

The Yamagishi Absolute-Zero Standby and Hawking Phase-Transition Theory

— 3rd ed.: The Critical Radius Contains No G , and the 8π Is Not a Solid Angle — [Paper 52]

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— *From thinking to syncing.* —

ABSTRACT

The critical mass M_c at which the Hawking temperature equals the temperature of the cosmic microwave background separates the phase in which a black hole grows on net from the phase in which it evaporates. For $T_{\text{CMB}} = 2.725$ K one finds $M_c = 4.50 \times 10^{22}$ kg (about 0.61 lunar masses), with a Schwarzschild radius of 66.9 μm . The second edition quantified this and checked eleven numbers. The third edition re-verifies all eleven and then decomposes **what is inside those numbers**. The central claim is a single line: **the critical radius contains no G** .

$$r_s(M_c) = \frac{2GM_c}{c^2} = \frac{2G}{c^2} \cdot \frac{\hbar c^3}{8\pi G k_B T_{\text{CMB}}} = \frac{\hbar c}{4\pi k_B T_{\text{CMB}}}$$

G cancels and disappears (verified symbolically). The critical **mass** carries the gravitational constant; the critical **size** does not — it is a thermal length. Moreover the 4π that remains there is **not a solid angle**. It is what is left of 8π after division by 2, and its address is (the period 2π of the Euclidean section) $\times$ (the 2 of $\kappa = c^2/2r_s$). The 8π of the Hawking temperature is $4 \times 2\pi$ and contains a **periodicity**; the 8π of Einstein's equation is $2 \times 4\pi$ and contains a **solid angle**. Both equal 25.13; their roots differ. What Paper 17 asked for was not the assertion of distinct roots but **the writing of their addresses**. This paper writes them.

Scope of this paper: The content of Sections 3 and 4 lies **within standard black-hole thermodynamics**. Both the existence of the critical mass and the fact that all observed astrophysical black holes are on the absorbing side are well known (Adams & Laughlin 1997). This paper claims no new physics; it re-verifies existing quantities and writes the addresses of their internal structure. The “standby power” reading of Section 2 is a **Layer-3 (non-scientific) interpretation**, and nothing from Section 3 onwards depends on it.

1. Introduction

Absolute zero (-273.15°C) is the limit at which thermal motion ceases, yet quantum mechanics requires that even there a system does not come completely to rest. Under the uncertainty principle $\Delta x \Delta p \geq \hbar/2$, a vanishing momentum uncertainty ($\Delta p = 0$) makes the position uncertainty diverge ($\Delta x \rightarrow \infty$), leaving the spatial coordinate of the particle undefined.

The first half of this paper treats that fact; the second half determines quantitatively the phase-transition condition of black-hole thermodynamics. **The two are independent:** no conclusion from Section 3 onwards uses E_{ZPE} , the extended Pythagorean equation, or the expression for kT (verified in the third edition). Whatever the standing of the first half, the quantitative content of the second is unaffected.

2. Absolute Zero and the Zero-Point Energy

2.1 The requirement of holding a coordinate register

One may read the universe OS as needing each degree of freedom to maintain a minimal excitation in order to hold the spatial pixel structure in a register. The ground-state energy of a harmonic oscillator,

$$E_{\text{ZPE}} = \frac{1}{2} \hbar \omega$$

cannot be removed by any amount of cooling. As $T \rightarrow 0$ the thermal degrees of freedom are erased, but this term remains. Thus far the physics is standard quantum mechanics.

2.2 [Third edition] “Minimum standby power” is not yet a number

The first and second editions called the expression above the **minimum standby power of the system**. The third edition **withdraws that name**. The reason is not physical: it is that **the quantity is not yet a quantity**.

Observation 2.1 ($\frac{1}{2} \hbar \omega$ is not a number until ω is given)

The phrase “minimum standby power” names a **single number**. But $\frac{1}{2} \hbar \omega$ is a function of ω , and this paper never says which ω is to be taken. Indeed:

- For a single oscillator, lowering ω sends $\frac{1}{2} \hbar \omega \rightarrow 0$. **There is no minimum over modes; the infimum is 0** (verified numerically: 3.3×10^{-34} J at $\omega = 2\pi \cdot 1$ Hz, 3.3×10^{-31} J at $2\pi \cdot 10^3$ Hz, 1.7×10^{-19} J at $2\pi \cdot 5 \times 10^{14}$ Hz).

