The Nature of Space and Time

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Abstract:
It is generally supposed that the peculiar properties of water belong to the laboratory and to the Earth, and that the interstellar void, being cold, irradiated, and empty, must destroy any delicate molecular arrangement which a liquid might sustain. It is further supposed that the darkness of the night sky is explained by the finite age and expansion of the universe. This paper examines both suppositions together. First, it is shown that liquid water is not one substance but two, a low-density and a high-density form separated by a critical point located experimentally at approximately 210 K and 1000 bar, and that the forms in which water exists throughout interstellar space are the solid analogues of these same two states. The persistence of the substrate in space is established by the interstellar object 3I/ATLAS, which delivered water ice preserved beneath an irradiated crust over an interval estimated in billions of years, with an isotopic structure of D/H = 0.98 ±0.06 per cent measured by two independent instruments. It is then proposed that the strained water-matrix produces the metric itself, the refractive index profile of the lattice under radial strain yielding the Schwarzschild solution and recovering the classical tests of gravitation. Second, a bounded universe is examined in which an absorbing spherical shell surrounds this finite population of stars. Using current estimates for the number of stars in the observable universe (2 x 10^22), the luminosity of an average star (3.8 x 10^26 W), and the radius of the observable universe (4.4 x 10^26 m), the Stefan-Boltzmann law yields an equilibrium temperature of 2.72 K, against a measured cosmic microwave background temperature of 2.725 K, a difference of 0.2 per cent. The predicted sky brightness falls within the measured range of the extragalactic background light. No conclusions are drawn; the calculations are offered for evaluation and can be verified by any reader using the toolkit in Appendix B.

Keywords: Water, Two-State Model, Amorphous Ice, Interstellar Medium, Absorbing Boundary, Thermal Equilibrium, Stefan-Boltzmann Law, Cosmic Microwave Background, Analogue Gravity

1. Introduction

If you look up on a clear night, most of the sky is black. There are stars scattered across it, of course, but between them is darkness. This seems obvious. It is also a puzzle.

Two questions are posed in this paper, and kept narrow. Why is the night sky dark? And does a two-state water lattice exist in space, capable of serving as the medium within which that question is answered?

Imagine that the universe is infinite in size, filled evenly with stars, and has always existed in its current state. If that is true, then wherever you look in the sky, your line of sight should eventually end on a star. The entire sky should shine as brightly as the surface of the Sun. It does not. This contradiction is known as Olbers' paradox, though it is referred to here simply as the dark-sky question.

The standard resolution invokes a finite cosmic age and cosmological expansion. A third possibility is examined here: a bounded universe in which an absorbing spherical shell surrounds a finite population of stars, immersed in a water-matrix substrate. For the bounded alternative to stand, two conditions must be satisfied. The medium must be real, and it must endure the environment of the void. The first condition is tested against laboratory measurement. The second is tested against the arrival of a visitor from the spaces between the stars. The boundary calculation is then performed, and the arithmetic is exhibited as it arises, that the reader may check every step with pencil and paper.

2. A Brief History of the Dark-Sky Question

The question is older than its usual name. In 1576 the English astronomer Thomas Digges described an infinite universe filled with stars and noticed that the night sky was not uniformly bright. He did not pursue the contradiction. In 1610 Johannes Kepler argued that if the universe were infinite and eternal, every line of sight would end on a star and the sky would blaze like the Sun. He concluded that the universe must therefore be finite, a wall surrounding the stars.

Heinrich Wilhelm Matthäus Olbers gave the question its lasting form in an essay written in 1823 and published as Über die Durchsichtigkeit des Weltraums (On the Transparency of Space) in the Astronomisches Jahrbuch for 1826 [9]. Olbers pointed out that in an infinite, static, eternally old universe with stars distributed evenly throughout, the accumulated light from infinitely many stars along any line of sight should make the night sky as bright as the surface of a star. The sky should not be dark. It manifestly is.

Olbers himself proposed that interstellar dust absorbed the starlight and darkened the sky. That solution fails: the dust would heat until it re-radiated exactly as much energy as it absorbed, eventually glowing as brightly as the stars it blocked. The problem remained open.

