Inside the Sun Light Advances on a Clock of Length Squared, and Outside on a Clock of Length

— The ratio of the two clocks is how many mean free paths fit in the radius, 3.315810917 times 10 to the 10, and the number of years moves by orders of magnitude with the mean free path while the exponent 2 does not — the separator is whether the step length is taken fixed or exponentially distributed — [Paper 1048]

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— From thinking to syncing. —

Abstract

Light crosses the radius of the Sun in 2.3 seconds.Yet to seep out from within takes incomparably longer.This paper counts the two as clocks of different dimension.No new theorem and no new law is claimed. First, and this is the core. The two clocks have different dimensions——outside, the speed of light times a time is a length, and the radius of 6.957×10 to the 8 metres is crossed in 2.320605410 seconds. Inside, a diffusion coefficient times a time is a length squared. The same light on the same journey is measured by a clock of length in one place and a clock of length squared in the other(Sections 2 and 5). **Second, the exponent 2 came out of actually walking the walk——counting the steps needed to leave balls of radius 10, 20, 40 and 80, the exponent is 1.956974369 for a fixed step length and 1.907885588 for an exponentially distributed one. Both rise towards 2 from below, and the two partial fits differ by −0.026278000 and 0.026673691, opposite in sign, so this is not a systematic bias**(Section 3). **Third, the coefficients match what kinetic theory predicts——dividing the step count by the radius squared gives 0.967130469 for fixed steps and 0.486542708 for exponential ones, a ratio of 1.987760688. Taking the diffusion coefficient to be a third of the mean free path times the speed of light predicts exactly 1.0 and 0.5**(Section 5). **Fourth, the ratio of the two clocks is how many mean free paths fit in the radius——from the mean density with Thomson scattering alone, the mean free path is 0.020981292886 metres, and dividing the radius by it gives 3.315810917×10 to the 10. The seeping time divided by the crossing time is exactly that**(Section 4). **Fifth, the number of years, by contrast, moves——the same computation gives 2438.299729045 years, but 1219.149864523 years if the step length is taken exponential, and a hundred thousand years if the mean free path is taken to be 0.000511586808 metres. The years are inversely proportional to the mean free path and change by a factor of two with the step convention alone**(Section 4). **Sixth, so the core is placed on what does not move——what does not move is the exponent 2 and the fact that the ratio counts mean free paths. The separator is whether the step length is taken fixed or exponentially distributed**(Section 5). **Keywords**: diffusion, random walk, mean free path, dimensional analysis, the Sun, radiative transport.

Scope of this paper (scope note): **No new theorem and no new law is claimed——the square law of the random walk, the kinetic estimate of the diffusion coefficient as a third of the mean free path times the speed, and the diffusive nature of radiative transport in the Sun are all standard (Mitalas and Sills 1992; Kippenhahn and others 2012).The structure of the Sun is not solved——density and temperature are held constant and the opacity is Thomson scattering alone. The real mean free path changes by orders of magnitude with depth.No claim about the number of years——what is counted is a ratio and an exponent, not how old the sunlight is.What is carried is not called a photon——absorption and re-emission exchange them, so what is carried is energy.Nothing about how long a reservoir lasts——the age of gravitational contraction was counted in Paper 497, a different question.The values are examples——the radii, the number of walks and the seed are given numbers.Relation to earlier papers： Paper 119 showed that a flow parameter advances not inside a manifold but through the space of manifolds, and that its dimension is length squared——here light inside a single star advances on that clock of length squared.Paper 445 showed that what the waiting is for is diffusion, not reaction——that was a chemical setting and this is the inside of a star, with the same square law setting the magnitude.Paper 755 showed that whether a bigger pump helps swaps with the ratio of mean free path to pipe diameter——what acts here is a ratio of the same form, the radius over the mean free path.Paper 497 showed that Kelvin's calculation was never refuted and that what was replaced was the reservoir——that is how long a reservoir lasts, this is how long transport takes, and the ratio is 2.587110314×10 to the minus 4.Paper 118 showed that coordinate time, proper time and entropy are three different logical types——here a fourth appears inside a single star, a clock whose dimension is length squared.**What is added is **measuring the exponent by walking the walk under two step conventions, matching the coefficients 1 and 0.5 against the kinetic prediction, checking that the ratio of the two clocks counts mean free paths, listing how the years move with the mean free path and the step convention**, and **inverting for the mean free path that would give a hundred thousand years**.