- Summed over all field modes, $\sum_k \frac{1}{2} \hbar \omega_k$ **diverges**. With a cutoff $k_{\max}$ it grows as $k_{\max}^4$, and a finite value is obtained only when the cutoff is put in by hand (verified numerically: 2.0×10^{-4} , 2.0×10^8 , 2.0×10^{20} J/m³ for $k_{\max} = 10^6, 10^9, 10^{12}$ m⁻¹).

So “minimum standby power” has **no number**, neither as an infimum nor as a sum.

This touches a discipline the corpus set for itself. Paper 15 states that a convention must be a number, not a function of the configuration. E_{ZPE} is a function of the configuration variable ω , and becomes a number only once ω is chosen. This paper chooses none. **Hence “minimum standby power” is so far a phrase, not a quantity.**

What remains: that the zero-point energy cannot be removed by cooling is a standard fact, and this correction does not touch it. What is corrected is only **calling it “minimum” and treating it as one number**. The third edition calls $E_{\text{ZPE}} = \frac{1}{2} \hbar \omega$ the zero-point energy of a given mode, and asserts no minimality.

2.3 The Yamagishi extended Pythagorean equation and its standing

Taking the relation between temperature and velocity space from Paper 20 (overclock thermodynamics), $kT = \frac{4}{3} \pi v^2$, one may consider the form in which the thermal and zero-point degrees of freedom are added orthogonally to the relativistic energy relation:

$$E^2 = (m_0 c^2)^2 + (pc)^2 + (kT)^2 + E_{\text{ZPE}}^2 \quad (2)$$

[Second-edition correction: a retracted value of Paper 20]: The first edition wrote the temperature relation of Paper 20 as $kT \sim \frac{4}{3} \pi v^3$. That is the value of the *first* edition of Paper 20, and it has been retracted. The correct relation is $kT = \frac{4}{3} \pi v^2$ (the power of v was one too high). As the third edition of Paper 18 shows, applying equipartition $\langle E_k \rangle = \frac{3}{2} k_B T$ to $E_k = 2\pi v^2$ gives $kT = \frac{2}{3} E_k = \frac{4}{3} \pi v^2$, and v^3 is never obtained. This type of error — a retracted value surviving in other papers — has been detected three times in the corpus (Papers 16 and 19, and here).

Remark 2.2 (the standing of equation (2) — important): Every term of (2) has the dimension of energy squared, so it is dimensionally consistent. However, **adding the thermal energy kT as an independent component orthogonal to the momentum term is a formulational assumption of this framework, not a consequence of standard relativistic thermodynamics**. In the standard treatment the internal thermal energy of a composite system **contributes to its invariant mass** (a hot box has a larger rest mass). Thermal energy is thus a quantity to be absorbed into m_0 , and adding it as a fourth component orthogonal to m_0 double-counts under a naive reading.

[Third edition: the limitation is carried out]: The second edition stated the limitation correctly but left (2) standing as a claim of the body. The third edition **quarantines it explicitly as an assumption**. Equation (2) is a decomposition proper to this framework rather than a derivation from standard theory, and **it is used in none of the quantitative conclusions of this paper** (verified in the third edition: neither Theorem 3.1, Corollary 3.2, Proposition 3.3, nor Corollary 3.4 refers to it). The results of the paper therefore stand however the standing of this equation is settled.

3. The Core: The Critical Mass of the Hawking Phase Transition

Because a black hole has negative heat capacity, it falls into a growing phase or a shrinking phase according to its temperature relative to the environment. This section fixes that boundary quantitatively.

3.1 The phase-transition equation

With the Hawking temperature

$$T_{\text{BH}} = \frac{\hbar c^3}{8\pi G M k_B} \quad (3)$$

and the temperature T_{CMB} of the cosmic microwave background, the evolution of the mass is governed by

$$\frac{dM}{dt} = \kappa (T_{\text{CMB}}^4 - T_{\text{BH}}^4), \quad \kappa > 0$$

so that:

1. **Absorbing phase** ($T_{\text{CMB}} > T_{\text{BH}}$): absorption of environmental thermal noise exceeds emission and the mass grows.
2. **Evaporating phase** ($T_{\text{CMB}} < T_{\text{BH}}$): emission exceeds absorption, the mass decreases, and the hole eventually evaporates.

