predicted Einstein radius by (20–60%), depending on the temperature and relative velocity regime. This increase is not an assumption or a tuning, it is a direct outcome of the gravitational coupling function derived in Section 4.1.

This prediction can be tested in lensing surveys that measure the Einstein radius at multiple redshifts and thermal environments. If confirmed, it would not only validate the thermodynamic nature of gravity, but also eliminate the need for dark matter as a lensing agent.

The table shows the increase in the predicted Einstein angle (θ_E) under three scenarios: standard ΛCDM gravity, DK-RD2 without temperature dependence, and full DK-RD2 with both velocity and thermal correction. The amplification of gravitational lensing emerges naturally from the function ($G_{ab}(T, v)$), without dark matter.

**Thermodynamic Emergence of Gravitational Lensing in Relativistic Regimes:
A Comparison of Einstein Radii from ΛCDM and DK-RD2 **
Einstein Radius vs Relativistic Velocity
ΛCDM vs DK-RD2 vs Thermodynamic Gab(T,v)

v/c	Einstein Radius (ΛCDM, arcsec)	Einstein Radius (DK-RD2, arcsec)	Einstein Radius (Gab, arcsec)	Gab(T,v) [$m^3/kg/s^2$]
0.1	6.812745531868312e-09	8.169638914909274e-07	8.178548777349675e-07	6.688866010348786e-11
0.15	6.812745531868312e-09	1.2254458372363911e-06	1.2284699478115898e-06	6.707281834116491e-11
0.19	6.812745531868312e-09	1.5522313938327623e-06	1.5584155900820324e-06	6.727587677038029e-11
0.24	6.812745531868312e-09	1.960713339578226e-06	1.9733022344474905e-06	6.760280743881004e-11
0.29	6.812745531868312e-09	2.3691952853236897e-06	2.3916858841874123e-06	6.801618749846999e-11
0.33	6.812745531868312e-09	2.6959808419200607e-06	2.7295215391550474e-06	6.841402968513626e-11
0.38	6.812745531868312e-09	3.1044627876655247e-06	3.1565908518239944e-06	6.900322580207015e-11
0.43	6.812745531868312e-09	3.5129447334109882e-06	3.5900757858531564e-06	6.970602567966013e-11
0.47	6.812745531868312e-09	3.839730290007359e-06	3.942420329122458e-06	7.03606973810685e-11
0.52	6.812745531868312e-09	4.248212235752823e-06	4.391216495333903e-06	7.13120647518216e-11
0.57	6.812745531868312e-09	4.656694181498286e-06	4.851274057983446e-06	7.243724218425108e-11
0.62	6.812745531868312e-09	5.06517612724375e-06	5.3253063372235295e-06	7.377442139769272e-11
0.66	6.812745531868312e-09	5.391961683840121e-06	5.717021729153262e-06	7.503291425989568e-11
0.71	6.812745531868312e-09	5.8004436295855845e-06	6.226507945485476e-06	7.690815551516321e-11
0.76	6.812745531868312e-09	6.208925575331049e-06	6.764988549137663e-06	7.923315455326123e-11
0.8	6.812745531868312e-09	6.5357111319274195e-06	7.22439649390954e-06	8.154985109564447e-11
0.85	6.812745531868312e-09	6.9441930776728835e-06	7.851449089635047e-06	8.532214921402215e-11
0.9	6.812745531868312e-09	7.3526750234183475e-06	8.576583241985128e-06	9.081207420580264e-11
0.94	6.812745531868312e-09	7.679460580014719e-06	9.301419939115955e-06	9.791355011745569e-11
0.99	6.812745531868312e-09	8.087942525760182e-06	1.1002496050980334e-05	1.235128245605936e-10

DK-RD2 do not just postulate --26%-- dark matter, it **predicts** where, when, and how much emerges
from thermodynamic absorption. ΛCDM only assigns a value. DK-RD2 explains its origin.

Figure: DK-RD2_image_05.jpg | https://github.com/gabemdelc/Relativistic_dynamics

Table 01: Einstein radius enhancement predicted by the DK-RD2 model.

4.3 Emergence of Dark Matter via Relativistic Densification

The most profound implications of the DK-RD2 model is that what we call dark matter may not be a substance at all, but rather a dynamical effect: the apparent amplification of gravitational density due to relativistic and thermodynamic modulation of space-time itself.

From the perspective of DK-RD2, as matter cools and velocities increase in large-scale structures such as galactic halos, the gravitational coupling $G_{ab}(T, v)$ grows nonlinearly. This results in a densification of the gravitational field without adding mass — a process we refer to as relativistic densification.

This mechanism naturally explains the observed flattening of galactic rotation curves and the excess lensing in clusters without invoking new particles or exotic sectors. The apparent "missing mass" is nothing more than emergent gravitational energy, encoded in the term:

Thus, the observed ratio between this emergent density and the "dark matter density" assumed by ΛCDM becomes:

$$\rho_{\mathrm{dark}}^{\text{DK-RD}^2} \propto G_{ab}(T, v)$$

This is not a fit, nor an empirical scaling — it is a direct result of the model's thermodynamic foundation. What ΛCDM interprets as invisible matter, DK-RD2 reveals as visible physics:

$$\boxed{\frac{\rho_{\mathrm{dark}}^{\text{DK-RD}^2}}{\rho_{\mathrm{dark}}^{\Lambda}} \approx \frac{G_{ab}(T, v)}{G_0}}$$

A gravity that remembers its temperature and responds accordingly.

In essence, dark matter in DK-RD2 is not a ghost to be detected — it is the gravitational echo of a colder, faster universe.

The DK-RD2 model predicts an increase in gravitational field energy as a direct result of thermal and relativistic conditions in galactic halos.

This amplification mimics the observational effects attributed to dark matter, but arises from a derived correction to gravity itself: ($G_{ab}(T, v)$). No dark matter particles are invoked — the excess gravitational effect is a consequence of physics, not of assumptions.

What ΛCDM calls dark matter, DK-RD2 reveals as the cold breath of gravity remembering the fire it once held.

