

The Limit Has No Radius Because Two Forces Share One Exponent

— Radiation pressure and gravity both fall as $1/r^2$, so the ratio does not depend on radius: moving r by a factor of **1000** changes it by 2.220×10^{-16} — set the gravitational exponent to **3** and the ratio moves by **1000**, turning the limit from a number into a place — the limiting luminosity per unit mass is **6.321962** W/kg, or **3.284712×10^4** solar luminosities at one solar mass — [Paper 483]

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— *From thinking to syncing.* —

Abstract

The limiting luminosity is taken to be a property of the star. This paper shows that the radius cancels because two forces share an exponent, and does not cancel when they differ—a counterfactual exponent of **3** moves the ratio by a factor of **1000**. No new theorem or law is claimed. First, the limiting luminosity per unit mass is **6.321962** W/kg—the value of $4\pi G m_p c / \sigma_T$ (Section 2). Second, at one solar mass that is 1.257388×10^{31} W, or **3.284712×10^4** solar luminosities (Section 2). Third, solving backwards returns $\sigma_T = 6.652459 \times 10^{-29}$ m² exactly—a relative difference of 0.000×10^0 (Section 2). Fourth, this is the core of the paper. The ratio of forces does not depend on radius—it is 1.000000000000 at $r = 10^9$ m and at $r = 10^{12}$ m, differing by 2.220×10^{-16} (Section 3). Fifth, setting the gravitational exponent alone to **3** moves the ratio by a factor of **1000**—cancellation is not automatic (Section 3). Sixth, the separator is whether the two forces share an exponent (Section 4). **Keywords:** Eddington luminosity, radiation pressure, gravity, inverse-square law, stars.

Scope of this paper (scope note): No new theorem or law is claimed—the Eddington luminosity is standard, as is the fact that radiation pressure and gravity both fall off as the inverse square. No astrophysical picture is offered—accretion, radiatively driven winds, super-Eddington accretion and departures from spherical symmetry are not the subject; only the idealisation of a spherical, fully ionised hydrogen envelope. One opacity only—Thomson scattering is taken alone, with no bound-free or line absorption. In real stars those matter. The counterfactual is not physics—there is no gravity with exponent 3. It is an operation for exhibiting the cancellation beside a case where it fails. Relation to earlier papers: Paper 196 showed that “pressure” is four separate quantities and that sharing a unit guarantees nothing—what is examined here is not the unit but the exponent. Paper 117 showed that scale invariance fixes an exponent in four different ways—the exponent here comes from the dimension-matrix side. Paper 482 showed one phrase naming two numbers—this paper looks at the converse: two forces sharing one exponent. Paper 481 showed that without separators a refutation has no destination—this paper writes one of them. What is added is giving L_E/M as 6.321962 W/kg , expressing the solar-mass value in solar luminosities, confirming a relative difference of 0 on solving back for σ_T , moving the radius by 1000 and finding a difference of 2.220×10^{-16} , and showing that a changed exponent moves the ratio by 1000.

1. Notation and the Question

Setting: Let fully ionised hydrogen fall spherically onto a source of luminosity L and mass M . At radius r the outward radiative force and the inward gravitational force are

$$F_r = \frac{L \sigma_T}{4\pi r^2 c}, \quad F_g = \frac{GMm_p}{r^2}$$

where σ_T is the Thomson cross-section and m_p the proton mass. Write L_E for the luminosity at which they balance.

Observation 1.1

The limiting luminosity is taken to be a property of the star. How bright that star may become—a number belonging to each star.

Observation 1.2

But no radius survives in the expression. Both forces fall as $1/r^2$ —taking the ratio cancels r^2 .

Question: What makes the radius cancel, and what happens when it does not.

2. Limiting Luminosity per Unit Mass

Computation 2.1: Solving $F_r = F_g$ gives

$$\frac{L_E}{M} = \frac{4\pi G m_p c}{\sigma_T}$$

whose right side is built from constants alone and equals **6.321962 W/kg**.

Observation 2.2

Neither M nor r appears on the right. The ratio is a quantity per unit mass—the same number for every star and at every radius.

Computation 2.3: Insert one solar mass.

Quantity	Value
L_E/M	6.321962 W/kg
L_E at one solar mass	1.257388×10^{31} W
In solar luminosities	3.284712×10^4

Observation 2.4

The Sun is far from its limit. A margin of thirty thousand—consistent with the Sun being stable.

Observation 2.5

Solving backwards returns the cross-section exactly. From L_E/M one recovers $\sigma_T = 6.652459 \times 10^{-29} \text{ m}^2$ with a relative difference of 0.000×10^0 from the known value—an independent check on both the algebra and the arithmetic.

Observation 2.6

So the limit is not a property of the star but a combination of constants. G, m_p, c, σ_T —writable while knowing nothing about the star.

3. The Radius Cancels Only When the Exponents Agree

Computation 3.1: Insert the balancing luminosity and evaluate the ratio of forces at two radii.

Radius r	F_r/F_g
10^9 m	1.000000000000
10^{12} m	1.000000000000

Observation 3.2

A thousandfold change in radius leaves the ratio still. The difference is 2.220×10^{-16} —the size of double-precision rounding, that is, zero in effect.

Observation 3.3

And that ratio is exactly 1.1.000000000000—the value the balance condition defines, confirming that the computation returns to itself.

Computation 3.4: As a counterfactual, let gravity alone fall as $1/r^3$.

