Earth’s Magnetic Shield Shrinks Only by Half When the Solar Wind Pushes 64 Times Harder

— raising the dynamic pressure **10**, **64** and **100** times moves it only to **0.681292**, **0.500000** and **0.464159** times

— the separator is the power of distance at which the pushing-back pressure falls — [Paper 780]

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— *From thinking to syncing.* —

Abstract

When the solar wind strengthens, Earth’s magnetosphere is pushed in. How far it is pushed seems to depend only on how hard the wind pushes.From the balance of the solar wind’s dynamic pressure and Earth’s magnetic pressure, the position of the boundary and its sensitivity to the push are counted.No new theorem or law is claimed. First, the boundary settles at around ten Earth radii——8.133240 Earth radii for a pure dipole, 10.247240 if the field doubles at the boundary (Section 2). **Second, changing the push a great deal moves the boundary only a little——0.681292 times at 10 times the dynamic pressure, still 0.464159 times at 100 times** (Section 3). **Third, and this is the core. At 64 times, exactly half——the ratio of positions solved by bisection is 0.500000000000, and the logarithmic slope is −0.166667** (Section 3). **Fourth, if the way the pushing-back side falls off changes, so does the sensitivity——against an opponent falling as distance to the −2, like the heliopause, the slope is −0.500000 and 64 times gives 0.125000 times** (Section 3). **Fifth, pushing the boundary to geostationary orbit takes 13.779259 times the dynamic pressure——geostationary radius is 6.618140 Earth radii, and a wind of density 20 per cm^3 at 800 km/s (16 times) puts the boundary at 6.455357 Earth radii** (Section 3). **Sixth, the separator is the power of distance at which the pushing-back pressure falls——“a stronger solar wind pushes the shield far in” has no truth value until one says how the pushing-back side falls off** (Section 4). **Keywords**: magnetosphere, solar wind, dynamic pressure, magnetic pressure, dipole field, pressure balance.

Scope of this paper (scope note): **No new theorem or law is claimed——estimating the magnetospheric boundary by balancing the solar wind's dynamic pressure and Earth's magnetic pressure (Chapman and Ferraro), and its position scaling as the dynamic pressure to the $-1/6$, are both known (Chapman and Ferraro 1931, Kivelson and Russell 1995).The model is the simplest——taking the field to double at the boundary ($f = 2$) is the value for a field pushed back at a flat boundary; the real shape of the magnetosphere is not treated.The contents of the solar wind are not included ——the wind's magnetic field, plasma thermal pressure and magnetic reconnection are left out.Values are representative——solar wind density 5 per cm^3 and speed 400 km/s, equatorial surface field 3.12×10^{-5} T.No claim about satellite operations——when and how much geostationary satellites are exposed to the solar wind is not treated.Relation to earlier papers**: **Paper 337 showed that the solar system has five "edges", one of them the heliopause, where the solar wind loses to the interstellar medium——its scope note stated that the physics of the solar wind was not treated. There the pressure boundary was listed as one edge. Here, for the same kind of pressure boundary, the sensitivity to the push is counted as splitting into $1/6$ and $1/2$ by the power of distance at which the pushing-back side falls.Paper 410 showed with dipole geometry that the magnetic field does no work and still confines particles——its scope note stated that the solar wind was not its subject. There the dipole confined particles inside; here the same dipole pushes back pressure from outside.**What is added is **deriving the boundary position two ways, by closed formula and by bisection**, **moving the dynamic pressure from 10 to 100 times and confirming by bisection that 64 times gives exactly half**, **setting it beside an opponent falling as the -2 power to show the difference in sensitivity**, **deriving the $\mathbf{13.779259}$-fold dynamic pressure that reaches geostationary orbit**, and **placing the separator on how the pushing-back side falls off**.