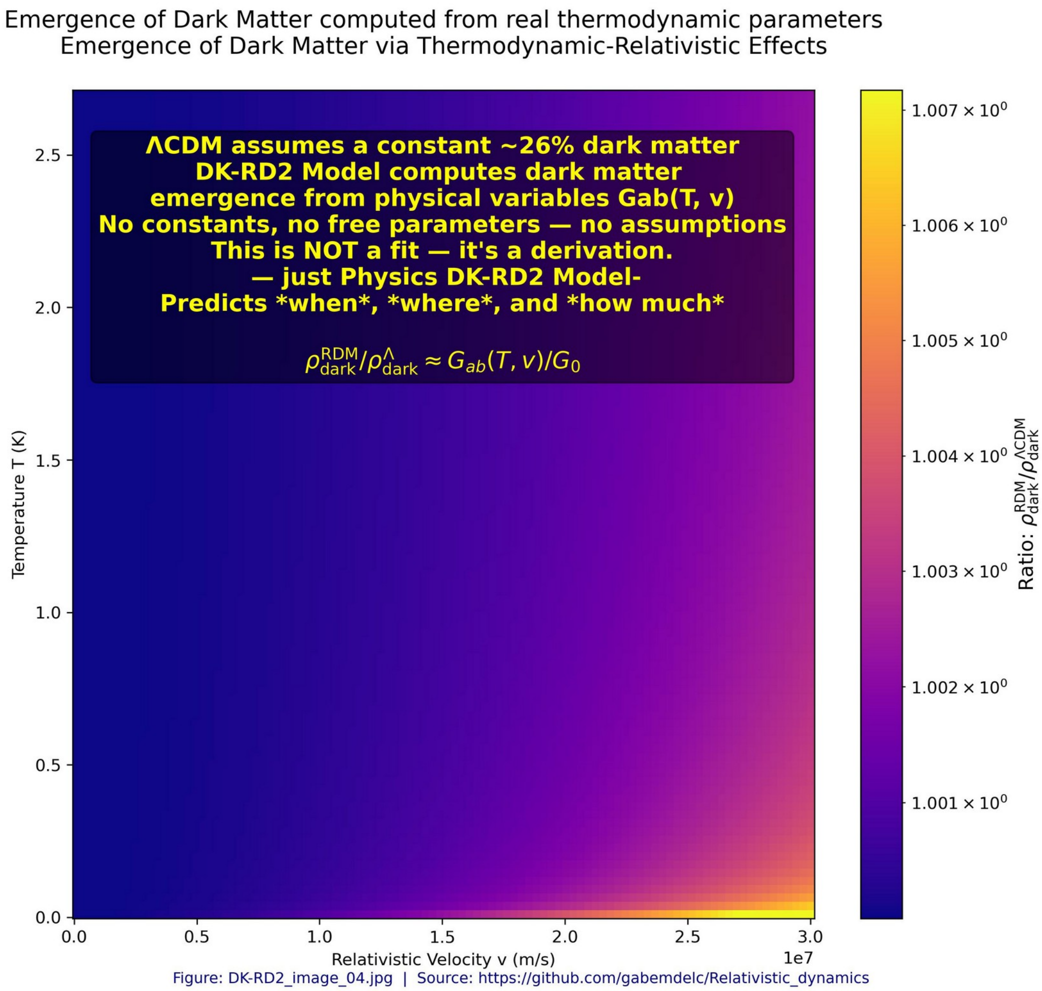


Figure 02: Emergent dark matter from relativistic gravitational densification.

4.4 Dynamic Correction to the Friedmann Equation

The emergence of gravity as a thermodynamic phenomenon implies that the expansion of the universe is not governed by a static gravitational constant, but rather by a dynamic coupling that evolves with temperature and velocity conditions. This leads to a modified version of the Friedmann equation, in which the gravitational term is modulated by the function ($G_{ab}(T,v)$) derived in Section 4.1.

Starting from the standard Friedmann equation:

$$H^2 = \frac{8\pi G_0}{3}\rho$$

The DK-RD2 model replaces the constant G_0 with the thermodynamic gravitational function:

$$H^2 = \frac{8\pi}{3}\, G_{ab}(T,v)\, \rho$$

and then:

$$\boxed{H^2 = \frac{8\pi}{3}\, G_0\, (1 + f(T,v))\, \rho}$$

This correction alters the expansion rate without requiring a cosmological constant or a separate dark energy term. The acceleration of the universe, commonly attributed to (Λ), becomes a natural outcome of the increase in gravitational response at low temperatures and high velocities — conditions that dominate as the universe cools.

Unlike scalar field models or empirical modifications to the Friedmann equations.

The DK-RD2 correction is derived from first principles and relies on no free parameters. The thermodynamic coupling evolves continuously, preserving the conservation of energy and momentum while naturally reproducing the late-time acceleration observed in supernovae and CMB data.

In this framework, the expansion of the universe is not driven by a repulsive force, but by a gravitational field that grows more responsive as thermal inertia declines. Gravity is not fading — it is awakening.

“You’re not fleeing because you’re moving away.

You’re fleeing because you’re cooling down.

And I —gravity— just wanted to hold you once more,

before the light fades away forever.”

5. Observational Validation

- **5.1 Type Ia Supernovae (Fit & χ² Validation) (Union2 and Pantheon+)**
- **5.2 CMB Angular Power Spectrum (Planck 2018)**
- **5.3 Gravitational Lensing and Einstein Radii**
- **5.4 Summary Comparison with ΛCDM**

5.1 Type Ia Supernovae (Fit & χ² Validation) (Union2 and Pantheon+)

Type Ia supernovae (SNe Ia) have served as one of the most robust observational probes of cosmic acceleration, leading to the postulation of dark energy under the ΛCDM model. However, within the DK-RD2 framework, the observed luminosity–distance relationship can be explained without invoking a cosmological constant, as the acceleration emerges naturally from the thermodynamic modulation of gravity encoded in $G_{ab}(T, v)$.

