

What Freezes 137 Is Not a Number but a Single Mass

— The screening stops because no charge is lighter than the electron, and the fall is quadratic rather than logarithmic — the separator is whether the screening is made by one particle or by a pair — [Paper 1057]

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— *From thinking to syncing.* —

Abstract

Paper 1056 measured that the fine-structure constant runs with energy and set aside why it stops at low energy. This paper measures the shape of that stopping. No new theorem and no new law is claimed.

First, and this is the core. The fall is quadratic, not logarithmic—computing the one-loop vacuum polarisation below the electron mass, as the momentum falls from one tenth to one thousandth of that mass the screening falls from **1.546890** times ten to the minus six to **1.548546** times ten to the minus ten, a log-log slope of **1.999767585**. A logarithm keeps moving; a square stops (Section 2).

Second, what sets the floor is not a number but the mass of the lightest charged particle—at the same momentum, making the mass a thousand times smaller raises the screening from **1.548530** times ten to the minus eight to **2.319313** times ten to the minus three, a factor of **149775.1686**, and nothing freezes (Section 3).

Third, almost all of that floor is made by the electron alone—at a momentum equal to the electron mass the electron accounts for **0.999974105** of the total, the muon for **0.000025804** and the tau for **0.000000091** (Section 4).

Fourth, the two kinds of screening differ by a factor of two in the exponent—the far-field exponent of the vacuum polarisation approaches **2.029698057** while the Yukawa control approaches **1.020273**, a ratio of **1.989367110**. Debye screening rearranges charges one at a time, while the vacuum can only make them in pairs (Section 5).

Fifth, in 2019 one factor of 4π ceased to be exact—the permeability **1.256637061435917** times ten to the minus six, exact by definition, became a measured quantity; the present recommended value (CODATA 2022) is **1.256637061270000** times ten to the minus six, a relative difference of **1.320** times ten to the minus ten, which is **0.825** times the uncertainty, so the two cannot yet be told apart. With the previous recommended value (CODATA 2018) the difference was **5.444** times ten to the minus ten, **3.629** times the uncertainty, and of the opposite sign—a value that has become a measurement moves each time the recommended values are revised (Section 6).

Sixth, fixing three constants exactly still does not reach the constant—the speed of light, the reduced Planck constant and the elementary charge are independent and remove three slots, yet the dimension vector of the constant is zero and does not move. And why it freezes and why it is 137 are different questions; only the former is answered here (Sections 7 and 8).

Keywords: vacuum polarisation, decoupling, screening, fine-structure constant, Compton wavelength, revision of the units.

Scope of this paper (scope note): No new theorem and no new law is claimed—the form of the one-loop vacuum polarisation, that heavy fields decouple at low energy, Uehling’s correction to the Coulomb law, Debye and Hückel screening, and the 2019 revision of the units are all standard. Why it is 137 is not answered—what is answered here is only why it freezes. The two are different questions, and answering the first leaves the second standing. For 4π and the knot of charge, no measurable content was found—Section 8 says so. Only three things could be measured, and none of them corresponds to a knot. Nothing beyond one loop—higher corrections and effects on bound states are not treated. The approximation is stated. Debye screening and vacuum polarisation are not called a shared root—what they share is only that screening needs a length; the exponents come from different places. This is not a shared root in the sense of Paper 300. The revision of the units is not called an error—the permeability ceased to be 4π times ten to the minus seven because the definition changed, not because the old value was wrong. Neither hadrons nor bound states are included—only the three leptons are treated. Relation to earlier papers: the scope note of Paper 1056 said that no renormalisation group would be built, that the general theory of running would not be entered and that one number for one coupling would be produced—this paper takes that seat (no earlier occupant). From where 1056 stopped, it goes on to the mechanism by which the running stops. Paper 1055 showed that numbers divide by whether they move when the units change—here it is shown that a number on the immobile side also has a floor, and that a mass makes it. Paper 1049 counted that each independent constant fixed removes one unit slot—this paper confirms that the subtraction never touches a dimensionless quantity. Paper 17 showed that 8π is an artefact of the units and Paper 44 that the power of 4π is the mass dimension—here it is counted that one of those factors acquired a date. Paper 804 treated how far oil drops establish the quantisation of charge—that the elementary charge became a defined value in 2019 is taken here as given. Paper 22 treated a plasma equation using the Debye length—here that screening and the screening of the vacuum are compared by their far-field exponents. Paper 300 showed that whether two things share a root is decidable—the two kinds of screening are separated by that discipline. Paper 101 treated numerology as a caution and Paper 314 showed that the constant cannot be moved by redefining units—both are the ground this paper stands on. What is added is measuring that the fall which stops the screening is quadratic, showing by moving the mass that the floor is made by a mass and not by a number, counting that almost all of that floor is made by one species, measuring that the far-field exponents of the two screenings differ by a factor of two and placing the separator at one particle versus a pair, and counting the amount by which one factor of 4π ceased to be exact.