Remark 3.0 (third edition: κ is not a constant)

The second edition wrote κ as a positive constant. Physically $\kappa = \sigma A/c^2$, and through the horizon area $A = 4\pi r_s^2 \propto M^2$ κ depends on M (greybody factors modify it further). **This changes no conclusion of the section:** $\kappa > 0$ multiplies the bracket, so the location of the zero of dM/dt and the direction of the flow on either side are decided by the sign of the bracket alone. What changes is **how fast**, not **which way**. The third edition writes κ as a positive quantity that may depend on M .

3.2 Determination of the critical mass

Theorem 3.1 (critical mass of the Hawking phase transition)

The critical mass bounding the two phases follows from $T_{\text{BH}} = T_{\text{CMB}}$ as

$$M_c = \frac{\hbar c^3}{8\pi G k_B T_{\text{CMB}}}$$

Substituting $T_{\text{CMB}} = 2.725 \text{ K}$,

$$M_c = 4.50 \times 10^{22} \text{ kg} \approx 0.61 M_{\text{Moon}}$$

with a Schwarzschild radius of

$$r_s = \frac{2GM_c}{c^2} = 6.69 \times 10^{-5} \text{ m} = 66.9 \text{ }\mu\text{m}$$

Proof Solving $T_{\text{BH}} = T_{\text{CMB}}$ for M gives the result immediately. The numerical substitution uses $\hbar = 1.0546 \times 10^{-34} \text{ J}\cdot\text{s}$, $c = 2.9979 \times 10^8 \text{ m/s}$, $G = 6.6743 \times 10^{-11} \text{ m}^3\text{kg}^{-1}\text{s}^{-2}$, $k_B = 1.3806 \times 10^{-23} \text{ J/K}$ (re-verified in the third edition: $M_c = 4.5024 \times 10^{22} \text{ kg}$, $M_c/M_{\text{Moon}} = 0.6132$, $r_s = 66.87 \text{ }\mu\text{m}$).

Physical picture: The critical black hole has **six tenths of the mass of the Moon while being the size of a grain of sand (diameter 0.134 mm)**. This extreme contrast displays the divorce between mass and scale in black-hole thermodynamics.

Corollary 3.2 (every existing black hole is in the absorbing phase)

All astrophysically observed black holes satisfy $M \gg M_c$ and are therefore without exception in the absorbing phase:

Object	Mass	Hawking temperature
Critical mass M_c	$4.50 \times 10^{22} \text{ kg}$	$2.725 \text{ K} (= T_{\text{CMB}})$
Stellar-mass BH	$10 M_{\odot}$	$6.17 \times 10^{-9} \text{ K}$
Sgr A*	$4.3 \times 10^6 M_{\odot}$	$1.44 \times 10^{-14} \text{ K}$

The temperature of a stellar-mass black hole is only about 2.3×10^{-9} times that of the CMB, so **no black hole in the present universe is evaporating on net** (verified numerically: 2.264×10^{-9}).

[Note] **This conclusion is standard.** That astrophysical black holes are colder than the CMB and are net absorbers is a well-known fact of black-hole thermodynamics (Adams & Laughlin 1997 and others). **The contribution here is the explicit numerical value of the critical mass; the conclusion itself is not new.**

Proposition 3.3 (cosmological growth of the critical mass)

From Theorem 3.1, $M_c \propto T_{\text{CMB}}^{-1}$, and cosmic expansion lowers $T_{\text{CMB}} \propto a^{-1}$ (with a the scale factor), so $M_c \propto a$: **the critical mass grows monotonically with the expansion.** Black holes now in the absorbing phase will therefore pass one by one into the evaporating phase in a sufficiently cooled far future. For a $10 M_\odot$ hole this requires $T_{\text{CMB}} < 6.17 \times 10^{-9}$ K, that is a growth of the scale factor by about 4.4×10^8 (verified numerically).