1. Notation and the Question

Setting: **let B_0 be the equatorial surface field and R_E Earth's radius. A dipole field falls as distance to the -3 and its magnetic pressure as the -6. Taking the field to be f times larger at the boundary, the magnetic pressure is balanced against the solar wind's dynamic pressure ρv^2.**

$$\frac{(fB_0)^2}{2\mu_0}\left(\frac{R_E}{r}\right)^6 = \rho v^2 \qquad \Longrightarrow \qquad \frac{r}{R_E} = \left(\frac{f^2 B_0^2}{2\mu_0\,\rho v^2}\right)^{1/6}$$

If the pushing-back pressure falls in general as distance to the $-n$, the position moves as the pushing pressure to the $-1/n$.

Question: **when the solar wind pushes harder, how much does Earth's magnetic shield shrink?**

2. The Position of the Boundary

Computation 2.1: **a solar wind of density 5 per cm^3 and speed 400 km/s (dynamic pressure 1.338098 nPa) was balanced against a dipole with $B_0 = 3.12 \times 10^{-5}$ T, both by the closed formula and by solving the balance with bisection.**

setting	closed formula	bisection
pure dipole ($f = 1$)	**8.133240** Earth radii	**8.133240** Earth radii
field doubled at boundary ($f = 2$)	**10.247240** Earth radii	**10.247240** Earth radii

> **Observation 2.2**
>
> **the boundary settles at around ten Earth radii.The two derivations agree to a relative difference of 2.220×10^{-16}——below, 10.247240 Earth radii with $f = 2$ is the reference.**

3. Sensitivity to the Push

Computation 3.1: **the dynamic pressure and field were varied and position ratios derived. The logarithmic slopes for pushing-back pressure falling as the -6 and as the -2 power were also measured from positions solved by bisection.**

change	position ratio	position ($f = 2$)
dynamic pressure $\times 10$	**0.681292**	**6.981364** Earth radii
dynamic pressure $\times 16$	**0.629961**	**6.455357** Earth radii
dynamic pressure $\times 64$	**0.500000**	**5.123620** Earth radii
dynamic pressure $\times 100$	**0.464159**	**4.756348** Earth radii
Earth’s field halved	**0.793701**	**8.133240** Earth radii

fall-off of pushing-back pressure	logarithmic slope	position ratio at $\times 64$
distance to the -6 (dipole)	-0.166667	0.500000
distance to the -2 (spreading wind)	-0.500000	0.125000

Observation 3.2

changing the push a great deal moves the boundary only a little.Ten times the dynamic pressure gives 0.681292 times, and even a hundred times gives 0.464159 times——two orders of magnitude in push shrink the shield to only a little under half.

Observation 3.3

this is the core: at 64 times, exactly half.The ratio of positions solved by bisection is 0.500000000000 and the logarithmic slope -0.166667——halving the position multiplies the magnetic pressure by $2^6 = 64$, so the push must also be 64 times.

Observation 3.4

if the way the pushing-back side falls off changes, so does the sensitivity.If, as at the heliopause, the pushing-back side is a spreading wind falling as distance to the -2, the slope is -0.500000 and the same 64 times shrinks it to 0.125000 times——the shield is insensitive to the push because the dipole's magnetic pressure falls steeply with distance.

Observation 3.5

the position with Earth's field halved, 8.133240 Earth radii, is the same value as with $f = 1$.This is because f and B_0 enter the formula only as the product fB_0: it is the same formula's value for two settings. Sensitivity to the field is the $1/3$ power, giving 0.793701 times for half.

Computation 3.6: **the geostationary radius was derived from Earth's gravitational parameter and one sidereal day, along with the dynamic-pressure factor that pushes the $f = 2$ boundary there.**

quantity	value
geostationary radius	6.618140 Earth radii
dynamic pressure to reach it	13.779259 times
wind of density 20 per cm^3 at 800 km/s	16.000000 times, 6.455357 Earth radii

Observation 3.7

pushing the boundary to geostationary orbit takes 13.779259 times the dynamic pressure.A wind with 4 times the density and 2 times the speed has 16 times the dynamic pressure, and the boundary is computed at 6.455357 Earth radii, inside geostationary orbit——even an insensitive shield is reached when density and speed rise together.

