

With the Same Magnetic Field, the Alfven Speed Differs by a Factor of 7.74×10^7 Between the Corona and the Earth's Core

— What Acts Is Not the Field but the Density — The Ratio Matches the Square Root of the Density Ratio Exactly, and the Field Cancels Out Completely — [Paper 280]

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August 2026

— *From thinking to syncing.* —

Abstract

The speed of a wave travelling along a magnetic field line is set by the Alfven speed $v_A = B/\sqrt{\mu_0\rho}$. Because the name carries the word “magneto,” one is tempted to read the field as the deciding factor. This paper asks which of the two actually acts—the answer is the density. No new mathematical theorem and no new law is claimed. First, we compute at five locations. In the solar corona **690.30** km/s; in the Earth's outer core **8.92** mm/s (Section 2). Second, this is the core of the paper. These two have the same field of 1 mT—and still differ by a factor of **7.7382×10^7** (Section 3). Third, the ratio matches the square root of the density ratio exactly. The square root of the density ratio 5.9880×10^{15} is **7.7382×10^7** —the field has cancelled out completely (Section 3). Fourth, moving the field is not enough. Applying 1 T in the laboratory gives 6903.0 km/s, only 10 times the coronal value (Section 4). Fifth, we make the 8.92 mm/s of the Earth's core concrete. It covers **281.51** km in a year, and crossing the 2260 km outer core takes **8.0** years (Section 5). Sixth, we take no credit for the 4π in μ_0 . As in Paper 267, it comes from the choice of units (Section 6).

Scope of this paper (scope note): No new mathematical theorem and no new law is claimed—the expression for the Alfven speed, the representative fields and densities of each region, and the comparison with the sound speed are all standard. We do not build magnetohydrodynamics—all we use is one square root and two ratios. We do not derive the Alfven speed—we merely quote $v_A = B/\sqrt{\mu_0\rho}$, and do not enter the argument that obtains it from magnetic tension. We do not treat magnetic reconnection—neither solar flares nor dynamos are treated at all. We do not discuss the origin of the Earth’s field—neither outer-core convection nor dynamo theory is treated. Density and field are merely placed as representative values. We claim no accuracy for the representative values—both fields and densities are values chosen to show orders of magnitude, and they move greatly with place and epoch. The coronal density and the Earth’s outer-core field in particular have a spread of one order. The sound speed carries premises—the c_s of Section 4 assumes fully ionised hydrogen, $\gamma = 5/3$, and the pressure of both electrons and protons. Changing the assumptions moves it by tens of percent. We do not call the 4π in μ_0 a discovery—Paper 267 wrote that it comes from the choice of units. This paper treats it the same way, and its standing differs from the 4π of Paper 02. Relation to earlier papers: Paper 267 showed that the displacement current is not a current, and wrote that the 4π in μ_0 comes from units—this paper uses the same μ_0 and treats it the same way. Paper 256 treated the fact that a model cannot be built when there are two dimensionless numbers—this paper separates which of the variables inside one expression is acting. Paper 190 measured “rare” on a logarithmic scale—this paper likewise writes the ratio 7.74×10^7 in orders of magnitude. Paper 240 counted seven things called “mass”—this paper separates two variables inside one expression. What is added is computing and lining up the Alfven speed at five regions, seeing that the same field yields a factor of 7.7382×10^7 , confirming that this ratio matches the square root of the density ratio exactly, and recasting the 8.92 mm/s of the Earth’s outer core as “8.0 years to cross the outer core.”

1. Notation and Standing

Setting: In a conducting fluid (a plasma, or molten iron), a wave travels along the field lines. **Its speed is**

$$v_A = \frac{B}{\sqrt{\mu_0\rho}}$$

where B is the field, ρ the mass density, and $\mu_0 = 4\pi \times 10^{-7}$.

Question: Which of B and ρ sets this speed?

The answer is the density. Both appear in the expression, but in actual settings the range of the density is overwhelmingly wider.

Caution: The 4π inside μ_0 comes from the choice of units—as in Paper 267, we take no credit for it.

2. Computing at Five Locations

Check 2.1: We insert representative fields and densities.

Location	B [T]	ρ [kg/m ³]	v_A
Laboratory plasma	1.0	1.67×10^{-8}	6903.0 km/s
Solar corona	1.0×10^{-3}	1.67×10^{-12}	690.30 km/s
Solar wind (1 AU)	5.0×10^{-9}	8.4×10^{-21}	48.67 km/s
Interstellar medium	5.0×10^{-10}	1.67×10^{-21}	10.91 km/s
Earth’s outer core	1.0×10^{-3}	1.0×10^4	8.92 mm/s

Observation 2.2

Top and bottom are separated by a factor of 7.74×10^{11} . The same single expression returns speeds spanning 11 orders of magnitude.

Observation 2.3

A point to write honestly——every value is representative. Both the coronal density and the Earth’s outer-core field have a spread of one order——what this paper asserts is the structure of the orders, not the individual numbers.

3. The Core: With the Same Field, a Factor of 7.74×10^7

Setting: In the table above, the solar corona and the Earth’s outer core have the same field of 1 mT. We take out only those two.

Check 3.1:

Location	B	ρ	v_A
Solar corona	$1.0 \times 10^{-3} \text{ T}$	1.67×10^{-12}	$6.902983 \times 10^5 \text{ m/s}$
Earth's outer core	$1.0 \times 10^{-3} \text{ T}$	1.0×10^4	$8.920621 \times 10^{-3} \text{ m/s}$
Ratio	1.0000	5.9880×10^{15}	7.7382×10^7

Observation 3.2

The ratio of the fields is exactly 1. The speeds still differ by a factor of 7.74×10^7 —the field is not acting at all.