Corollary 3.4 (evaporation time in vacuum — a reference value)

The time for a black hole of mass M to evaporate completely **in an empty vacuum** is

$$t_{\text{evap}} = \frac{5120\pi G^2 M^3}{\hbar c^4} \quad (8)$$

Substituting $M = M_c$ gives $t_{\text{evap}} \approx 2.43 \times 10^{44}$ yr, about 1.8×10^{34} times the age of the universe 1.38×10^{10} yr (verified numerically: 2.433×10^{44} yr, 1.763×10^{34}).

[Second-edition correction: the standing of this value — important]: The first edition headed this corollary “the evaporation time of the critical black hole”. But M_c is defined by $T_{\text{BH}} = T_{\text{CMB}}$, so substituting into the phase-transition equation gives $dM/dt|_{M=M_c} = 0$: **the critical black hole does not evaporate at all.** Moreover the equilibrium is **unstable**: by negative heat capacity, a mass slightly above M_c has $T_{\text{BH}} < T_{\text{CMB}}$ so absorption wins and it grows, while slightly below it emission wins and it shrinks (verified numerically in the third edition: $T_{\text{BH}} = 2.7525$ K $> T_{\text{CMB}}$ at $M = 0.99M_c$, and 2.6980 K $< T_{\text{CMB}}$ at $M = 1.01M_c$). M_c is a watershed, not a stable point. Equation (8) assumes zero ambient radiation, so 2.43×10^{44} yr is a reference value for “if there were no CMB”. For comparison, a $10 M_\odot$ hole gives $t_{\text{evap}} \approx 2.10 \times 10^{70}$ yr (verified numerically).

3.3 [Third edition] The critical radius contains no G

Here begins the new content of the third edition. The second edition placed M_c and r_s side by side as numbers but **did not look at whether they carry the same constants.**

Corollary 3.5 (the disappearance of G)

The Schwarzschild radius at the critical mass is

$$r_s(M_c) = \frac{2GM_c}{c^2} = \frac{2G}{c^2} \cdot \frac{\hbar c^3}{8\pi G k_B T_{\text{CMB}}} = \frac{\hbar c}{4\pi k_B T_{\text{CMB}}}$$

in which **G cancels and disappears** (verified symbolically: the result contains no G).

That is, the critical **mass** M_c carries the gravitational constant as G^{-1} , while the critical **size** $r_s(M_c)$ **carries it not at all**. The latter is $1/4\pi$ of the **purely thermal length** $\hbar c/(k_B T_{\text{CMB}})$ (verified numerically: $\hbar c/(k_B T_{\text{CMB}}) = 8.403 \times 10^{-4}$ m, whose $1/4\pi$ is **66.87 μm** , matching r_s of Theorem 3.1).

The cancellation is no accident. M_c is obtained by equating $T_{\text{BH}} \propto 1/(GM)$ to T_{CMB} , hence $M_c \propto 1/G$; and $r_s \propto GM$ is proportional to G . Composing the two, G must cancel. **How strong gravity is moves the critical mass up or down, but does not move the critical size.**

Caution (what is not claimed): This does not mean G is physically irrelevant. M_c depends on G , and the evaporation time $t_{\text{evap}} \propto G^2 M^3$ depends on it too. What disappears does so **in this one combination** and no further. **Nor does this paper claim that the cancellation is absent from the literature:** it is two lines of algebra, and it would be unsurprising to find it recorded. What the paper does is **write out the composition** of two quantities the corpus had already computed.

3.4 [Third edition] The address of the 8π

A 4π remains on the right of Corollary 3.5. **That 4π is not a solid angle.**

Observation 3.6 (the two 8π have distinct roots)

The corpus handles several expressions containing 8π (Papers 17, 35). The 8π in the T_{BH} of this paper and the 8π in Einstein's equation are **equal in value and different in root**:

Expression	Split	Where each factor comes from
$T_{\text{BH}} = \frac{\hbar \kappa}{2\pi c k_B}, \kappa = \frac{c^4}{4GM}$	$8\pi = 4 \times 2\pi$	4: Schwarzschild factors / 2π : period of the Euclidean section
$G_{\mu\nu} = \frac{8\pi G}{c^4} T_{\mu\nu}$	$8\pi = 2 \times 4\pi$	2: trace reversal / 4π : solid angle (Paper 35)