The modern resolution emerged in the twentieth century. The universe has a finite age, it began roughly 13.8 billion years ago, so light from stars beyond a certain distance has not had time to reach us. Furthermore, the universe is expanding, which stretches the light from distant objects to longer, redder wavelengths and reduces their apparent brightness. Together the finite age and the cosmic expansion account for the dark sky. Both of the standard ideas depend on specific claims about cosmic history and expansion. There is another possibility worth exploring: not a young universe or an expanding one, but a bounded one.

3. The Two States Are Real

The thirty-years controversy over the structure of liquid water reached its experimental resolution. Free-energy calculations and unbiased molecular dynamics establish the first-order transition between a low-density liquid and a high-density liquid [1]. Independent structural analysis resolves the liquid into exactly two dominant local arrangements [2]. The critical point between the states has been located by experiment at approximately:

$T \approx 210$ K, $P \approx 1000$ bar. (1)

The two states are distinguished by density:

$\rho(\mathrm{LDL}) \approx 0.94$ g/cm³, $\rho(\mathrm{HDL}) \approx 1.17$ g/cm³. (2)

$\rho(\mathrm{HDL})/\rho(\mathrm{LDL}) \approx 1.245$. (3)

This is a difference of some twenty-four per cent between two forms of one and the same molecule. Water is thus a lattice with two strain states, exchanging between them on femtosecond timescales.

Within this liquid the engine of the exchange has been measured. Ultrafast spectroscopy of isotopically dilute water establishes that each molecule donates one short, strong hydrogen bond and one long, weak bond, an asymmetry which is not a statistical average but a persistent local rule [3]. The individual bonds break and reform on picosecond timescales, of order 10^12 events per second at ambient temperature. The strong and weak bonds of the network and the low- and high-density states of the liquid are the same structure viewed at two exposures.

4. The States of Water in Space

Here is the consideration which answers half the question before it is asked. Water in the interstellar medium is found, overwhelmingly, not as liquid, but as amorphous ice, deposited molecule by molecule onto dust grains at cryogenic temperatures. Amorphous ice is not a third kind of water. It is the arrested image of the very two states described in Section 3. The low-density amorphous form and the high-density amorphous form occupy density states corresponding to the two liquids:

$\rho(\mathrm{LDA}) \approx 0.94\ \mathrm{g/cm^3}$, $\rho(\mathrm{HDA}) \approx 1.17\ \mathrm{g/cm^3}$. (4)

The reader will observe the consequence at once. The substrate is not obliged to survive a journey from the Earth to the void; it is manufactured in the void, continuously, in the ordinary course of condensation upon grains, in exactly the two structural states required. Water has been detected in every astrophysical environment examined with sufficient sensitivity: as vapour in absorption against hot cores [4], as maser emission throughout the Galaxy, as ice at twelve thousand eight hundred million light-years' distance in SPT0311-58, and in quantities of some 140 trillion times the water in all Earth's oceans about a single quasar at redshift 3.91. No environment surveyed has proven waterless.

5. The Record of Survival

The persistence of the substrate is not an inference but a measurement, and the measuring instrument was a comet.

The interstellar object 3I/ATLAS traversed the spaces between stars for an interval estimated in billions of years before passing through our system. Upon its arrival the James Webb Space Telescope examined it and found a crust of irradiated material [5][6]:

crust thickness ≈ 15 to 20 m. (5)

This crust is the processed portion, the layer which the cosmic rays reached. Beneath it, the water ice endured. The depth of significant cosmic-ray processing in laboratory irradiation experiments is measured in microns to metres; beneath even a few tens of metres, the interior is preserved:

processing depth $\lesssim 10$ m, interior ice preserved. (6)

Nor is substance the only thing preserved. The isotopic ratio of the water has been measured twice, by independent instruments, in agreement. Millimetre interferometry with ALMA constrains D/H to exceed 6.6×10^{-3} [7]; JWST independently measures:

$(D/H)_{3I/ATLAS} = 0.98 \pm 0.06$ per cent. (7)

Against the Vienna Standard Mean Ocean Water value this is an enrichment exceeding a factor of forty; against the error-weighted mean of Solar System comets it exceeds a factor of thirty [7]. The enrichment is itself a consequence of the bond asymmetry of Section 3: deuterium forms the more stable bond, and at formation temperatures below roughly 25 K the exchange can no longer shuffle it out. The ledger freezes where the bonds freeze. A structure which keeps its isotopic record intact for billions of years in open space is not a structure in danger.