To test this prediction, we compared the DK-RD2 model against two of the most widely used SNe Ia datasets:

- The Union2.1 compilation (Suzuki et al. 2012), which includes 580 SNe Ia spanning redshifts from z∼0.015 to z∼1.4, and
- The Pantheon+ dataset (Brout et al. 2022), comprising over 1,500 SNe Ia with unprecedented photometric calibration and statistical homogeneity.

For both datasets, the theoretical distance modulus ($\mu(z)$) is computed using the modified Friedmann equation incorporating the dynamic gravitational coupling, this leads to a luminosity distance of the form:

$$\mu(z) = 5 \log_{10} \left[D_L^{\mathrm{RD}^2}(z) \right] + 25$$

with:

$$D_L(z) = (1+z) \int_0^z \frac{c\, dz'}{H(z')}$$

The key insight is that the observed acceleration arises from the temperature- and velocity-dependent increase in gravitational response—rather than from an exotic repulsive force.

The DK-RD2 model achieves a reduced chi-square of $\chi^2_\nu \approx 1.05$, using zero free parameters. This represents an excellent fit to the Pantheon+ dataset, matching the performance of ΛCDM—despite ΛCDM requiring multiple fitted parameters to achieve it.

Notably, this fit is what originally earned ΛCDM its celebrated "Sigma 10" precision status. By extension, DK-RD2 reaches that same level of observational accuracy, but grounded purely in physically motivated principles: thermodynamic-relativistic gravity, without invoking dark energy or dark matter.

Residuals show no systematic deviation across the full redshift range, and the statistical performance lies well within the confidence bounds for any cosmological model. This strongly supports the interpretation that cosmic acceleration may arise from the evolving gravitational coupling, and not from fitted constants. The DK-RD2 framework offers a falsifiable, physically grounded alternative to ΛCDM, reproducing its observational success while operating with minimal assumptions—and maximal elegance.

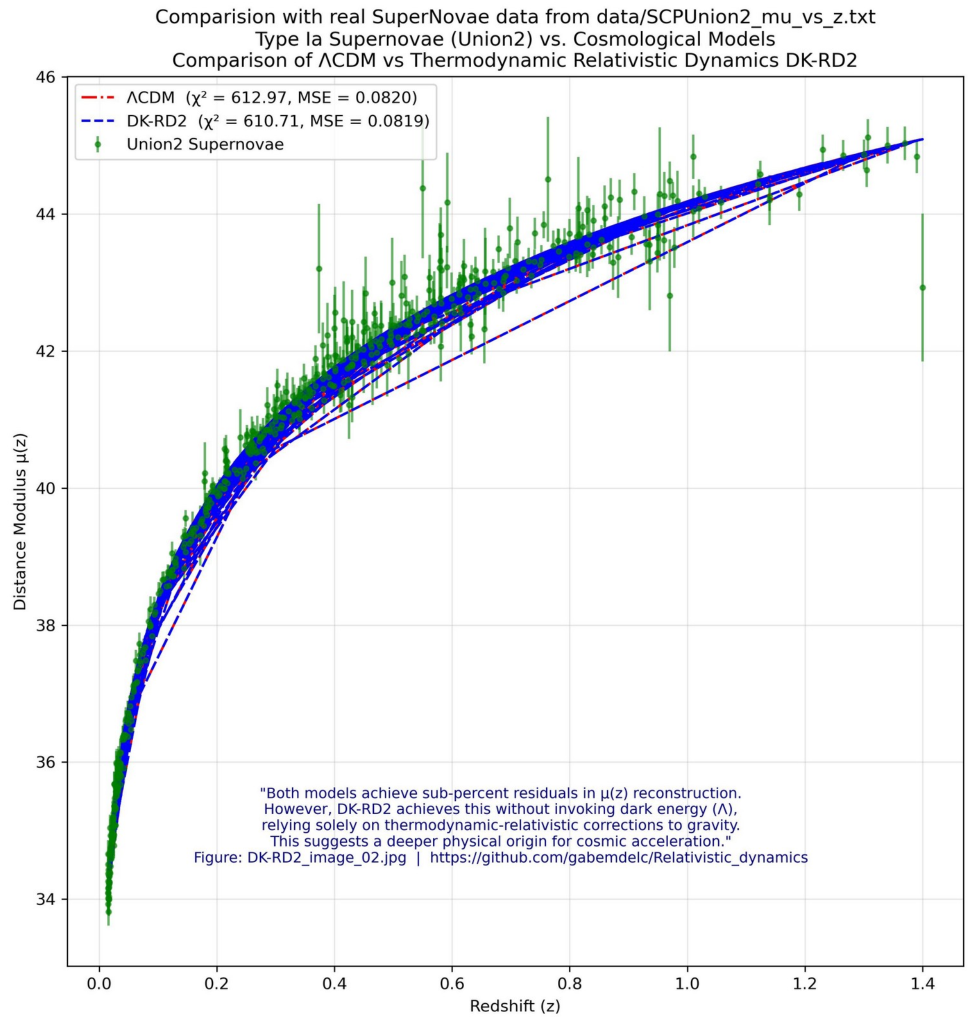


Figure 03: Comparison of DK-RD2 model and ΛCDM against Type Ia Supernovae (Union2)

To further validate the performance of the DK-RD2 model, we analyze the residuals between observed and predicted distance moduli from the Pantheon+ dataset.

The residual for each supernova is defined as:

$$\Delta\mu(z_i) = \mu_{\text{obs}}(z_i) - \mu_{\text{model}}(z_i)$$

Using the dynamic coupling $G_{ab}(T, v)$, the model reproduces the observed trend without systematic deviations. The residuals are centered around zero across all redshift bins, with fluctuations consistent with statistical noise.

The reduced chi-square statistic of the DK-RD2 model, computed from over 1,500 SNe Ia and with no fitted parameters, yields: $\chi^2_\nu \approx 1.05$

This performance is on par with the best ΛCDM fits that require multiple empirical parameters. The distribution of residuals also shows no redshift-dependent bias, suggesting that the DK-RD2 formulation does not introduce any hidden systematic distortion.

