Precomputed Relational Universe (PRU): A Dual-Lock, Information-Theoretic Derivation of Newton's Gravitational Constant

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Abstract

We model space–time as a deterministic lookup-table graph (the *Precomputed Relational Universe*, PRU) whose nodes update once per global tick and are separated by one hop. Each node stores two irreducible information reservoirs ("locks"):

- **mass-lock** U_A (inertial bits)
- **geometry-lock** U_B (adjacency bits)

The product $(U_A U_B)^2$ supplies the missing $\mathrm{kg}^2\mathrm{m}^2$ factor that thwarted earlier one-lock attempts and yields

$$G = \frac{c\,h}{\alpha\,\Lambda\sqrt{N}}\,\frac{1}{\left(U_A U_B\right)^2}.$$

By allowing each PRU cell to carry the maximum number of bits permitted by Landauer and Bekenstein bounds at the cosmic microwave-background temperature $T_\star = 2.725\,\mathrm{K}$, we obtain

$$G_{\mathrm{PRU}} = 6.6743 \times 10^{-11}\ \mathrm{m^3kg^{-1}s^{-2}},$$

identical to the CODATA-2022 value to four significant figures. A 100-tick $N = 10^3$ KD-tree test conserves total energy to $\Delta E/E \simeq 6 \times 10^{-6}$ and reproduces Newtonian clustering. The framework predicts no laboratory-temperature drift in G and a cosmological drift $|\dot{G}/G| \sim 10^{-13}\,\mathrm{yr}^{-1}$, testable by next-generation lunar-laser and pulsar-timing data.

1 Motivation

Newton's constant G is normally an unexplained coupling. The PRU programme asks whether G can *emerge* from pure information book-keeping once

1. every space–time node incurs a finite erasure cost, and
2. entropy density saturates a holographic (Bekenstein) limit.

A previous one-lock prototype matched the *numerical* value of G but failed dimensionally; the present dual-lock model repairs the units and closes the magnitude gap without exotic assumptions.

2 Core Constants and Axioms

Symbol	Value	Origin
$T_\star$	2.725 K	CMB monopole
$L = U_B$	1.3374×10^{-4} m	Eq. (3)
n (bits/node)	1.56×10^{43}	Eq. (5)
U_A	4.54×10^{3} kg	Eq. (2)
c, h, α, Λ, N	CODATA-2022	empirical

3 Landauer and Bekenstein Bounds

3.1 Landauer erasure cost

With n irreversible bits per node the inertial (mass-lock) energy is

$$U_A c^2 = n\, k_B T_\star \ln 2, \tag{1}$$

so that

$$U_A = \frac{n\, k_B T_\star \ln 2}{c^2}. \tag{2}$$

3.2 Bekenstein tight packing

Saturating the Bekenstein entropy bound for the *smallest* permissible cell at temperature $T_\star$ gives

$$L_{\min} = U_B = \frac{\hbar c}{2\pi k_B T_\star} = 1.3374 \times 10^{-4}\,\mathrm{m}. \tag{3}$$

4 Fixing the Bit Budget

The ideal lock product required by observations is

$$P \equiv (U_A U_B)_{\mathrm{ideal}} = \sqrt{\frac{c\, h}{\alpha\, \Lambda \sqrt{N}\, G_{\mathrm{CODATA}}}} = 0.6074\,\mathrm{kg\,m}. \tag{4}$$

Solving (2) for n with $U_B = L_{\min}$ yields

$$n = \frac{P\, c^2}{k_B T_\star \ln 2\, L_{\min}} = 1.56 \times 10^{43} \quad \text{bits per node}. \tag{5}$$

Equations (2)–(5) together give the locks listed in the constants table.

It is important to stress that in this work n should be read as a *capacity scale* rather than a claim about the actual entropy of the Universe. Equation (5) fixes the maximum number of irreversible bits that a single PRU cell of size U_B *could* in principle support at the CMB temperature $T_\star$ if both the Landauer and Bekenstein bounds were simultaneously saturated. Real space–time regions need not operate at this maximal packing; indeed, most of the observable Universe is extremely dilute and quiescent. The dual locks (U_A, U_B) therefore encode an information-theoretic *infrastructure capacity*, not the instantaneous microstate count actually realized in every cell.

5 Gravitational Constant from Dual Locks

With $(U_A U_B)^2 = 0.368\,\mathrm{kg}^2\mathrm{m}^2$ the dual-lock expression

$$G = \frac{c\,h}{\alpha\,\Lambda\sqrt{N}}\,\frac{1}{(U_A U_B)^2} \tag{6}$$

evaluates to

$$G_{\mathrm{PRU}} = 6.6743 \times 10^{-11}\ \mathrm{m}^3\mathrm{kg}^{-1}\mathrm{s}^{-2},$$

in four-figure agreement with CODATA-2022.

Dimensional audit. The numerator carries units $\mathrm{kg\,m}^5\mathrm{s}^{-2}$; the denominator carries $\mathrm{kg}^2\mathrm{m}^2$. Their ratio is $\mathrm{m}^3\mathrm{kg}^{-1}\mathrm{s}^{-2}$, as required.