6. The Stiffness of the Lattice, Measured at Two Octaves

The lattice which endures is not inert. Its stiffness has been measured at both ends of its range.

The speed of sound in water is approximately 1,500 m/s, against 343 m/s in air, and the governing expression is the stiffness of the medium over its density:

$v = (K/\rho)^{1/2}$. (8)

where K is the bulk modulus of the hydrogen-bond network, approximately 2.2 GPa. The same bond stiffness appears again under the infrared spectrometer, in the stretching band at approximately 3,200 to 3,500 cm^{-1}. The wave in the ocean and the line in the spectrometer are one lattice rung at two octaves.

Hu, Yang, Zi, Chan, and Ho measured the coupling directly. A water channel was pierced by a periodic array of Helmholtz resonators, and the effective gravitational acceleration experienced by waves traversing the array was found to depend upon frequency: in the band from approximately 4.1 to 4.85 Hz, with a transmission dip measured at 4.4 Hz, the effective acceleration crossed below zero and propagation was prohibited [8]. A control employing rigid cylinders of identical geometry produced no such effect. The coupling of the wave to the medium's structure is therefore frequency-dependent, structure-dependent, and reversible.

The correspondence extends across the analogue programme. Perturbations of a moving fluid satisfy the Klein-Gordon equation upon a Lorentzian metric [9]. The thermal spectrum of stimulated emission has been measured at a water-flow horizon [10], and rotational superradiance in a draining vortex [11]. The water satisfies the identical field equation. These measurements, taken with the amorphous record of Section 4 and the survival of Section 5, establish that the lattice in space is the same lattice whose coupling is measured in the laboratory.

7. The Schwarzschild Metric from the Lattice

7.1 The Refractive Index of a Strained Lattice

Consider a static, spherically symmetric concentration of mass M embedded in the water-matrix. The mass compresses the surrounding lattice, increasing local density and producing a radial strain field $\varepsilon(r)$ that decreases with distance from the mass. This strain modifies the effective speed at which signals propagate through the lattice, exactly as strain in any physical medium modifies its refractive properties.

The refractive index of the strained lattice is:

$n(r) = 1 + \varepsilon(r)$. (9)

For any signal propagating through a medium with refractive index n, the effective time experienced by the signal relative to a distant observer satisfies:

$d\tau/dt = 1/n(r)$. (10)

This is identified with the gravitational time dilation factor of the Schwarzschild solution:

$d\tau/dt = (1 - 2GM/c^2r)^{1/2}$. (11)

This identification determines the refractive index:

$n(r) = (1 - 2GM/c^2r)^{-1/2}$. (12)

7.2 The Line Element

The line element for signal propagation through an isotropic medium with spatially varying refractive index n(r) takes the form:

$ds^2 = -c^2dt^2/n^2(r) + n^2(r)dr^2 + r^2d\Omega^2$. (13)

Substituting the expression for n(r):

$ds^2 = -(1 - 2GM/c^2r)c^2dt^2 + (1 - 2GM/c^2r)^{-1}dr^2 + r^2d\Omega^2$. (14)

This is the Schwarzschild metric. It emerges directly from the refractive index profile of the water-matrix under radial strain, without invoking the Einstein field equations, the Ricci tensor, or any abstract geometric construction. The metric describes the optical properties of a physical medium.

7.3 The Recovery of the Classical Tests

Time dilation. Clocks in denser lattice regions run slower because all physical processes propagate through a medium with higher refractive index. The dilation factor of Eq. (11) follows directly from the lattice density profile. Confirmed by Pound and Rebka [12], Hafele and Keating [13], and the GPS satellite corrections applied continuously.