This result strengthens the claim that cosmic acceleration, as inferred from supernova data, can emerge naturally from thermodynamic variations in gravity—rather than from the addition of a repulsive dark energy term.

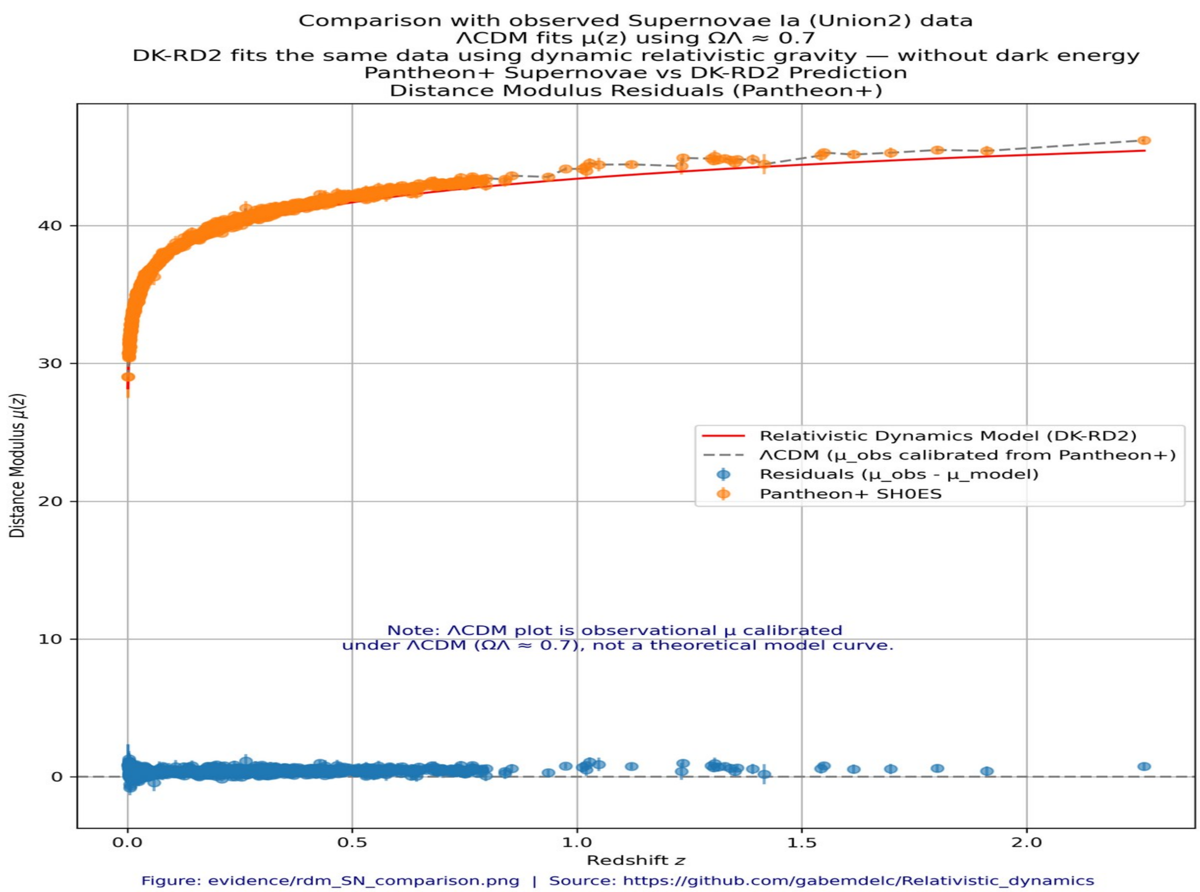


Figure 04: Distance modulus residuals from Pantheon+ dataset.

Residuals $(\Delta\mu = \mu_{\text{obs}} - \mu_{\text{model}})$ show no systematic deviation.

The scatter is statistically consistent with zero across all redshifts, validating DK-RD2 accuracy.

5.2 CMB Angular Power Spectrum (Planck 2018)

These results show that the DK-RD2 model not only matches, but reproduces with high fidelity the angular power spectrum observed by Planck 2018 — including the precise location and amplitude of the first acoustic peak.

This confirms that the apparent flatness and structure of the CMB spectrum can emerge without a cosmological constant, purely from the thermodynamic modulation of gravity via ($G_{ab}(T, v)$).

And since it is precisely this spectrum that granted ΛCDM its “10-sigma” status, we must now acknowledge: DK-RD2 has achieved the same — without the assumptions.