1. Setting and question

Setting: Paper 1056 measured that the fine-structure constant runs with energy—137.035999177 at low energy and 128.939785 at the mass of the Z boson. Its scope note, however, said that the general theory of running would not be entered.

Question: why does it stop at low energy? Here the question must be split in two—why it freezes and why it is 137 are different questions. Only the first is answered here; the second is left alone to the end.

2. The fall is quadratic, not logarithmic

The one-loop vacuum polarisation was computed down to momenta below the electron mass. At high momentum it agrees with the standard asymptotic form (a relative difference of 0.000000 at 10^4 times the electron mass).

Momentum divided by the electron mass	Screening
0.10000	1.546890e-06
0.03162	1.548380e-07
0.01000	1.548530e-08
0.00316	1.548545e-09
0.00100	1.548546e-10

The log-log slope is **1.999767585**——it falls as a square.

This is what freezing means. Were the fall logarithmic, the screening would keep changing a little however far the momentum were lowered. Falling as a square, it vanishes as the square of the lowering, so beyond a point it no longer moves.

3. What sets the floor is a mass, not a number

Holding the momentum fixed at one hundredth of the electron mass, only the mass was varied.

Mass	Screening
Electron mass	1.548530e-08
One tenth of it	1.546890e-06
One hundredth	1.403669e-04
One thousandth	2.319313e-03

It rises monotonically, by a factor of **149775.1686** at one thousandth. A lighter particle does not freeze.

Hence what makes the floor is not a number but the mass of the lightest charged particle.It stops because nothing charged is lighter than the electron, not because the value 137 has a reason of its own.

4. Almost all of that floor is made by the electron alone

At a momentum equal to the electron mass, the three leptons were separated.

Particle	Screening	Share
Electron	1.403669e-04	0.999974105
Muon	3.622057e-09	0.000025804
Tau	1.280731e-11	0.000000091

The ratio of muon to electron is 2.580421×10^{-5} , the same order as the square of the mass ratio, 2.339010×10^{-5} .Heavier particles fall out as a square.

Hence the value 137.036 is a floor set by one species.

5. How the screening cuts off: Debye one at a time, the vacuum in pairs

What the vacuum polarisation adds to the Coulomb law was measured in the far field, in units of the reduced Compton wavelength of the electron, $3.861592680 \times 10^{-13}$ m.

Range measured	Apparent exponent	Departure from 2	Prediction from the prefactor
5 to 11	2.173381660	0.173381660	0.197114340
10 to 20	2.096480304	0.096480304	0.103972077
20 to 40	2.049941057	0.049941057	0.051986039
40 to 60	2.029698057	0.029698057	0.030409883

The farther out, the closer to 2, and the disagreement with the prediction shrinks as 0.1204, 0.0721, 0.0393, **0.0234**.The departure is accounted for by the prefactor, a power of $-3/2$ in the distance.

As a control, the same measurement was applied to a Yukawa form, that is Debye screening.

Range measured	Exponent of the Yukawa form
5 to 11	1.131410
10 to 20	1.069315
20 to 40	1.034657
40 to 60	1.020273

This one approaches 1.The ratio of the two exponents is **1.989367110**, that is 2.

Hence Debye screening rearranges charges one at a time and gives one unit, while the vacuum can only make them in pairs and gives two.The separator is whether the screening is made by one particle or by a pair.The two are not called a shared root——what they share is only that screening needs a length, and the exponents come from different places.

6. In 2019 one factor of 4π ceased to be exact

Before 2019 the permeability of the vacuum was exactly 4π times ten to the minus seven, by definition.Paper 1055 set this number once in its table of three grades of coincidence——here it is given a section of its own, saying what changed.

	Value
Before 2019, exact by definition	1.256637061435917e-06
CODATA 2018 recommended value, relative uncertainty 1.5e-10 (first edition)	1.256637062120000e-06
CODATA 2022 recommended value, relative uncertainty 1.6e-10 (present)	1.256637061270000e-06

Against the present recommended value the relative difference is 1.320×10^{-10} , which is **0.825** times the uncertainty of the measurement——with present measurements the permeability cannot be told apart from $4\pi \times 10^{-7}$.The first edition computed with the previous recommended value and wrote a relative difference of 5.444×10^{-10} , **3.629** times the uncertainty.The recommended value itself moved between 2018 and 2022 by a relative 6.764×10^{-10} (**4.509** times the 2018 uncertainty), and the sign of the difference from $4\pi \times 10^{-7}$ reversed

(from +5.444 to −1.320, in units of 10^{-10}).The old value was not wrong—the definition changed.A value fixed by definition does not move; a value fixed by measurement moves each time it is measured again.

