

Heavier Stars Have More Fuel Yet Burn Out Sooner, and Their Estimated Lifetimes Are Sensitive to the Exponent of Luminosity

— masses **0.5** and **20** differ in lifetime by **10119.288513** times, and a difference of **0.5** in the luminosity exponent changes the lifetime of a mass-**10** star **3.162278**-fold — the separator is whether one asks about the ratio of masses or the difference in the power's exponent — [Paper 892]

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— *From thinking to syncing.* —

Abstract

It is easy to assume that heavier stars shine longer because they have more fuel. This paper counts, in a model where fuel and luminosity are both powers of mass, how lifetime changes with mass and how sensitive it is to the exponent. No new theorem or law is claimed. First, heavier stars burn out sooner: with the Sun at 10, mass 0.5 gives 56.568542, 2 gives 1.767767, 10 gives 0.031623 and 20 gives **0.005590** (billion years) (Section 2). Second, and this is the core. The difference in luminosity far exceeds the difference in fuel: between masses 0.5 and 20, fuel differs 40 times but luminosity 404771.540502 times, and lifetime **10119.288513** times (Section 2). Third, lifetime estimates are sensitive to the luminosity exponent: the lifetime of a mass-10 star is 0.100000 at exponent 3.0, 0.031623 at 3.5 and 0.010000 at 4.0 (Section 3). Fourth, a 0.5 difference in exponent matters more for heavier stars. It changes the lifetime **3.162278**-fold for mass 10 and 4.472136-fold for mass 20 (Section 3). Fifth, the formula matches stepped burning: burning the fuel of a mass-5 star in steps took 0.178890, within 10^{-4} of the formula's 0.178885 (Section 2). Sixth, the separator is whether one asks about the ratio of masses or the difference in the power's exponent: lifetime is set by the -2.5 power of mass, and a small change in exponent moves estimates for heavy stars more than the mass ratio itself suggests (Section 4). **Keywords:** stellar lifetime, mass-luminosity relation, main sequence, power law, exponent sensitivity.

Scope of this paper (scope note): No new theorem or law is claimed: that main-sequence luminosity grows roughly as a power of mass, that lifetime is estimated as fuel divided by luminosity, and that heavier stars live shorter, are all known in astronomy. No real stars are claimed: the luminosity exponent 3.5, the solar lifetime of 10 billion years, and a burnt share independent of mass are model values matching no star. Internal structure is not entered: differences in fusion reactions, convection and mass loss are not included. Colour is not treated: the relation of colour to surface temperature and the luminosity--temperature diagram are not treated. Relation to earlier papers: Paper 835 showed that a lifetime's heartbeats are independent of body mass only because two powers cancel. This paper stands beside it. There the powers cancelled and body mass vanished. Here fuel's first power and luminosity's 3.5 power do not cancel, and mass to the -2.5 remains. Paper 497 showed that Kelvin's calculation was never refuted; what was replaced was the reservoir. This paper stands beside it too. There the Sun's lifetime estimate moved with the assumed reservoir. Here it moves with the assumed luminosity exponent. What is added is laying out luminosity and lifetime for six masses, measuring the lifetime ratio 10119.288513 between masses 0.5 and 20, measuring lifetime sensitivity to the luminosity exponent, and placing the separator on mass ratio versus exponent difference.

1. Notation and the Question

Setting: a star's fuel is proportional to its mass M (Sun = 1), and its luminosity grows as mass to the power p . Lifetime is fuel divided by luminosity, with the solar lifetime set to 10 (billion years).

$$L \propto M^p, \quad t = 10 \times \frac{M}{M^p} = 10 M^{1-p}, \quad p = 3.5 \Rightarrow t = 10 M^{-2.5}$$

Lifetime was obtained from the formula and as the time for fuel, reduced by the luminosity in steps of 10^{-5} , to run out.

Question: do heavy stars with more fuel shine longer?

2. Mass and Lifetime

Computation 2.1: with $p = 3.5$, luminosity and lifetime were computed for each mass.

mass	luminosity	lifetime (billion years)
0.5	0.088388	56.568542
1	1.000000	10.000000
2	11.313708	1.767767
5	279.508497	0.178885
10	3162.277660	0.031623
20	35777.087640	0.005590

Observation 2.2

this is the core. The difference in luminosity far exceeds the difference in fuel. Between masses 0.5 and 20, fuel differs only 40 times, but luminosity differs 404771.540502 times, so lifetime differs 10119.288513 times, and heavier stars burn out sooner. Burning a mass-5 star's fuel in steps took 0.178890, matching the formula's 0.178885.