1. Notation and the question

Setting: **take the radius of the Sun to be $R = 6.957 \times 10^{8}$ m and its mass 1.98847×10^{30} kg.Write l for the mean free path, the distance light travels between scatterings.The crossing time outside is R/c; the seeping time inside is the number of steps times l/c.The walks used seed 20260920 and balls of radius 10, 20, 40 and 80, with 4000, 4000, 2000 and 600 walkers.**

Question: **what differs between outside and inside?**

2. The clock outside: proportional to length

Computation 2.1: **$R/c = 2.320605410$ seconds.Doubling the radius exactly doubles the time, and a tenfold radius gives a tenfold time, not a hundredfold one.**

> **Observation 2.2**
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> this is a clock of length.Multiply by the speed of light and a length comes out——time and length correspond one to one, and the exponent of the proportionality is 1.

3. The clock inside: proportional to the radius squared

Computation 3.1: walks were run and the steps to leave the ball counted.

Radius	Steps, fixed	Divided by radius squared	Steps, exponential	Divided by radius squared
10	107.025750000	1.070257500	59.433000000	0.594330000
20	413.249500000	1.033123750	215.224000000	0.538060000
40	1662.501000000	1.039063125	828.664500000	0.517915313
80	6189.635000000	0.967130469	3113.873333333	0.486542708

The slopes on a log-log plot are $\mathbf{1.956974369}$ for fixed steps and $\mathbf{1.907885588}$ for exponential ones.Doubling the radius multiplies the steps by $\mathbf{3.861215642}$, closer to 4 than to the 2 of straight-line travel.

Computation 3.2: fitting only the three smallest and only the three largest radii gives 1.978662679 and 1.952384679 for fixed steps, 1.900726004 and 1.927399695 for exponential ones.The standard error at radius 80 (relative 0.026634454 and 0.024526597) carries over to the slope as 0.019212697 and 0.017692200, and the differences are smaller than twice that.The differences are $\mathbf{-0.026278000}$ and $\mathbf{0.026673691}$, opposite in sign.

> **Observation 3.3**
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> the departure is noise, not bias.That the sign of the difference reverses between the two step conventions is the evidence——a bias due to the finite radius would push both the same way.

4. Applied to the Sun

Computation 4.1: the mean density is $\mathbf{1409.822455899}$ kg/m^{3}, the electron number density $\mathbf{7.164494681} \times 10^{29}$ /m^{3}, and the mean free path from Thomson scattering alone $\mathbf{0.020981292886}$ m.Dividing the radius by it gives $\mathbf{3.315810917} \times 10^{10}$, the step count is its square, $\mathbf{1.099460204} \times 10^{21}$, and the seeping time is $\mathbf{2438.299729045}$

years.The seeping time divided by the crossing time is $\mathbf{3.315810917} \times 10^{10}$, exactly the radius over the mean free path.

Computation 4.2: changing the mean free path moves the years directly.

Mean free path	Years	Radius divided by it
0.020981292886 m	$2.438299729 \times 10^{3}$	$3.315810917 \times 10^{10}$
0.001 m	$5.115868076 \times 10^{4}$	$6.957000000 \times 10^{11}$
0.0003 m	$1.705289359 \times 10^{5}$	$2.319000000 \times 10^{12}$

A hundred thousand years requires a mean free path of $\mathbf{0.000511586808}$ m, which is $\mathbf{0.024382997}$ of the value above.The years are inversely proportional to the mean free path: make it ten times finer and they grow tenfold.

> **Observation 4.3**
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> what does not move is the ratio.The years move by orders of magnitude with the choice of mean free path, but the ratio of the two clocks is always how many mean free paths fit in the radius——it has the same form as the ratio Paper 755 found in a vacuum pump, where what acted was the mean free path against the diameter of the pipe.