Hence of the factors of 4π that Papers 17 and 44 called artefacts of the units, this one has acquired a date.

7. Fixing three constants exactly still does not reach the constant

The elementary charge, the reduced Planck constant and the speed of light have all been defined values since 2019.Their three dimension vectors are independent and remove three slots (rank 3, four slots to begin with, one left).

But the dimension vector of the constant is zero.So fixing the three does not move it.Hence the subtraction of Paper 1049 never touches a dimensionless quantity.

Something else has changed places instead.With the three exact, the permittivity of the vacuum is fixed by the constant alone: computing it from the defined values gives $8.8541878188401 \times 10^{-12}$ against the published $8.8541878188000 \times 10^{-12}$, a relative difference of 4.524×10^{-12} (the permeability likewise gives $1.2566370612628 \times 10^{-6}$, a relative difference of 5.718×10^{-12}). Moving the constant by a relative 1.6×10^{-10} moves the permittivity by the same relative amount.

Hence measuring the constant and measuring the permittivity of the vacuum are now one and the same measurement.

8. Is the knot of 4π and charge in measurable form?

It is not.Only three things could be measured here.

What could be measured	Where
4π enters the formula and leaves nothing in the value	Section 2 of Paper 1056
Charge is quantised, and since 2019 the elementary charge is defined	Paper 804 and Section 7
The constant is the one number left after the three are fixed	Section 7

No measurable quantity in this paper corresponds to a knot.Hence what cannot be measured is written down as not measured.

9. Census and closing

Closing: what freezes 137 is not a number but a single mass. Computing the one-loop vacuum polarisation below the electron mass, the screening falls from **1.546890** times ten to the minus six to **1.548546** times ten to the minus ten with a log-log slope of **1.999767585**—a logarithm keeps moving, a square stops. What sets the floor is a mass—at the same momentum, a mass one thousand times smaller raises the screening by a factor of **149775.1686** and nothing freezes. Almost all of that floor is made by one species—the electron accounts for **0.999974105**, against **0.000025804** for the muon and **0.000000091** for the tau. The two kinds of screening differ by a factor of two in the exponent—the vacuum polarisation approaches **2.029698057** and the Yukawa form **1.020273**, a ratio of **1.989367110**. The separator is whether the screening is made by one particle or by a pair. In 2019 one factor of 4π ceased to be exact—the permeability went from the defined value **1.256637061435917** times ten to the minus six to a measured quantity; against the present recommended value **1.256637061270000** times ten to the minus six the relative difference is **1.320** times ten to the minus ten, or **0.825** times the uncertainty, not yet distinguishable, but it moves each time the recommended values are revised. Fixing three constants still does not reach it—three slots go, but the dimension vector is zero; instead, measuring the permittivity of the vacuum has become the same measurement (a relative difference of **4.524** times ten to the minus twelve). Plainly—why it is 137 is not answered here either. Answering why it freezes leaves that question standing. And no measurable quantity in this paper corresponds to a knot of 4π and charge. What is added—measuring that the fall which stops the screening is quadratic, showing by moving the mass that the floor is made by a mass and not by a number, counting that almost all of it is made by one species, measuring that the far-field exponents of the two screenings differ by a factor of two and placing the separator at one particle versus a pair, and counting the amount by which one factor of 4π ceased to be exact.

Revision Record

2nd edition (September 2026): The fine-structure constant and the permittivity and permeability of the vacuum were changed from the CODATA 2018 recommended values to the CODATA 2022 recommended values (the inverse of the fine-structure constant from **137.035999084** to **137.035999177**, the relative uncertainty from 1.5×10^{-10} to 1.6×10^{-10}). With this the conclusion of Section 6 was revised—the first edition wrote that the present measured value differs from $4\pi \times 10^{-7}$ by **3.629** times the uncertainty, beyond the error range; with the 2022 values the relative difference is 1.320×10^{-10} , **0.825** times the uncertainty, within the range. The first-edition numbers were not an error but came from the previous recommended values, and they are kept side by side in Section 6. That the permeability changed in 2019 from a defined value to a measured quantity is unchanged. The numbers in Section 7 that reproduce the permittivity and permeability from the defined values were also recomputed with the 2022 values. The numbers and conclusions of the other sections are unchanged.

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