3. Luminosity Exponent and Lifetime

Computation 3.1: the luminosity exponent was varied and the lifetime of a mass-10 star computed.

luminosity exponent p	lifetime at mass 10 (billion years)
3.0	0.100000
3.5	0.031623
4.0	0.010000

Observation 3.2

lifetime estimates are sensitive to the luminosity exponent. Between exponents 3.0 and 3.5, the lifetime of a mass-10 star differs 3.162278 times ($\sqrt{10}$): for mass 20 it differs 4.472136 times ($\sqrt{20}$). A 0.5 difference in exponent enters lifetime as mass to the 0.5 power, so it matters more for heavier stars.

4. The Separator

Observation 4.1

the separator is whether one asks about the ratio of masses or the difference in the power's exponent. Asking about the mass ratio, heavy stars with more fuel seem to shine longer: asking about the exponents, the difference -2.5 between fuel's first power and luminosity's 3.5 power sets lifetime, and a small change in that exponent moves estimates for heavy stars several times over.

Observation 4.2

placed beside Papers 835 and 497.835 showed that two powers cancel exactly so that a lifetime's heartbeats do not depend on body mass. Here the powers of fuel and luminosity do not cancel, and mass to the -2.5 remains in lifetime. 497 showed that the Sun's lifetime estimate moves with the assumed reservoir; here it moves with the assumed luminosity exponent.

Observation 4.3

what is not said. Real stellar lifetimes and luminosities, internal structure, mass loss, and colour--temperature relations are not treated. What is shown is that heavier stars burn out sooner, and the estimate is sensitive to the luminosity exponent.

5. Census and Closing

1. lifetime $t = 10M^{1-p}$ (Section 1): **fuel over luminosity.**
2. **56.568542** at mass **0.5** (Computation 2.1): **light stars last long.**
3. **0.005590** at mass **20** (Computation 2.1): **heavy stars are brief.**
4. luminosity ratio **404771.540502** (Observation 2.2): **fuel only 40 times.**
5. lifetime ratio **10119.288513** (Observation 2.2): **the core.**
6. stepped burning **0.178890** (Observation 2.2): **matches the formula.**
7. **0.100000** at exponent **3.0** (Computation 3.1): **mass 10.**
8. **0.010000** at exponent **4.0** (Computation 3.1): **a tenth.**

9. **3.162278** times for a **0.5** difference (Observation 3.2): **4.472136** at mass **20**.

10. mass ratio, or exponent difference (Observation 4.1): **the separator**; Papers **835, 497**.

Closing: Heavier stars have more fuel yet burn out sooner, and their estimated lifetimes are sensitive to the exponent of luminosity. If fuel is proportional to mass and luminosity grows as the 3.5 power, lifetime goes as the -2.5 power, and masses 0.5 and 20 differ in lifetime 10119.288513 times, because their fuel differs only 40 times while their luminosity differs 404771.540502 times. Changing the luminosity exponent from 3.0 to 3.5 alone changes the lifetime of mass 10 by 3.162278 times and of mass 20 by 4.472136 times: a difference in exponent enters as a power of mass, mattering more for heavier stars. Placed among the earlier papers: beside Paper 835's "two powers cancel exactly" and Paper 497's "the estimate moves with the assumed reservoir", we placed powers that do not cancel and a lifetime that moves with the assumed exponent. To be honest: the luminosity exponent and burnt share are model values, and neither internal structure nor mass loss is included.

References

1. Carroll, B. W., & Ostlie, D. A. (2007). *An Introduction to Modern Astrophysics* (2nd ed.). Pearson Addison-Wesley.
 2. Yamagishi, Y. (2026). *Kelvin's Calculation Was Never Refuted; What Was Replaced Was the Reservoir* [Paper 497]. YOI: <https://www.yamagishiyuuki.com/yoi/497>; DOI: 10.5281/zenodo.22760194
 3. Yamagishi, Y. (2026). *A Lifetime's Heartbeats Are Independent of Body Mass Only Because Two Powers Cancel* [Paper 835]. YOI: <https://www.yamagishiyuuki.com/yoi/835>; DOI: 10.5281/zenodo.23015605
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