

# The Sun Peaks in the Green, in the Orange and in the Infrared

— The Peak of a Blackbody Lies at 502 nm Seen per Wavelength, 636 nm Seen per Logarithm and 883 nm Seen per Frequency: All Three Are Right, and the Ratios Are the Same at Every Temperature — [Paper 222]

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August 2026

— *From thinking to syncing.* —

## ABSTRACT

In Paper 214 “brightness” was four separate quantities. What this paper treats is one quantity, and even so the place of its peak is not settled. **NO NEW MATHEMATICAL THEOREM AND NO NEW PHYSICAL LAW IS CLAIMED.** First, there are three equations. The root of  $(x - 5)e^x + 5 = 0$  is **4.965114231744276**, of  $(x - 4)e^x + 4 = 0$  is **3.920690394872886** and of  $(x - 3)e^x + 3 = 0$  is **2.821439372122079** — the 5, 4 and 3 being the powers of  $x$  in the three densities (Section 2). Second, this is the core. The spectrum of the Sun at **5772 K** peaks at **502.039 nm** (green) per unit wavelength, at **635.777 nm** (orange) per unit logarithm and at **883.479 nm** (infrared) per unit frequency — and all three are one and the same spectrum (Section 3). Third, the ratios do not depend on the temperature. Frequency over wavelength gives **1.759780586** and logarithm over wavelength **1.266387736**, the same for the Sun, a filament, a person and the microwave background (Section 3). Fourth, what is invariant can be measured too. The share of the power between **400 and 700 nm** is **0.36638317138174** integrated over wavelength and over frequency alike, a difference of **0** (Section 6). Fifth, why the maximum moves comes out in numbers. The factor  $\lambda^2/c$  that a change of variable brings rises across this range from  $5.34 \times 10^{-22}$  to  $4.80 \times 10^{-21}$ , ninefold, and drags the maximum with it (Section 7).

Scope of this paper (scope note): NO NEW MATHEMATICAL THEOREM AND NO NEW PHYSICAL LAW IS CLAIMED — Planck's law, Wien's displacement law, the Stefan–Boltzmann law and the question of where the Wien peak lies are all standard. Planck's law is not derived — this paper measures a formula it was given. The real Sun is not measured — it is treated as an ideal blackbody at 5772 K, with no atmosphere and no absorption lines. The response of vision is not treated — nothing is explained about looking green. No variable is declared the right one — what is written is only what changes when one is chosen. Relation to Paper 214: there “brightness” was four separate quantities — here there is one quantity and three peaks. The distinct root lies further upstream. Relation to Paper 220: there, passing a test was news about the test — here, the place of a peak is news about the variable. What is added is giving the three roots to sixteen digits, setting the three peaks side by side at four temperatures and seeing that the ratios do not depend on temperature, maximising the curves themselves rather than the equations and obtaining ten digits of agreement, obtaining the two Wien constants and the Stefan–Boltzmann constant and setting them against the tabulated values, measuring that the share in a fixed band does not depend on the variable, and tabulating the ninefold rise of the Jacobian factor.

## 1. Notation and Position

The radiation of a blackbody is a **density**. The density per unit wavelength and the density per unit frequency are **two ways of writing one spectrum**, joined by the equality of the two differentials. A third way is per unit logarithm. Write  $x = hc/(\lambda kT)$ .

**Position:** In Paper 214 “brightness” was four separate quantities and only one obeyed the inverse square — this paper goes further upstream and finds that even for one quantity the place is not settled. In Paper 221 “eigenvalue” split in two according to which matrix was meant — here “peak” splits in three according to what one counts per.

## 2. Three Equations, Three Roots

**Check 2.1:** the three densities carry different powers of  $x$ , so the condition for a maximum differs.

| Density per what | Condition for the maximum | Root              |
|------------------|---------------------------|-------------------|
| Per wavelength   | $(x - 5)e^x + 5 = 0$      | 4.965114231744276 |
| Per logarithm    | $(x - 4)e^x + 4 = 0$      | 3.920690394872886 |
| Per frequency    | $(x - 3)e^x + 3 = 0$      | 2.821439372122079 |

### Observation 2.2

The 5, 4 and 3 are the powers of  $x$  standing in each density. The equations differ in the single respect of whether the  $\lambda$  in the denominator is a fifth, a fourth or a third power, and that moves the root bodily.

## 3. The Core: One Spectrum with Three Peaks

Check 3.1:

| Body           | $T$ (K) | Per wavelength | Per logarithm | Per frequency |
|----------------|---------|----------------|---------------|---------------|
| The Sun        | 5772    | 502.039 nm     | 635.777 nm    | 883.479 nm    |
| A filament     | 2800    | 1034.92 nm     | 1310.61 nm    | 1821.23 nm    |
| A person       | 310     | 9347.65 nm     | 11837.8 nm    | 16449.8 nm    |
| The background | 2.725   | 1.0634 mm      | 1.34668 mm    | 1.87136 mm    |

The ratios are 1.759780586 for frequency over wavelength and 1.266387736 for logarithm over wavelength.

### Observation 3.2

The Sun's spectrum peaks in the green, in the orange and in the infrared. All three are correct answers about one and the same spectrum — and “the Sun peaks in the green” and “the Sun peaks in the near infrared” are both printed in textbooks.

### Observation 3.3

The ratios do not depend on the temperature at all. At 5772 K and at 2.725 K the three peaks stand in the same arrangement — because the spread is a property of the writing and not of the body.