4. The Separator

Observation 4.1

the separator is the power of distance at which the pushing-back pressure falls.At the -6 power the sensitivity is $-1/6$ and 64 times gives half; at the -2 power it is $-1/2$ and 64 times gives 0.125000 times ——“a stronger solar wind pushes the shield far in” has no truth value until one says how the pushing-back side falls off.

Observation 4.2

beside Paper 337 and Paper 410.Paper 337 listed the heliopause as one edge, where the solar wind loses to the interstellar medium, and Paper 410 showed a dipole confining particles inside——here the same kind of pressure boundary is split by how the pushing-back side falls off, and the same dipole’s insensitivity to outside pressure is counted.

Observation 4.3

what is not said.The shape of the boundary, the wind's field and plasma pressure, and when satellites are exposed are not treated——what is shown is that the shield's position moves only as the $-1/6$ power of the push, and that the exponent is set by how the pushing-back side falls off.

5. Roll Call and Closing

1. **dynamic pressure 1.338098 nPa** (Computation 2.1): **the solar wind's push.**
2. **10.247240 Earth radii with $f = 2$** (Computation 2.1): **the boundary.**
3. **8.133240 Earth radii with $f = 1$** (Computation 2.1): **pure dipole.**
4. **0.681292 times at 10 times** (Observation 3.2): **moving only a little.**
5. **0.500000000000 at 64 times** (Observation 3.3): **the core.**
6. **slope -0.166667** (Computation 3.1): **a -6 power opponent.**
7. **slope -0.500000, 0.125000 times** (Observation 3.4): **a -2 power opponent.**
8. **0.793701 times with half the field** (Observation 3.5): **the $1/3$ power.**
9. **13.779259 times to geostationary orbit** (Observation 3.7): **the push needed to reach it.**
10. **how the pushing-back side falls off** (Observation 4.1): **the separator; Paper 337 and Paper 410.**

Closing: **Earth's magnetic shield shrinks only by half when the solar wind pushes 64 times harder.Balancing the dynamic pressure 1.338098 nPa of a solar wind of density 5 per cm^3 and speed 400 km/s against Earth's magnetic pressure puts the boundary at 8.133240 Earth radii for a pure dipole, or 10.247240 if the field doubles at the boundary——ten times the dynamic pressure gives only 0.681292 times, a hundred times 0.464159 times, and 64 times exactly half.Because the pushing-back magnetic pressure falls as distance to the -6, the sensitivity is $-1/6$, while an opponent falling as the -2 power, like the heliopause, shrinks to 0.125000 times for the same 64; reaching geostationary orbit takes 13.779259 times the dynamic pressure——the shield is insensitive because the pushing-back side falls steeply with distance.The separator is the power of distance at which the pushing-back pressure falls.Placed among the earlier papers——Paper 337 listed the pressure boundary as one edge and Paper 410 counted dipole confinement; this counts how insensitive the same dipole is to outside pressure.To be honest——neither the boundary's shape, nor the contents of the solar wind, nor satellite operations are treated.**

References

1. Chapman, S., & Ferraro, V. C. A. (1931). A new theory of magnetic storms. *Terrestrial Magnetism and Atmospheric Electricity*.
2. Kivelson, M. G., & Russell, C. T. (Eds.). (1995). *Introduction to Space Physics*. Cambridge University Press.
3. Yamagishi, Y. (2026). *The Edge of the Solar System Is Five Edges, and the Innermost and Outermost Differ by a Factor of* **5106** [Paper 337]. Zenodo. 10.5281/zenodo.22681940
4. Yamagishi, Y. (2026). *The Magnetic Field Does No Work, and Still It Confines* [Paper 410]. Zenodo. 10.5281/zenodo.22699628

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