Both are **25.13**. But one contains a **periodicity** and the other a **solid angle**. **It is not one number appearing twice; it is two numbers of different provenance that happen to be equal.**

This is what Paper 17 asked for. Its third edition states that asserting distinct roots is only half the job, and that a claim becomes checkable only when the address of each root is written. Here is the address for the 8π of T_{BH} : it comes not from the area of a sphere but from the period $\beta = 1/(k_B T)$ of the Euclideanised time coordinate, entering through the surface gravity κ as $T = \hbar\kappa/(2\pi c k_B)$. It is the same root as the 2π of the Unruh effect, and a different root from the 4π of Gauss's law.

Corollary 3.7 (the address of the 4π of Corollary 3.5)

The 4π in $r_s(M_c) = \hbar c/(4\pi k_B T_{\text{CMB}})$ is what is left of the 8π of T_{BH} after division by the 2 of $r_s = 2GM/c^2$:

$$4\pi = \frac{8\pi}{2} = \frac{4 \times 2\pi}{2} = 2 \times 2\pi$$

Its address is therefore (the 2 of $\kappa = c^2/2r_s$) $\times$ (the Euclidean period 2π). **This is a different root from the solid-angle 4π treated in Papers 35 and 51.** That two things look alike is no ground for their being the same — the same caution Paper 51 raised for the shell theorem, where the 4π cancelled on both sides and vanished. Here it does not vanish: it remains, without being a solid angle.

4. Interpretation in the Universe OS — Layer 3 (non-scientific)

What follows is interpretation, not theorem, and is quarantined as Layer 3 (non-scientific). The quantitative results above use none of it. In the picture of a universe OS, absolute zero may be read as a **stable standby mode** — dynamic processing halts, but the zero-point term holding the coordinate registers remains. Black-hole evaporation may likewise be read as a **thermal garbage collection** triggered when the temperature gradient with the environment reverses. The critical mass of Theorem 3.1 then corresponds to the threshold of “what size of data block becomes a collection target”, and Proposition 3.3 to that threshold being raised as the system cools. **This paper gives no independent proof that the reading is a physical necessity beyond metaphor.** What is established is the quantitative content of Theorem 3.1, Corollary 3.2, Proposition 3.3 and Corollary 3.5, all of which hold without adopting the reading.

5. Conclusion

This paper establishes the following.

1. **The critical mass of the Hawking phase transition, $M_c = \hbar c^3 / (8\pi G k_B T_{\text{CMB}}) = 4.50 \times 10^{22} \text{ kg} \approx 0.61 M_{\text{Moon}}$, with Schwarzschild radius $66.9 \mu\text{m}$ (Theorem 3.1). All eleven numbers were re-verified in the third edition and all agreed.**
2. Every existing astrophysical black hole is in the absorbing phase, none evaporating on net (Corollary 3.2). **This conclusion is itself standard; the contribution is the numerical value.**
3. The critical mass grows as $M_c \propto a$ with the cosmic expansion (Proposition 3.3).
4. At M_c one has $dM/dt = 0$, so **no evaporation occurs**; and the equilibrium is **unstable**, making M_c a watershed rather than a stable point. The figure $2.43 \times 10^{44} \text{ yr}$ is a reference value assuming vacuum (Corollary 3.4).
5. [Third edition] **The critical radius contains no G : $r_s(M_c) = \hbar c / (4\pi k_B T_{\text{CMB}})$ (Corollary 3.5, verified symbolically). The critical mass carries the gravitational constant; the critical size does not.**
6. [Third edition] **The 8π of T_{BH} is $4 \times 2\pi$ (a periodicity) and has a different root from the $8\pi = 2 \times 4\pi$ (a solid angle) of Einstein's equation (Observation 3.6). The 4π surviving in Corollary 3.5 is likewise not a solid angle but $2 \times 2\pi$ (Corollary 3.7).**
7. [Third edition] **The 5120π of equation (8) is not an independent number: it is the 15360π of the Hawking power (Paper 43) divided by the power 3 of M . Integrating $dM/dt = -\hbar c^4 / (15360\pi G^2 M^2)$ produces $M^3/3$, and $15360/3 = 5120$ (verified symbolically). They are not two numbers but two faces of one root.**
8. [Third edition] **“Minimum standby power” is withdrawn as a name: $\frac{1}{2}\hbar\omega$ is not a number until ω is given; the infimum over modes is 0 and the sum diverges (Observation 2.1). Following the discipline of Paper 15, the claim of minimality is withdrawn.**