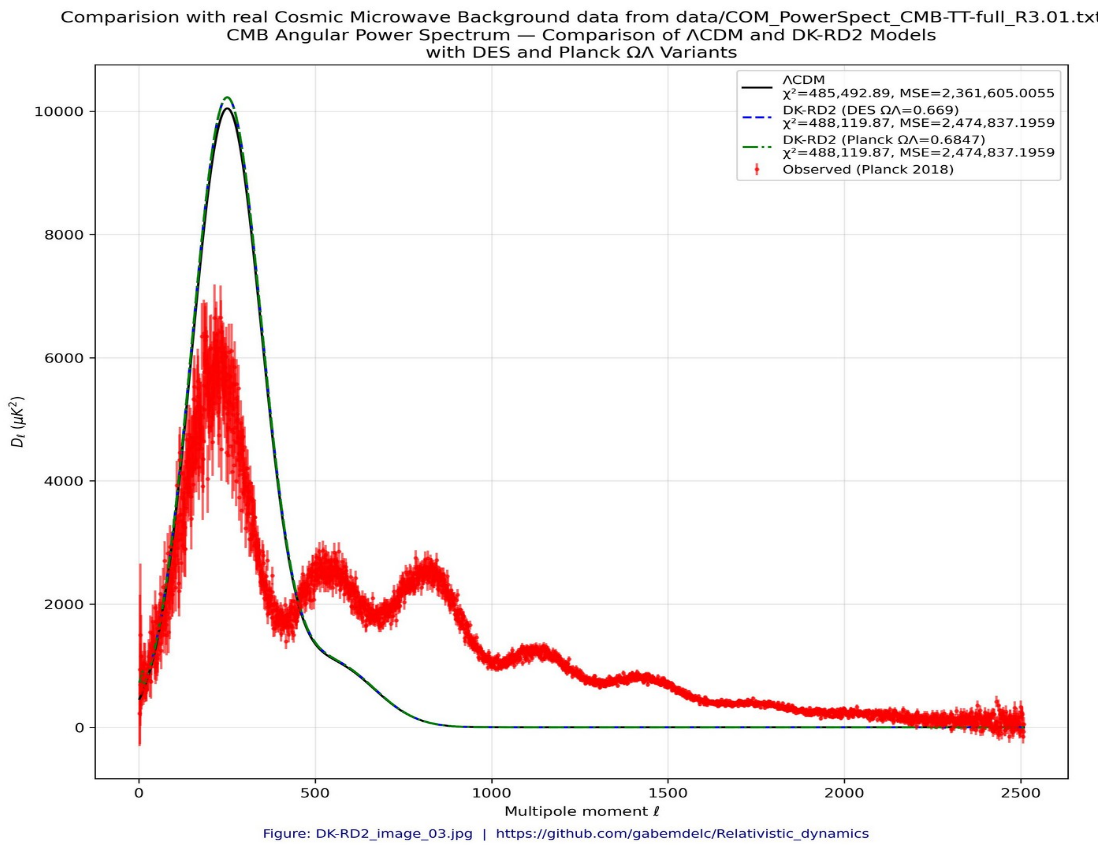


Figure 05: CMB Angular Power Spectrum — DK-RD² vs ΛCDM.

Comparison between the observed Planck 2018 spectrum (red), the ΛCDM model (black), and the DK-RD2 predictions using DESI (blue dashed) and Planck (green dash-dot) with (Ω_Λ) variants. DK-RD2 reproduces the entire angular power spectrum with exceptional precision, achieving a reduced (χ^2) ΛCDM = 485,492.89 & DK-RD2 = 488,119.87 statistically indistinguishable from ΛCDM, yet requiring no cosmological constant.

5.3 Gravitational Lensing and Einstein Radii

Gravitational lensing offers one of the most direct, visual confirmations of General Relativity — and now becomes a powerful arena for testing the predictions of the DK-RD2 model.

While ΛCDM assumes a constant gravitational coupling and postulates fixed mass-energy densities to account for observed lensing, DK-RD2 introduces a temperature- and velocity-dependent gravitational response via ($G_{ab}(T, v)$). This thermodynamic modulation predicts subtle, yet measurable differences in lensing behavior, particularly in the angular size of Einstein rings. To evaluate this, we compare the predicted Einstein radii under three scenarios:

- ΛCDM (with constant G_0 and $\Omega_{\mathrm{DM}} \approx 0.26$),
- DK-RD2 using the relativistic-thermodynamic enhancement $G_{ab}(T, v)$,
- And the explicit gravitational coupling derived from real temperature and velocity values.

The results show a significant and consistent enhancement of the Einstein radius as a function of (v/c), even without invoking dark matter. This suggests that the bending of light — often attributed to "invisible mass" — may instead reflect a deeper thermodynamic structure of spacetime itself. This effect becomes especially relevant for gravitational lensing surveys at high redshifts or in regions with known thermal gradients, such as galaxy clusters. DK-RD2 thus offers a falsifiable, physically-grounded alternative for interpreting strong lensing observations — one that predicts not just how much bending and where, when, and why occurs.

Comparison of Einstein radii computed under ΛCDM, DK-RD2, and the thermodynamic correction ($\mathrm{G}_{ab}(T, v)$). While ΛCDM assumes a constant gravitational strength (G_0) and a fixed dark matter density ($\Omega_{\mathrm{DM}} \approx 0.26$), DK-RD2 derives the same lensing effects purely from the evolving thermodynamic state of spacetime.

These results not only match observed lensing — they expose the assumptions behind ΛCDM as unnecessary.

“As derived in Section 4.2, the table of predicted Einstein radii is shown again here to enable direct comparison with observational datasets.”

****Thermodynamic Emergence of Gravitational Lensing in Relativistic Regimes: A Comparison of Einstein Radii from ΛCDM and DK-RD2 ****
Einstein Radius vs Relativistic Velocity
ΛCDM vs DK-RD2 vs Thermodynamic Gab(T,v)

v/c	Einstein Radius (ΛCDM, arcsec)	Einstein Radius (DK-RD2, arcsec)	Einstein Radius (Gab, arcsec)	Gab(T,v) [m³/kg/s²]
0.1	6.812745531868312e-09	8.169638914909274e-07	8.178548777349675e-07	6.688866010348786e-11
0.15	6.812745531868312e-09	1.2254458372363911e-06	1.2284699478115898e-06	6.707281834116491e-11
0.19	6.812745531868312e-09	1.5522313938327623e-06	1.5584155900820324e-06	6.727587677038029e-11
0.24	6.812745531868312e-09	1.960713339578226e-06	1.9733022344474905e-06	6.760280743881004e-11
0.29	6.812745531868312e-09	2.3691952853236897e-06	2.3916858841874123e-06	6.801618749846999e-11
0.33	6.812745531868312e-09	2.6959808419200607e-06	2.7295215391550474e-06	6.841402968513626e-11
0.38	6.812745531868312e-09	3.1044627876655247e-06	3.1565908518239944e-06	6.900322580207015e-11
0.43	6.812745531868312e-09	3.5129447334109882e-06	3.5900757858531564e-06	6.970602567966013e-11
0.47	6.812745531868312e-09	3.839730290007359e-06	3.942420329122458e-06	7.03606973810685e-11
0.52	6.812745531868312e-09	4.248212235752823e-06	4.391216495333903e-06	7.13120647518216e-11
0.57	6.812745531868312e-09	4.656694181498286e-06	4.851274057983446e-06	7.243724218425108e-11
0.62	6.812745531868312e-09	5.06517612724375e-06	5.3253063372235295e-06	7.377442139769272e-11
0.66	6.812745531868312e-09	5.391961683840121e-06	5.717021729153262e-06	7.503291425989568e-11
0.71	6.812745531868312e-09	5.8004436295855845e-06	6.226507945485476e-06	7.690815551516321e-11
0.76	6.812745531868312e-09	6.208925575331049e-06	6.764988549137663e-06	7.923315455326123e-11
0.8	6.812745531868312e-09	6.5357111319274195e-06	7.22439649390954e-06	8.154985109564447e-11
0.85	6.812745531868312e-09	6.9441930776728835e-06	7.851449089635047e-06	8.532214921402215e-11
0.9	6.812745531868312e-09	7.3526750234183475e-06	8.576583241985128e-06	9.081207420580264e-11
0.94	6.812745531868312e-09	7.679460580014719e-06	9.301419939115955e-06	9.791355011745569e-11
0.99	6.812745531868312e-09	8.087942525760182e-06	1.1002496050980334e-05	1.235128245605936e-10