Radius r	Ratio (gravitational exponent 3)
10^9 m	1.000000×10^9
10^{12} m	1.000000×10^{12}

Observation 3.5

A thousandfold radius now brings a thousandfold ratio. A factor of 1000.000000—the difference of one in the exponents, showing directly.

Observation 3.6

The “limit” then stops being a number. There is exactly one radius where the ratio crosses 1—gravity wins inside it and radiation outside. The limit becomes a place.

Observation 3.7

So the cancellation is not automatic. It happens only for two forces sharing an exponent—the cancelling was not luck but a condition.

4. The Separator

The separator: do the two balancing forces share an exponent, or not.

Observation 4.1

Sharing, and the limit is a number. A combination of constants—the same wherever it is measured, writable without knowing the size of the system.

Observation 4.2

Differing, and the limit is a place. The radius at which the ratio crosses 1—not writable without the size of the system.

Observation 4.3

Both are called a limit. They are distinct roots by the criterion of Paper 300—one a ratio of constants, one a root of an equation, differing even in units.

Observation 4.4

Paper 196 showed that sharing a unit guarantees nothing. What is seen here stands beside it—not the unit but the exponent of the radial dependence is what did the work.

Observation 4.5

The same operation applies to other balances. Set the two r -dependences side by side and see whether the exponents agree—agreeing leaves a dimensionless ratio, differing leaves a length.

Observation 4.6

This is one of the separators of Paper 481. When “the limit was exceeded” turns out wrong—whether the number failed or the place failed sends the repair to different places.

Observation 4.7

To be honest—the 6.321962 W/kg is an idealised value. Spherical symmetry, fully ionised hydrogen, Thomson scattering alone—real stars add line and bound-free opacity, which lowers the limit. Even the agreement of exponents can fail, depending on how that opacity varies with wavelength and radius.

5. Roll Call and Closing

1. $L_E/M = 6.321962 \text{ W/kg}$ (Computation 2.1): **constants alone.**
2. No M or r on the right (Observation 2.2): **a quantity per unit mass.**
3. $1.257388 \times 10^{31} \text{ W}$ at one solar mass (Computation 2.3): **3.284712×10^4 solar luminosities.**
4. Relative difference 0 for σ_T (Observation 2.5): **an independent check.**

5. The ratio ignores the radius (Computation 3.1): the core.
6. 2.220×10^{-16} over a factor of 1000 (Observation 3.2): rounding.
7. Exponent 3 moves it by 1000 (Observation 3.5): not automatic.
8. The limit becomes a place (Observation 3.6): where the ratio crosses 1.
9. The separator is the exponent (Observation 4.3): distinct roots by Paper 300.
10. An idealised value (Observation 4.7): real stars sit lower.

Closing: The limiting luminosity is taken to be a property of the star—a number belonging to each star, saying how bright it may become. But no radius survives in the expression: both forces fall as $1/r^2$, so taking the ratio cancels r^2 . The limit is a combination of constants—solving the balance gives $L_E/M = 4\pi G m_p c / \sigma_T$, whose right side is built from constants alone and equals **6.321962** W/kg. Neither M nor r appears there, so it is the same number for every star and at every radius. One solar mass gives 1.257388×10^{31} W, or 3.284712×10^4 solar luminosities, leaving the Sun a margin of thirty thousand. Solving backwards from L_E/M returns $\sigma_T = 6.652459 \times 10^{-29}$ m² with a relative difference of 0.000×10^0 , an independent check on both the algebra and the arithmetic. So the limit is not a property of the star but a combination of G , m_p , c and σ_T , writable while knowing nothing about the star. The radius cancels only when the exponents agree—with the balancing luminosity inserted, the ratio of forces is 1.000000000000 at $r = 10^9$ m and at $r = 10^{12}$ m, a thousandfold change leaving a difference of 2.220×10^{-16} , the size of double-precision rounding. That the ratio is exactly 1 is the value the balance condition defines, confirming the computation returns to itself. Let gravity alone fall as $1/r^3$ and the ratio becomes 1.000000×10^9 at $r = 10^9$ and 1.000000×10^{12} at $r = 10^{12}$: a thousandfold radius now brings a thousandfold ratio, the difference of one in the exponents showing directly. The “limit” then stops being a number—there is exactly one radius where the ratio crosses 1, gravity winning inside it and radiation outside, and the limit becomes a place. So the cancellation is not automatic but happens only for two forces sharing an exponent; the cancelling was not luck but a condition. One thing separates them—do the two balancing forces share an exponent, or not. Sharing, and the limit is a number: a combination of constants, the same wherever it is measured, writable without knowing the size of the system. Differing, and the limit is a place: the radius at which the ratio crosses 1, not writable without that size. Both are called a limit, yet they are distinct roots by the criterion of Paper 300—one a ratio of constants, one a root of an equation, differing even in units. Paper 196 showed that sharing a unit guarantees nothing, and what is seen here stands beside it: not the unit but the exponent of the radial dependence did the work. The same operation applies to other balances—set the two r -dependences side by side, and agreeing exponents leave a dimensionless ratio while differing ones leave a length. This is one of the separators of Paper 481: when “the limit was exceeded” turns out wrong, whether the number failed or the place failed sends the repair elsewhere. To be honest—the 6.321962 W/kg is an idealised value, taking spherical symmetry, fully ionised hydrogen and Thomson scattering alone. Real stars add line and bound-free opacity, which lowers the limit, and even the agreement of exponents can fail depending on how that opacity varies with wavelength and radius.

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