5.1 Scope

- **What this paper shows:** the critical mass giving $T_{\text{BH}} = T_{\text{CMB}}$ and its attendant quantities (M_c , r_s , the T_{BH} of each object, $M_c \propto a$, t_{evap}), together with **the internal composition of those numbers** — that $r_s(M_c)$ contains no G , the address of the 8π , and that 5120π and 15360π share one root. **The quantitative content lies within standard black-hole thermodynamics and was verified independently.**
- **What this paper does not show:** (i) any new physical law — **there is none**; (ii) that the extended Pythagorean equation (2) follows from standard theory — **it is an assumption of this framework and is used in no conclusion here** (Remark 2.2); (iii) that the readings “standby power” and “garbage collection” are more than metaphor (Section 4, quarantined as Layer 3); (iv) that the critical black hole actually evaporates (Corollary 3.4); (v) that the cancellation of G in Corollary 3.5 is unrecorded in the literature — **it is two lines of algebra and this has not been checked**; (vi) that E_{ZPE} is a single number (Observation 2.1).
- **What remains: equal values may have different roots.** 8π arises both from a periodicity and from a solid angle. On seeing the same symbol, ask first for its address (Papers 17, 51).

Revision Record

Added in the third edition (August 2026)

1. **The title is unchanged; only the subtitle was replaced:** the second edition's subtitle set the first half (zero-point standby power) beside the second (critical mass), whereas the content of the third edition lies on the second side. The main title is kept as it stands.
2. **Corollary 3.5 added (the disappearance of G):** $r_s(M_c) = \hbar c / (4\pi k_B T_{\text{CMB}})$, verified symbolically.
3. **Observation 3.6 and Corollary 3.7 added (the address of the 8π):** Hawking's $8\pi = 4 \times 2\pi$ (periodicity) and Einstein's $8\pi = 2 \times 4\pi$ (solid angle) have distinct roots; the 4π left in Corollary 3.5 is not a solid angle either.
4. **5120π and 15360π identified as one root** (Conclusion 7, verified symbolically).
5. **Observation 2.1 added and the name “minimum standby power” withdrawn:** $\frac{1}{2} \hbar \omega$ is a function of ω , its infimum is 0 and its sum diverges (Paper 15).
6. **Remark 3.0 added:** κ is not a constant but depends on M (as M^2). The location of the zero and the direction of the flow are unchanged; only the rate changes.
7. **The limitation of Remark 2.2 carried out:** the extended Pythagorean equation is quarantined as an assumption, and it is stated explicitly that no conclusion of the paper uses it.
8. **Section 4 explicitly quarantined as Layer 3.**
9. **All eleven numbers re-verified:** $M_c = 4.5024 \times 10^{22}$ kg, $M_c/M_{\text{Moon}} = 0.6132$, $r_s = 66.87 \mu\text{m}$, diameter 0.134 mm, $T_{\text{BH}}(10M_\odot) = 6.169 \times 10^{-9}$ K, $T_{\text{BH}}(\text{Sgr A}^*) = 1.435 \times 10^{-14}$ K, ratio 2.264×10^{-9} , scale factor 4.417×10^8 , $t_{\text{evap}}(M_c) = 2.433 \times 10^{44}$ yr, $t_{\text{evap}}(10M_\odot) = 2.097 \times 10^{70}$ yr, ratio to the age of the universe 1.763×10^{34} . All agreed with the second edition's figures.
10. **DOIs added to the self-citations in the bibliography.**

The two corrections of the second edition (unchanged)

1. The temperature relation of Paper 20 cited in Section 2, $kT \sim \frac{4}{3} \pi v^3$, was a retracted value from the first edition of **Paper 20**. The correct relation is $kT = \frac{4}{3} \pi v^2$.
2. Corollary 3.4 was headed “the evaporation time of the critical black hole”, but **at M_c one has $dM/dt = 0$ by definition and there is no evaporation**. The figure is a reference value assuming vacuum.

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