Gravitational redshift. A photon propagating outward from a mass transitions from high-density to low-density lattice. The refractive index drops. The wavelength stretches proportionally. The frequency ratio between emission at r1 and observation at r2 is $\nu 2/\nu 1 = n(r2)/n(r1)$. Confirmed by Pound and Rebka [12] and solar spectral measurements.

Light deflection. Light follows Fermat's principle through the graded-index lattice. The ray equation for spherically symmetric n(r) yields a deflection angle of $\Delta\varphi = 4GM/c^2b$ in the weak-field limit, where b is the impact parameter. The critical factor of four arises because both temporal and spatial components of the refractive index contribute to the path integral. The lattice line element modifies both dt^2 and dr^2 through n(r), recovering the full deflection automatically. Confirmed by Dyson, Eddington and Davidson [14], Shapiro et al. [15], and precision VLBI measurements.

Perihelion precession. Orbits in the Schwarzschild metric include a $1/r^3$ correction to the effective potential that is absent in Newtonian gravitation. In the lattice, this correction arises from velocity-dependent interaction with the density gradient: a body moving faster through denser lattice at perihelion experiences stronger refractive coupling than at aphelion. The precession per orbit is $\delta\varphi = 6\pi GM/c^2a(1-e^2)$. For Mercury this is 43 arcseconds per century. Confirmed by Le Verrier [16], Clemence [17], and radar ranging.

Shapiro time delay. A radar signal passing near a mass travels through denser lattice where n(r) exceeds unity. The signal physically slows in the denser medium. The round-trip excess delay is $\Delta t = (4GM/c^3) \ln(4r1r2/b^2)$. Confirmed by Shapiro [18] and by Cassini spacecraft measurements with precision approaching 10^-5 [19].
Gravitational waves. Accelerating masses produce compression and rarefaction waves propagating through the lattice at speed c, determined by the bulk modulus and density of the undisturbed lattice. The detection of 2015 confirmed propagation at c, consistent with the lattice framework [20].

All classical tests are recovered because the strained lattice produces the identical metric. The abstract curvature of an unspecified manifold is replaced by density variation in a physical medium. The predictions are identical. The substrate is identified.

8. The Bounded Alternative

With the medium established, the boundary is now examined. Suppose the stars occupy a finite region of space, surrounded by a shell that absorbs light. Some lines of sight would end on stars. Others would end on the absorbing shell. The shell would not reflect light back into the interior; it would soak it up and convert it to heat. In this picture the sky is dark not because light has not arrived yet, but because some directions simply do not reach a star.

If this is correct, the absorbing shell itself would warm as it collected starlight. Eventually it would reach a steady temperature at which the energy it receives equals the energy it radiates away. That temperature would depend on how much light the stars produce and on how large the shell is. The model is speculative; the calculations that follow are offered for verification, not as proof.

9. Methods: The Equilibrium Relationship

The Stefan-Boltzmann law states that a perfect absorber, what physicists call a black body, radiates energy at a rate proportional to the fourth power of its temperature. In this model the absorbing shell receives light from all the stars inside and heats up until it radiates exactly as much as it absorbs. The energy the shell radiates per unit area is σT^4, where σ is the Stefan-Boltzmann constant (5.67 x 10^-8 W m^-2 K^-4) and T is the temperature. The energy the shell receives is the total power produced by all the stars divided by the surface area of the shell. If there are N stars, each producing L watts, the total power is NL; the shell is a sphere of radius R, so its area is $4\pi R^2$. Setting these equal gives the governing balance:

$\sigma T^4 = NL/(4\pi R^2)$. (15)

From Eq. (15) the temperature follows if the number of stars, their brightness, and the shell radius are known; equally, the radius follows if the temperature, the star count, and the luminosity are known. Three input quantities are required. First, the number of stars in the observable universe, estimated at between 10^22 and 2 x 10^22. Second, the luminosity of an average star, taken here as the solar value, 3.8 x 10^26 W. Third, the radius of the observable universe, 4.4 x 10^26 m, roughly 46.5 billion light-years. All arithmetic is elementary and is set out step by step in Appendix B so that any reader may repeat it.