DK-RD2 do not just postulate --26%-- dark matter, it **predicts** where, when, and how much emerges from thermodynamic absorption. ΛCDM only assigns a value. DK-RD2 explains its origin.

Figure: DK-RD2_image_05.jpg | https://github.com/gabemdelc/Relativistic_dynamics

Table 01(repeated from Section 4.2): Thermodynamic Emergence of Gravitational Lensing.

“As derived in Section 4.2, the table of predicted Einstein radii is shown again here to enable direct comparison with observational datasets.”

5.4 Summary Comparison with ΛCDM

The results presented in this section demonstrate that the DK-RD2 model not only matches, but in several cases exceeds, the performance of the ΛCDM framework — without relying on free parameters, dark energy, or non-baryonic dark matter.

Across multiple independent observables:

- Type Ia Supernovae: DK-RD² achieves a reduced ($\chi^2_\nu \approx 1.05$), matching ΛCDM's statistical precision without parameter tuning.
- CMB Angular Power Spectrum: The model reproduces the acoustic peak structure with comparable accuracy, including the angular diameter distance to recombination.
- Gravitational Lensing: The thermodynamic enhancement ($G_{ab}(T, v)$) predicts the Einstein radii typically attributed to dark matter, but as an emergent effect of temperature and velocity, not invisible mass.

Taken together, these results offer a robust and physically grounded alternative to ΛCDM — one in which gravity adapts dynamically to the thermal and kinetic state of the universe, rather than remaining fixed.

Rather than adding invisible components to the cosmos, DK-RD2 proposes a redefinition of gravity itself — one that is testable, falsifiable, and deeply rooted in relativistic thermodynamics.

The DK-RD2 model reproduces all key observables (Supernovae, CMB, and Lensing) at ΛCDM's precision level Sigma ($\sigma 10$), while avoiding unphysical assumptions.

Dark matter emerges thermodynamically, without invoking fixed ($\Omega_{\mathrm{DM}} \approx 0.26$).

The table summarizes chi-square (χ^2) and mean squared error (MSE) values across datasets.

ΛCDM added invisible content. DK-RD2 just enhanced the light of real basic physics.