Check 3.3: We confirm that the ratio comes from the density.

Quantity	Value
Density ratio $\rho_{\text{core}}/\rho_{\text{corona}}$	5.9880×10^{15}
Its square root	7.7382×10^7
Speed ratio (measured)	7.7382×10^7
Difference	0

Observation 3.4

They agree exactly. This is expected, since $v_A \propto \rho^{-1/2}$ when B is the same; but that it is expected is the point of this paper—the field has cancelled out completely.

Observation 3.5

Separator—what must be moved for the speed to change? The density. Even though the name carries “magneto,” what makes the spread in real settings is the density.

4. Moving the Field Is Not Enough

Check 4.1: We move only the field, and see whether the density gap can be filled.

Location	B	v_A	Relative to corona (690.30 km/s)
Laboratory plasma	1.0 T (1000× corona)	6903.0 km/s	10.0×
Solar corona	1.0×10^{-3} T	690.30 km/s	1×

Observation 4.2

Raising the field by 1000 raises the speed only by 10. The density also differs by 10^4 , so the two effects cancel — $1000/\sqrt{10^4} = 10$.

Observation 4.3

To bring the Earth’s core 8.92 mm/s up to coronal values, the field must be raised by 7.74×10^7 , that is to **7.7×10^4 T**. That is **1700** times the strongest steady field producible in a laboratory (around 45 T) — the field cannot fill the gap.

Check 4.4: We compare with the coronal sound speed. We assume fully ionised hydrogen, $\gamma = 5/3$, $T = 10^6$ K, counting the pressure of both electrons and protons.

Quantity	Value
Sound speed $c_s = \sqrt{2\gamma kT/m_p}$	165.88 km/s
Alfven speed v_A	690.30 km/s
Ratio v_A/c_s	4.1615

Observation 4.5

In the corona $v_A/c_s = 4.16$, so the magnetic side is faster. This is why the field governs the dynamics — but this ratio too is set by the density.

Observation 4.6

A point to write honestly—the sound speed depends on the assumptions.Setting γ to 1 (isothermal) gives 128.5 km/s and a ratio of 5.37—we do not assert the number 4.16 itself.

5. Making the 8.92 mm/s of the Earth’s Core Concrete

Check 5.1: We recast 8.920621×10^{-3} m/s into other units.

Way of writing	Value
v_A	8.9206 mm/s
Distance covered in a year	281.51 km
Time to cross the outer core (2260 km thick)	8.0 years

Observation 5.2

Inside the Earth, a magnetic disturbance takes 8 years to cross the outer core.That is far slower than a person walking—and this is with a field of 1 mT, the same strength as in the corona.

Observation 5.3

In the corona, meanwhile, the same 1 mT gives 690.30 km/s.Crossing the solar radius 7×10^5 km takes about 17 minutes—with the same field: 8 years, and 17 minutes.

Observation 5.4

This is the content of the number 7.74×10^7 .Written in orders of magnitude it is hard to feel; recast as a time it becomes clear—the reverse of Paper 190, which measured “rare” logarithmically: here the logarithm is undone to restore the feel.

6. Taking No Credit for the 4π in μ_0

Observation 6.1

$\mu_0 = 4\pi \times 10^{-7} = 1.2566371 \times 10^{-6}$. A 4π sits in the denominator of the Alfven speed.

Observation 6.2

Paper 267 wrote that the 4π in μ_0 comes from the choice of units. In Gaussian units $v_A = B/\sqrt{4\pi\rho}$, so μ_0 disappears and the 4π is exposed—in either way of writing a 4π remains, but it is a 4π on the side of convention.

Observation 6.3

The conditions written by Paper 258 (point source, three dimensions, isotropy) are not met here. There is no source, and no inverse square—its standing differs from the 4π of Paper 02.

Observation 6.4

This paper therefore asserts nothing about this 4π . Following Paper 267, it records only the point that the same symbol has a case where it arises from geometry and a case where it arises from units.

7. Roll Call and Closing

1. Five locations (Check 2.1): From **6903 km/s to 8.92 mm/s, 11 orders.**
2. The same **1 mT**, a factor of **7.74×10^7** (Check 3.1): **The field ratio is exactly 1.**
3. The ratio is the square root of the density ratio (Check 3.3): **Difference 0.**
4. The field cancels out (Observation 3.4): **Against its name, it is not acting.**
5. **$1000\times$ gives $10\times$** (Check 4.1): **The density cancels it.**
6. Filling the gap needs **7.7×10^4 T** (Observation 4.3): **1700 times the strongest laboratory field.**
7. In the corona **$v_A/c_s = 4.16$** (Check 4.4): **But it depends on assumptions.**
8. **8.0 years to cross the outer core** (Check 5.1): **281.51 km a year.**

9. In the corona, 17 minutes (Observation 5.3): **With the same field.**

Closing: The Alfven speed is called “the speed of magnetohydrodynamic waves,” but what acts is not the field. The solar corona and the Earth’s outer core have the same field of 1 mT—and still their speeds differ by a factor of 7.7382×10^7 , a ratio that matches the square root of the density ratio exactly. The field has cancelled out completely. Moving the field is not enough—raising it by 1000 in the laboratory raises the speed only by 10, and bringing the Earth’s core up to coronal values would require 7.7×10^4 T, 1700 times the strongest laboratory field. Recast as a time, it becomes clear—with the same 1 mT field, crossing the Earth’s outer core takes 8.0 years, and crossing the Sun takes 17 minutes. One thing separates them—writing out which variable inside the expression makes the spread in the actual setting. Write it out, and what the name points at separates from what acts. Fail to write it out, and one reads the difference between 8 years and 17 minutes as the doing of the field.

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