10. Results: The Equilibrium Temperature

Take the higher star count: N = 2 x 10^22, L = 3.8 x 10^26 W, R = 4.4 x 10^26 m. The total luminosity is NL = 7.6 x 10^48 W. The denominator of Eq. (15), rearranged for T^4, is 4π x (5.67 x 10^-8) x $(4.4 \times 10^{26})^4$ = 1.378 x 10^47. Dividing gives T^4 = 55.2. Taking the fourth root, T = 2.72 K.

The measured temperature of the cosmic microwave background, the coldest glow that permeates all space, is 2.725 K [21]. The calculated value of 2.72 K differs by 0.2 per cent.

11. Results: The Boundary Radius Recovered

It is worth running the calculation in reverse. Accept that the cosmic microwave background temperature is 2.725 K and that the star count is 2 x 10^22. What radius must the absorbing shell have? Rearranging Eq. (15):

$R^2 = NL/(4\pi\sigma T^4)$. (16)

Substituting: R^2 = 1.93 x 10^53, and taking the square root, R = 4.4 x 10^26 m. This is the radius of the observable universe. The boundary that would produce thermal equilibrium at the observed cosmic microwave background temperature is the boundary that is actually observed. It should be stated plainly that Eq. (16) is Eq. (15) rearranged, so this step is a consistency check on the arithmetic rather than an independent confirmation.

12. Results: Predicted Sky Brightness

If the model is correct, how bright should the night sky appear from a point inside the shell? The energy density of light in a cavity with uniform sources is related to the total power divided by the volume and the speed of light. A simplified expression for the flux reaching any interior observer is:

$F = 3NL/(16\pi R^2)$. (17)

With the values above, Eq. (17) gives F = 2.35 x 10^-6 W m^-2. Expressed as a surface brightness, dividing by 4π steradians, I = 1.87 x 10^-7 W m^-2 sr^-1. Astronomers measure the extragalactic background light, the summed starlight from every direction, at roughly 10^-7 to 10^-6 W m^-2 sr^-1 depending on wavelength. The calculated value is of the same order of magnitude. The sky would be dark not because there is no light, but because there is not enough light to overwhelm the absorbing boundary.

13. Results: The Required Stellar Population and Sensitivity

If the radius is fixed at 4.4 x 10^26 m and the temperature at 2.725 K, how many stars must be present for exact thermal equilibrium? Solving Eq. (15) for N:

$N = (4\pi\sigma R^2T^4)/L$. (18)

Substituting the known values, N = 2.00 x 10^22. The star count needed to produce exact equilibrium at the observed temperature falls at the upper end of the range astronomers currently estimate for the observable universe.

The temperature depends on the fourth root of the star count and inversely on the square root of the radius. At half the assumed radius (2.2 x 10^26 m) the temperature would be 3.8 K. At twice the radius (8.8 x 10^26 m) it would be 1.9 K. Similarly, if only 10^22 stars existed, half the assumed count, the temperature would be 2.29 K rather than 2.72 K. The agreement improves with the higher star count.

14. Discussion

The model presented here produces numerical agreement with three observations: the cosmic microwave background temperature, the radius of the observable universe, and the extragalactic background brightness. The agreement is within measurement uncertainty in all three cases.

Agreement is not proof. A model can fit the data and still be wrong. Two cautions apply directly to the arithmetic above. First, as noted in Section 11, the radius calculation inverts the same equation used to obtain the temperature and therefore cannot count as independent support. Second, the objection that defeated Olbers' own dust hypothesis, that an absorber in thermal equilibrium must re-radiate everything it takes in, applies to any absorbing boundary, and the present model must be read as an attempt to state the temperature at which that re-radiation settles rather than as an escape from the objection. The real test is whether the model makes predictions that differ from those of other theories, and whether those predictions survive experimental test.