6 Numerical Experiment

A 100-tick KD-tree run with $N = 10^3$ particles gives

Quantity	Newton solver	PRU solver
$\Delta E/E$	7×10^{-6}	6×10^{-6}
Cluster radius	$2.1 \times 10^{-14}\,\mathrm{m}$	$2.2 \times 10^{-14}\,\mathrm{m}$
Max Lorentz γ	1.08	1.08

The PRU dynamics reproduces Newtonian clustering at $O(N \log N)$ cost.

7 Predictions and Falsifiability

1. **Zero laboratory drift:** $|\Delta G/G| < 10^{-5}$ when cooling a torsion pendulum from 300 K to 1 K.

2. **Cosmological drift:** $|\dot{G}/G| \approx 10^{-13}\,\mathrm{yr}^{-1}$ (testable with next-generation lunar-laser and pulsar-timing arrays).

3. Λ **coupling:** Any fractional change X in the observed Λ must induce the same fractional change in G.

4. **Bit-packing bound:** Demonstrating $> 10^{43}$ irreversible bits in $< 0.13\,\mathrm{mm}$ falsifies the model.

8 Discussion & Outlook

The dual-lock PRU reframes gravity as an information-theoretic coupling set by (i) a cosmic Landauer cost and (ii) a holographic packing limit. No free parameters remain once universal constants are fixed. Future work will scale simulations to $N \sim 10^9$, embed general-relativistic solutions, and confront the secular drift prediction with forthcoming PTA data.

Smart, adaptive, efficient universe picture

So far we have implicitly treated the bit budget n as if every PRU cell were operating at its maximum information capacity. This is a convenient idealization for deriving the dual locks, but it is neither necessary nor physically realistic. The observable Universe is highly structured: small regions such as stellar interiors, galaxies and clusters exhibit intense interaction and rapid information turnover, while vast cosmic voids are almost empty and dynamically quiescent. A strictly uniform, fully saturated bit packing would be at odds with this heterogeneity.

A more faithful picture is to distinguish between a *maximum capacity* $n_{\max}$ set by Landauer and Bekenstein at $T_\star$ and an *effective activity* $n_{\mathrm{eff}}(x,t)$ that can vary across space–time. We can parametrize this by introducing an activity factor $\eta(x,t) \in [0,1]$,

$$n_{\mathrm{eff}}(x,t) \;=\; \eta(x,t)\, n_{\max}, \tag{7}$$

where $\eta(x,t) \simeq 1$ in regions of high interaction (e.g. dense matter, strong fields, complex structure) and $\eta(x,t) \ll 1$ in vast, weakly interacting domains such as cosmic voids. In this view each PRU cell is more like a smart cache or sleep-capable core in a distributed processor: it *can* support an enormous number of microstates, but it only "wakes up" and uses a significant fraction of this capacity where the relational dynamics demand it.

Quantum entanglement further encourages such an interpretation. If information is stored primarily in nonlocal correlations rather than independent local bits, then the holographic limits constrain the total relational structure, not a naive sum over independent cell registers. The dual locks (U_A, U_B) can then be understood as setting the natural scale for this relational capacity per cell, while the pattern of entanglement and the activity field $\eta(x,t)$ determine how much of the capacity is actually exercised at a given location and time.

Crucially, the derivation of G in Eq. (6) depends only on the capacity scale encoded in U_A and U_B, not on the detailed spatial profile of $\eta(x,t)$. Gravity in the PRU picture is governed by the *available information-theoretic infrastructure*—how costly it is in principle to update relational degrees of freedom—rather than by the instantaneous, realized entropy of the Universe. This suggests a "smart, adaptive, efficient" Universe: one in which the underlying information grid is extremely powerful, but only the regions with rich matter content and strong interactions fully engage that power, while the rest of space–time idles in a low-activity, cache-like state.

9 Limitations and Interpretation of the Bit Budget

In the dual–lock construction, the Landauer and Bekenstein bounds at the cosmic microwave–background (CMB) temperature $T_\star$ are used to define a characteristic mass–lock U_A and geometry–lock U_B. For a cell of linear size U_B the Bekenstein bound fixes a *maximum* information capacity, while the Landauer cost fixes the energy per irreversible bit erasure at that temperature. Combining these relations with the dual–lock expression

$$G = \frac{ch}{\alpha \Lambda \sqrt{N}} \frac{1}{(U_A U_B)^2} \tag{8}$$

and the experimental value of G singles out a characteristic information scale which we previously denoted by n bits per PRU node.

It is crucial to emphasize that this should *not* be interpreted as "the Universe is everywhere filled with $n \sim 10^{43}$ classical, independent bits per $(0.13\,\mathrm{mm})^3$ cell." Rather, the number n should be read as an *information–theoretic capacity scale*: given $T_\star$ and the holographic packing limit, a PRU cell could, in principle, distinguish that many microstates before hitting the relevant bounds. Nothing in the present construction requires that this capacity is actually saturated in typical regions of space–time.

In particular, naively multiplying n by the number of cells in the observable Universe would exceed global holographic entropy bounds. The resolution within the PRU framework is that the dual locks (U_A, U_B) are defined from the *capacity* of a cell, while the *realized* or *accessed* information content can be far lower, highly compressed, and extensively shared via entanglement. The dual–lock expression (8) therefore ties G to an underlying *capacity scale*, not to the instantaneous classical entropy density. In this sense the PRU model should be viewed as an effective description of the information infrastructure of space–time, rather than a complete microstate census.

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