5. The separator: a fixed step length or an exponentially distributed one

Computation 5.1: at the largest radius the measured coefficients are $\mathbf{0.967130469}$ for fixed steps and $\mathbf{0.486542708}$ for exponential ones, a ratio of $\mathbf{1.987760688}$.Taking $D = lc/3$, kinetic theory gives an exit time $R^2/(6D)$ and predicts $R^2/(2l^2)$ steps, a coefficient of 0.5.With a fixed step length $D = l^2/(6\tau)$ and the count is R^2/l^2, a coefficient of 1.0.Both predictions were met.

Computation 5.2: so for the same Sun and the same mean free path, the seeping time is $\mathbf{2438.299729045}$ years with fixed steps and $\mathbf{1219.149864523}$ years with exponential ones.The diffusion coefficient $D = lc/3 = \mathbf{2.096677789} \times 10^{6}$ m^2/s divided by the speed of light is $\mathbf{0.006993764295}$ m, a third of the mean free path.

Observation 5.3

dimension is what separates the two clocks.The speed of light is a length over a time, so multiplying gives a length; a diffusion coefficient is a length squared over a time, so multiplying gives a length squared—— Paper 119 settled, from the dimension of length squared, that a flow parameter advances through the space of manifolds rather than inside one. Here a clock of that same dimension measures how light advances inside a single star.

6. What is not claimed

Observation 6.1

the structure of the Sun is not solved.Density and temperature were held constant and the opacity was Thomson scattering alone——the real mean free path changes by orders of magnitude with depth, so the years obtained here are not an answer about the Sun.Nor is what is carried called a photon——absorption and re-emission exchange them, so what is carried is energy.Nor is the lifetime of a reservoir entered——the age of gravitational contraction is the work of Paper 497, at 9.4248×10^{6} years, a ratio of $2.587110314 \times 10^{-4}$ to the transport time here.

7. Census and closing

1. **crossing time 2.320605410 seconds** (Computation 2.1): **a clock of length.**
2. **exponents 1.956974369 and 1.907885588** (Computation 3.1): **towards 2 from below.**
3. **differences -0.026278000 and 0.026673691** (Computation 3.2): **noise, not bias.**
4. **steps grow by 3.861215642 when the radius doubles** (Computation 3.1): **not by two.**
5. **mean free path 0.020981292886 m** (Computation 4.1): **Thomson scattering alone.**
6. **ratio $3.315810917 \times 10^{10}$** (Computation 4.1): **a count of mean free paths.**
7. **2438.299729045 years** (Computation 4.1): **one choice among many.**
8. **a hundred thousand years needs 0.000511586808 m** (Computation 4.2): **the years move.**
9. **coefficients 0.967130469 and 0.486542708** (Computation 5.1): **the predicted 1.0 and 0.5.**
10. **1219.149864523 years** (Computation 5.2): **halved by the step convention.**

11. **fixed or exponential** (Observation 5.3): **the separator; Paper 118, Paper 119, Paper 445, Paper 497 and Paper 755.**

Closing: **Inside the Sun light advances on a clock of length squared, and outside on a clock of length.Outside, the speed of light times a time is a length and the radius is crossed in 2.320605410 seconds. Inside, a diffusion coefficient times a time is a length squared, and walking the walk gives exponents of 1.956974369 and 1.907885588, both rising towards 2 from below. Dividing the step count by the radius squared gives 0.967130469 and 0.486542708, matching the 1.0 and 0.5 of kinetic theory——the ratio of the two clocks is nothing but a count of how many mean free paths fit in the radius, 3.315810917×10 to the 10 for Thomson scattering alone.The separator is whether the step length is taken fixed or exponentially distributed——that alone splits the years into 2438.299729045 and 1219.149864523, and a mean free path of 0.000511586808 metres would give a hundred thousand. What moves is the years; what does not is the exponent and the ratio.Placed among the earlier papers——the fourth clock that Paper 119 settled by its dimension of length squared appears here inside a single star, and the ratio against the mean free path is the same form that acted in Paper 755.To be honest——that radiative transport in the Sun is diffusive has long been known. What is added is to measure the exponent and the coefficients under two step conventions, to match them against the kinetic prediction, and to set out how far the years move with the choices made.**

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