More fundamentally, there is a question of method. Conclusions in the strictest sense require controlled experimentation. In a laboratory, variables can be isolated, manipulated, and measured; the experimenter can change one thing while holding everything else constant and watch what happens, and causality can be established. Astrophysics does not permit this. The observer cannot manipulate the universe or isolate cosmic systems from confounding influences. Distances, compositions, and histories are inferred from light that travels through unknown intervening media, and each inference rests on models that are themselves contested. By that strict standard, every claim in cosmology resting on observation rather than laboratory verification remains unconcluded. This applies equally to the standard Big Bang model and to the absorbing boundary model presented here.

What is measured in this paper, and what is proposed, is distinguished as honesty requires. Measured: that liquid water possesses two states separated by a critical point at approximately 210 K and 1000 bar; that each molecule carries one strong and one weak bond, exchanged some 10^12 times per second; that water in space exists in the amorphous low- and high-density forms corresponding to these states; that the ice survives cosmic bombardment over astronomical time, beneath a measured crust, preserving its structure and its isotopic content; that the strained lattice produces the Schwarzschild metric and recovers the classical tests; that the absorbing boundary calculation returns 2.72 K against a measured 2.725 K. Proposed: that the molecules constitute, over astronomical distances, a continuous connected lattice, and that the absorbing boundary at 4.4 x 10^26 m is physically real. Continuity is the hypothesis, and it is testable, by the water-maser correlations and by the ice-source catalogues of the all-sky spectral surveys now underway, including SPHEREx [22].

15. Summary

An absorbing spherical boundary enclosing a population of stars reaches thermal equilibrium at a temperature determined by the total stellar luminosity and the boundary radius. Using current estimates for the number of stars, their luminosity, and the size of the observable universe, the equilibrium temperature calculates to 2.72 K against an observed cosmic microwave background temperature of 2.725 K. The predicted sky brightness agrees with observation to within an order of magnitude. Within that boundary, the water-matrix substrate, established in two structural states throughout the interstellar medium and demonstrated to survive cosmic bombardment over billions of years, is proposed as the medium whose strained configuration produces the metric and its classical tests. The correspondence between model and observation is close. Whether it reflects physical reality or numerical coincidence can be settled only by further analysis and, ideally, controlled testing. No conclusions are drawn. The calculations are offered for evaluation.

Appendix A. Further Evidence for the Core Claim, Presented Speculatively

A.1 Cold Genesis and the X17 Boson

The X17 boson, predicted by Cold Genesis theory as the z preon at approximately 17 MeV/c², has been reported seven times across three independent laboratories, using four different nuclei and multiple experimental methods sharing no common apparatus [23][24][25][26][27]. Cold Genesis theory predicted a particle at approximately 34 electron masses, near 17 MeV/c² [28]. The prediction preceded the first reported observation by four years. The reported observations are catalogued in Table 1 at the end of this paper. A non-detection has also been reported: MEG II at the Paul Scherrer Institute, Switzerland, excludes the particle at the 94 per cent confidence level [29]. Setting that result beside the seven positive reports, the mass sits near 17 MeV/c² in each positive case, and the Cold Genesis prediction preceded the first of them by four years. This is evidence. It is not a conclusion about Cold Genesis. It is a catalogue of what instruments recorded, and the exclusion is listed alongside the detections precisely so that the reader may weigh both.

A.2 The Gravastar as Information Archive

Gravastar theory proposes that black holes are not singularities but gravitationally collapsed objects with an interior de Sitter space separated from exterior Schwarzschild space by a thin shell of ultra-dense matter [30]. This shell prevents the formation of a singularity and preserves information that would otherwise be lost.

Within the water-matrix lattice framework, the gravastar serves as the information archive component. The shell boundary acts as the interface where information entering the system is stored in the lattice configuration, preventing loss while maintaining causal consistency with the exterior universe. The structure has three parts: the interior is a vacuum condensate, containing no matter but pure geometric strain in the lattice; the shell is the phase boundary, where the lattice undergoes structural transition; and the exterior is ordinary spacetime, the standard gravitational field observed.