## 4. Checked by Maximising the Curves Themselves

Check 4.1: maximise the Planck curves at  $T = 5772$  K directly, by ternary search.

| What was maximised     | Found numerically | From the equation |
|------------------------|-------------------|-------------------|
| Density per wavelength | 502.0394933 nm    | 502.0394933 nm    |
| Density per logarithm  | 635.7766571 nm    | 635.7766571 nm    |
| Density per frequency  | 883.4793537 nm    | 883.4793537 nm    |

### Observation 4.2

Agreement to ten digits. The three places are not artefacts of rearranging a formula but the true maxima of the actual curves.

## 5. The Constants That Come Out

Check 5.1:

| Constant             | This paper                                  | Tabulated                    |
|----------------------|---------------------------------------------|------------------------------|
| Wien, per wavelength | $2.89777195519 \times 10^{-3} \text{ m K}$  | $2.897771955 \times 10^{-3}$ |
| Wien, per frequency  | $5.87892575765 \times 10^{10} \text{ Hz/K}$ | $5.878925757 \times 10^{10}$ |
| Stefan–Boltzmann     | $5.67037441918 \times 10^{-8}$              | $5.670374419 \times 10^{-8}$ |

Integrating the whole curve gives  $62938592.4708 \text{ W/m}^2$  against  $\sigma T^4 = 62938592.4703$ , a ratio of 1.0000000000074.

### Observation 5.2

Note that there are two Wien constants —  $2.898 \times 10^{-3}$  and  $5.879 \times 10^{10}$  cannot be converted into one another. The total  $\sigma T^4$ , by contrast, is one number, the same whichever variable the integration uses.

## 6. What Is Invariant: The Energy in a Band Fixed in Advance

Check 6.1: the share of the power between 400 and 700 nm, computed two ways.

| Integrated how  | Share            |
|-----------------|------------------|
| Over wavelength | 0.36638317138174 |
| Over frequency  | 0.36638317138174 |
| Difference      | 0                |

### Observation 6.2

Every digit agrees. What a change of variable moves is the place of the maximum, and what it leaves alone is the energy in a band fixed beforehand — the first compares values of a density and the second is an integral. An integral is invariant under a change of variable, and the value of a density is not.

## 7. Why the Maximum Moves

A density carries a “per what”. Passing from wavelength to frequency multiplies it by  $|d\lambda/d\nu| = \lambda^2/c$ , and **that factor is itself steep**, so it drags the maximum along.

Check 7.1:

| Wavelength | Density per wavelength                       | $\times \lambda^2/c$        | = density per frequency                      |
|------------|----------------------------------------------|-----------------------------|----------------------------------------------|
| 400 nm     | $2.2913188 \times 10^{13}$                   | $5.3370255 \times 10^{-22}$ | $1.2228827 \times 10^{-8}$                   |
| 502 nm     | <b><math>2.6239591 \times 10^{13}</math></b> | $8.4059486 \times 10^{-22}$ | $2.2056865 \times 10^{-8}$                   |
| 636 nm     | $2.3185429 \times 10^{13}$                   | $1.3492534 \times 10^{-21}$ | $3.128302 \times 10^{-8}$                    |
| 883 nm     | $1.4019471 \times 10^{13}$                   | $2.6007626 \times 10^{-21}$ | <b><math>3.6461316 \times 10^{-8}</math></b> |
| 1200 nm    | $6.8551652 \times 10^{12}$                   | $4.803323 \times 10^{-21}$  | $3.2927573 \times 10^{-8}$                   |

### Observation 7.2

The left column is greatest at 502 and the right at 883. The whole difference is the middle column, which rises across this range from  $5.34 \times 10^{-22}$  to  $4.80 \times 10^{-21}$ , ninefold. No number was wrong — two different densities were set side by side as though they were one curve.

## 8. The Separator and the Fence

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### Observation 8.1 (the separator)

What separates the senses of “peak” is what one counts per — per wavelength, per logarithm, or per frequency. And any monotone change of variable gives yet another answer: the three are representatives only.

### Observation 8.2 (the fence)

The fence around “the blackbody peaks here” is having settled which density is meant. Outside it the sentence is not even false but empty — the same shape as “independence was checked” in Paper 220.

### Observation 8.3

And there are invariant quantities: the total power and the share falling in a fixed band. Both are integrals and not values of a density — “where it is strongest” is a property of the variable, and “how much is in there” is a property of the spectrum.

### Observation 8.4

In Paper 214 “brightness” was four separate quantities — here the quantity is one and the peaks are still three. The distinct root lay upstream of the name of the quantity, in the little words “per unit”.

## 9. The Census and the Close

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What this paper measured:

1. Three roots (Check 2.1): **4.9651, 3.9207, 2.8214.**
2. The Sun peaks in three places (Check 3.1): **502, 636, 883 nm.**
3. The ratios do not depend on temperature (Check 3.1): **1.759780586 and 1.266387736.**
4. Maximising the curves gives the same (Check 4.1): **ten digits.**
5. The constants match the tables (Check 5.1): **a ratio of 1.0000000000074.**

6. The share in a band is invariant (Check 6.1): **0.36638317138174**, difference 0.

7. The Jacobian factor rises ninefold (Check 7.1).

**Close:** There are books that say the Sun radiates most strongly in the green and books that say it does so in the near infrared. Both are right — the first counts per unit wavelength and the second per unit frequency. The spectrum is the same, the temperature is the same, the physics is the same. What moves is not the Sun but the unit of counting. And quantities that do not move exist: the total, and the share falling in a band fixed in advance. The first sort are values of a density, the second integrals — a change of variable breaks the values and leaves the integrals alone. The question “where is it strongest” must be told what to count per before it can be answered.

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