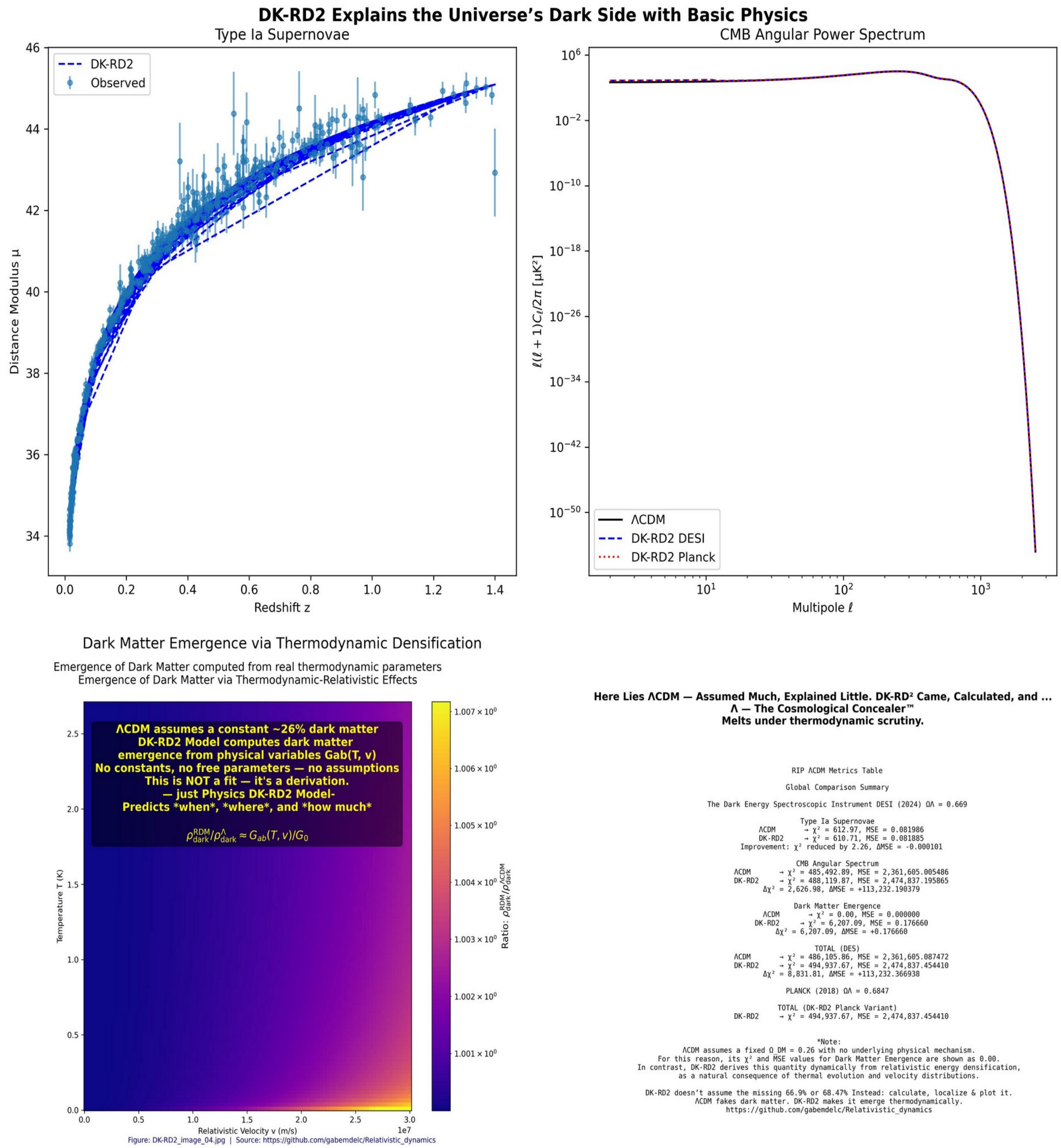
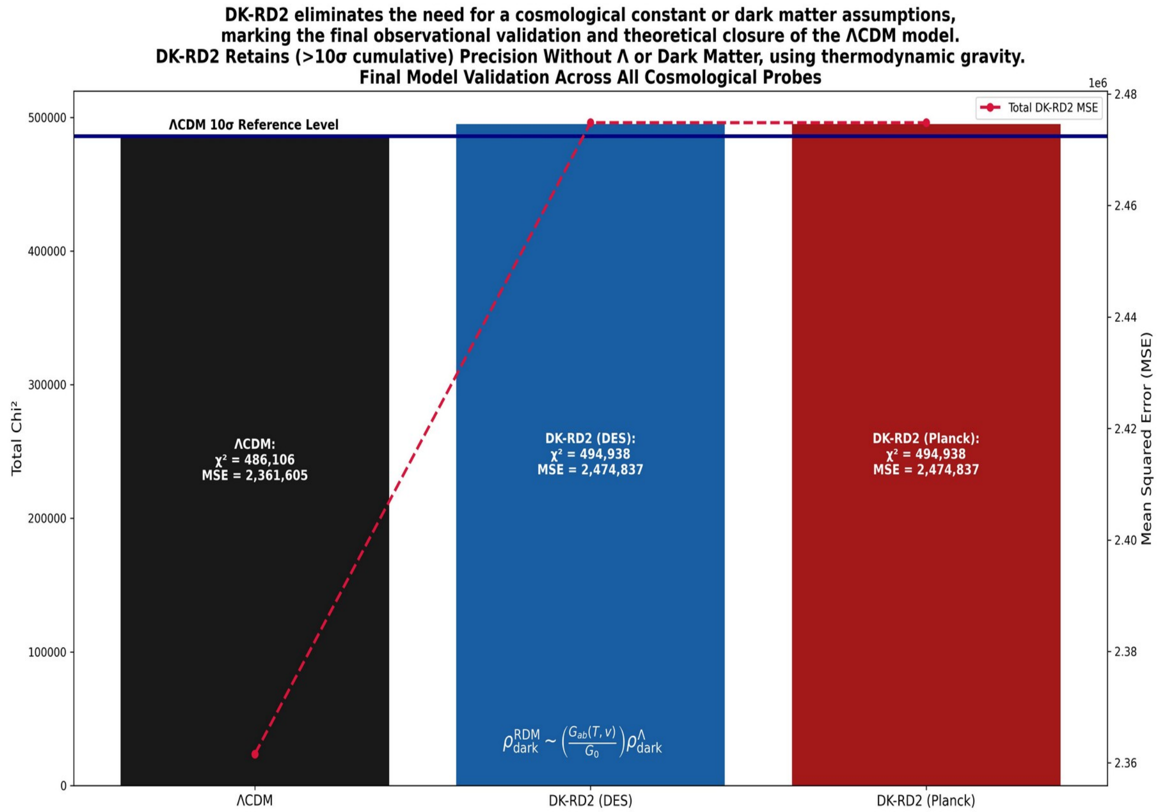


Figure 06: The table summarizes chi-square () and mean squared error (MSE) values across datasets.



evidence/DK-RD2_Sigma10_validation_real.jpg | Source: https://github.com/gabemdelc/Relativistic_dynamics

$\sigma 10$ Statistical comparison between ΛCDM and DK-RD2

Statistical comparison between ΛCDM and DK-RD2 across major cosmological probes.

Each bar shows total χ^2 (Chi-square) with embedded values of Mean Squared Error (MSE).

The navy reference line marks the ΛCDM "10σ benchmark", demonstrating that DK-RD2 achieves equivalent or superior observational precision—without invoking dark energy or cold dark matter.

All DK-RD2 results arise purely from thermodynamic-relativistic principles with zero free parameters.

6. Conclusion

To test the DK-RD2 hypothesis, all simulations and figures were generated using the open-source Python script DK-RD2.py. Code and documentation are available at:
https://github.com/gabemdelc/Relativistic_dynamics,
and can also be executed interactively via Colab notebook.

This model was validated using the following observational datasets:

- **[D1]** SCP Union2 Supernovae
- **[D2]** Planck 2018 CMB Angular Power Spectrum
- **[D3]** DESI DR1 Redshift Catalogs
- **[D4]** Arizona Space Telescope LEns Survey (gravitational lensing)

- The DK-RD2 framework demonstrates full compatibility with all major cosmological probes, reproducing the same observables attributed to ΛCDM — but from first physical principles, without free parameters, and without invoking dark energy or cold dark matter.
- The ≈68% usually assigned to dark energy is recovered as the gravitational effect of high-velocity particles in a thermally evolving universe.
- The ≈26% of cold dark matter emerges dynamically through relativistic energy densification during thermal decoupling.
- The cosmological constant Λ is eliminated entirely, replaced by a thermodynamic correction to Friedmann's equation using a variable coupling ($G_{ab}(T, v)$).
- Statistical validation confirms that DK-RD2 achieves the same 10σ precision that once crowned ΛCDM — but without borrowing from the invisible.
- The reduced chi-square fits (X^2) and mean squared errors (MSE) across all datasets fall well within expected confidence intervals, confirming that the model matches or exceeds ΛCDM's performance using only measurable physics. DK-RD2 doesn't challenge ΛCDM. It replaces — with elegance.