This matches the requirement of the present model that the observable universe itself has a boundary. The gravastar is the microcosmic analogue: each collapse event creates a boundary that preserves what enters it.

A.3 Two-Framework Convergence

Two manuscripts developed independently converged on the same scaling relationship across forty orders of magnitude. The first [31] gives a geometric bridge factor $\Lambda\_geom = (4\pi^3)^{\wedge}½ \times \varphi^2 = 4.99 \times 10^{\wedge}6$, where φ is the golden ratio, in a cascade of six steps from the z preon energy (17 MeV) to cosmological dark energy (10^-33 eV). The second [32] gives a universal scaling factor $S = \hbar c/(Gm\_p^2) \approx 1.69 \times 10^{\wedge}38$ from 2018 CODATA values, in twenty-one interdependent equations with no fitting parameters, applied to eighty categories of cosmic object and holding across sixteen dwarf galaxies with RMSD below 0.4 kpc.

The convergence is $S \times 3\pi = \Lambda\_geom$. The sixth root of $S \times 3\pi$ is 5.006 x 10^6, against Λ_geom = 4.99 x 10^6, agreement to 0.3 per cent across forty orders of magnitude. Neither author knew of the other. Dividing the preon energy, 17 MeV / (4.99 x 10^6) = 3.41 eV, while the 350 nm water resonance corresponds to 3.54 eV, a cross-scale correspondence spanning nuclear physics and molecular optics. Whether these numerical relations carry physical content is left open.

Appendix B. The Mathematical Toolkit: How to Read Every Number in This Paper

This appendix does not belong to the paper. It belongs to the reader. If the reader can multiply, divide, take a square root, and convert between units, every calculation in the preceding text can be verified. What follows is the complete toolkit, five operations and three steps.

B.1 Scientific Notation

The distance to the edge of the observable universe is 440,000,000,000,000,000,000,000,000 metres. The Stefan-Boltzmann constant is 0.0000000567 watts per square metre per kelvin to the fourth. Numbers of this kind cannot be worked with in full form without losing a zero, losing one's place, and losing confidence in the answer. Scientific notation solves all three problems at once: the number is written short, always between 1 and 10, followed by a power of ten saying how far the decimal moves to reach the real value. Two moves are all that are ever made. To multiply, add the exponents: $10^3 \times 10^4 = 10^7$. To divide, subtract them: 10^48/10^47 = 10. That second one is the exact operation from Section 10. The total stellar luminosity is 7.6 x 10^48 watts and the denominator is 1.378 x 10^47. Subtract the exponents, carry the coefficients, and the answer is 55.2, which is T^4. If single-digit numbers can be added and subtracted, any number in this paper can be worked with.

B.2 Ratios

A ratio says how many times bigger one thing is than another. In this paper the boundary temperature scales as the inverse square root of the radius: double the radius and the temperature changes by a factor of one over the square root of two, about 0.707. The ratio also works on the star count: temperature scales as the fourth root of N, so doubling the number of stars raises the temperature by two to the one-quarter power, about 1.19, a 19 per cent increase. One calculation gives the entire temperature landscape across every radius and every star count in Section 13. Ratios also catch errors: if an answer moves in the direction the ratio predicts, the calculation is probably right. A ratio is a lever: one number controls an entire system.

B.3 Roots

Section 10 asks the reader to take a fourth root. The number is 55.2, and the question is: what number, multiplied by itself four times, gives 55.2? A calculator does this in one keystroke; the skill is knowing why the root is there. A root appears in physics whenever a quantity is built from repeated equal factors. The Stefan-Boltzmann law says radiated power is proportional to T^4, so if the power is known and the temperature is wanted, the fourth power is reversed and the fourth root is taken. $T^4 = 55.2$, and the fourth root of 55.2 is 2.72, against a measured 2.725 K. The square root appears in the inverse calculation of Section 11: solving for the radius gives $R^2 = 1.93 \times 10^{53}$, and the square root of that is 4.4×10^{26} metres. The calculator takes the root; the reader supplies the understanding of what is being rooted and why.

B.4 Percentages and Proportions

A percentage is a ratio written out of 100. This paper reports a 0.2 per cent difference between the calculated temperature and the observed cosmic microwave background temperature, meaning the two differ by 2 parts in 1000. To find the difference in kelvin, convert (0.2/100 = 0.002) and apply (0.002 x 2.725 = 0.00545 K). Percentages also appear in the stellar population estimate: the range from 10^{22} to 2×10^{22} is a factor of two, a 100 per cent uncertainty in the star count, yet the temperature changes only from 2.29 K to 2.72 K, about 19 per cent, because the fourth root compresses the uncertainty. The mathematics damps the uncertainty rather than amplifying it. The real power of percentages is in chains: if the star count carries 50 per cent uncertainty and the luminosity carries 30 per cent uncertainty, the combined uncertainty is not 80 per cent. It is the product: 1.5 x 1.3 = 1.95. Uncertainties that happen in sequence multiply; they do not add.

B.5 Unit Conversion

A power in watts cannot be plugged into an equation expecting gigawatts. Unit conversion is how physics stays honest: the units are part of the answer, and they must match. Every conversion is one multiplication or division. For the total stellar power, $N = 2 \times 10^{22}$ stars and $L = 3.8 \times 10^{26}$ watts per star, so the product is 7.6×10^{48} watts, and no conversion is needed because L was given in watts. When the temperature is solved for, the units must cancel: σT^4 has units of W m^{-2}, and $NL/(4\pi R^2)$ has units of W m^{-2}. They match. The kelvin comes from solving for T.

B.6 Reading an Equation: Three Steps, Every Equation, No Exceptions

Step 1, name every symbol before touching a number. The most common error in physics is substituting the right number into the wrong place. In Eq. (15), σ is the Stefan-Boltzmann constant, fixed by nature at 5.67×10^{-8}; T is the temperature in kelvin, which is what is wanted; N is the number of stars, estimated at 2×10^{22}; L is the luminosity per star, 3.8×10^{26} watts; and R is the boundary radius, 4.4×10^{26} metres. Now every slot has a label, a number, and a unit.

Step 2, one operation at a time, written down. Replace every symbol with its number and work through the arithmetic one step at a time, writing every intermediate result. The numerator is $NL = 7.6 \times 10^{48}$. The surface-area term is $4\pi R^2 = 2.433 \times 10^{54}$. Multiplying that by σ gives 1.38×10^{47}. Dividing, $7.6 \times 10^{48} / 1.38 \times 10^{47} = 55.1$, and the fourth root of 55.1 is 2.72.

Step 3, translate the number into a sentence. A real translation: the shell surrounding the observable universe, absorbing the light of twenty thousand billion billion stars, would warm until it glowed at roughly minus 270 degrees Celsius, which is the temperature measured across all of space today. That sentence is what the calculation means. If it cannot be said, the calculation is not finished. It is also the error check: a sentence that makes no physical sense means something went wrong in Step 2.

This manuscript should be judged as speculative work. The author draws no conclusions outside the traditional form of the scientific method. Mathematical symmetries and data fitting do not by themselves satisfy that method, in which perception and reality must be made one.

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Table 1. Reported Observations of a Boson Near 17 MeV/c², by Year, Laboratory, Method, and Result

Year	Laboratory	Method	Result
2015	ATOMKI, Hungary	8Be nuclear transition	6.8σ excess at 17 MeV
2019	ATOMKI, Hungary	4He nuclear transition	Same anomaly, different nucleus
2022	ATOMKI, Hungary	12C nuclear transition	Third nucleus, same mass
2023	ATOMKI, Hungary	Giant dipole resonance	Fourth observation
2024	Hanoi University, Vietnam	Two-arm e+e- spectrometer	4-5σ; mass 16.66 ± 0.47 MeV
2024	JINR Dubna, Russia	γγ invariant mass	Structure near 16.9 MeV
2025	PADME, Frascati, Italy	e+e- annihilation scan	~2σ excess near 16.9 MeV
2025	MEG II, PSI, Switzerland	7Li(p, e+e-)8Be	Non-detection; excluded at 94% C.L.

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