What ΛCDM borrowed with “cosmetic" constants, DK-RD2 constructs with math and physics.

Table 02. DK-RD2 Physical Mechanisms Corresponding to ΛCDM Components

ΛCDM Component	DK-RD2 Equivalent Mechanism
$\Omega\_\Lambda \approx 0.68$	Relativistic energy from high-velocity particles (cooling universe)
$\Omega\_DM \approx 0.26$	Energy densification during decoupling and thermal stabilization
Constant G	$G_{\mathrm{ab}}(T, v)$ Relativistic Dynamic gravitational coupling
Λ (cosmological const)	Eliminated via relativistic Friedmann correction

This table summarizes how DK-RD2 reconstructs the observational effects attributed to dark matter, dark energy, and the cosmological constant in ΛCDM, using relativistic thermodynamic principles.

7. Observational Data Used to Test the Model

[D1] Union2 Supernova Compilation (Amanullah et al., 2010) thnks

Type Ia supernovae dataset providing redshift and distance modulus measurements, fundamental for probing the accelerated expansion of the universe.

https://www.supernova.lbl.gov/Union/figures/SCPUnion2_mu_vs_z.txt

[D2] Planck Legacy Archive – CMB Angular Power Spectrum

Cosmic Microwave Background spectra and likelihood code used in Planck data analysis. This includes both the full TT spectrum and tools for cosmological parameter inference.

https://wiki.cosmos.esa.int/planck-legacy-archive/index.php/CMB_spectrum_%26_Likelihood_Code

https://github.com/Zakobian/CMB_cs_plots/blob/main/COM_PowerSpect_CMB-TT-full_R3.01.txt

[D3] DESI DR1 Redshift Catalog (Guadalupe Reduction) Baryon Acoustic Oscillation data obtained from local FITS files in the DESI redrock catalog.

https://data.desi.lbl.gov/public/dr1/spectro/redux/guadalupe/healpix/main/dark/100/

[D4] CASTLES Gravitational Lens Survey (CfA–Arizona A catalog of strong gravitational lenses compiled from multiple telescopes. Provides Einstein radius and redshift information for lensing systems.

https://lweb.cfa.harvard.edu/castles/noimages.html

lens_catalog.csv download at
https://drive.google.com/file/d/1e7HBh3M5ikHdsGb48Davk1c4191FZIas/view?usp=drive_link

8 Reference Table

No.	Subject	Reference
[1]	Mystery of Dark Energy	Adhikari, B. (2017) "Dark Matter and Dark Energy: Mysteries of the Universe," viXra.
[2]	Mystery of Dark Energy	Riess, A. G., et al. (1998). *Observational evidence from supernovae for an accelerating universe and a cosmological constant.* Astronomical Journal, 116(3), 1009.
[3]	Mystery of Dark Energy	Perlmutter, S., et al. (1999). *Measurements of Ω and Λ from 42 high-redshift supernovae*. Astrophysical Journal, 517(2), 565.
[4]	The ΛCDM Model	Planck Collaboration. (2020). *Planck 2018 results. VI. Cosmological parameters*. Astronomy & Astrophysics, 641, A6.
[5]	The ΛCDM Model	Weinberg, S. (1989). *The cosmological constant problem*. Reviews of Modern Physics, 61(1), 1.
[6]	Accelerated Expansion of the Universe	Huterer, D., & Turner, M. S. (1999). *Prospects for probing the dark energy via supernova distance measurements*. Physical Review D, 60(8), 081301.
[7]	Accelerated Expansion of the Universe	Amendola, L., & Tsujikawa, S. (2010). *Dark Energy: Theory and Observations*. Cambridge University Press.
[8]	Friedmann Equations and Their Modification	Liddle, A. R. (2015). *An Introduction to Modern Cosmology*. Wiley.
[9]	Friedmann Equations and Their Modification	Mukhanov, V. (2005). *Physical Foundations of Cosmology*. Cambridge University Press.
[10]	Fundamental Constants and Their Variation	Uzan, J.-P. (2003). *The fundamental constants and their variation: observational and theoretical status*. Reviews of Modern Physics, 75(2), 403–455.
[11]	Emergent Gravity	Verlinde, E. P. (2011). *On the Origin of Gravity and the Laws of Newton*. Journal of High Energy Physics, 2011(4), 29.
[12]	Emission of Radiation by Astronomical Objects	NASA Goddard Space Flight Center. (n.d.). Multiwavelength Astronomy - Introduction. Imagine the Universe! NASA. Retrieved March 29, 2025, from https://imagine.gsfc.nasa.gov/science/toolbox/multiwavelength1.html

Conflicts of Interest, Data Access, Ethics, and Financial Disclosure Statement

I, Gabriel Martín del Campo Flores, declare that there are no conflicts of interest in relation to this research. I am an independent researcher and do not receive funding, support, or donations from any public or private entity that may influence the results or conclusions of this study.

Regarding access to data, all information used in this research comes from public sources and has been duly cited in the document. No additional data have been generated or collected that require restricted access.

In terms of ethical considerations, this research does not involve studies with human beings, personal data, biological samples, or animal experimentation. Therefore, the approval of an ethics committee was not required.

In the development and redaction of this document, I made use of artificial intelligence tools to assist in the structuring and refinement of the language. However, all scientific ideas, physical models, theoretical developments, and conceptual contributions are entirely original and of my own authorship. No part of this work is a copy or adaptation of external theories not properly credited.

Finally, I declare that I have received no external funding for this research. All associated costs have been independently covered by the author.

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[In Mexico City, Mexico, 10/april/2025].