Why Coulomb's Law Looks Like Newton's: Gravitic Motion One Level Down

David de Hilster and Robert de Hilster

Abstract. Coulomb's law and Newton's law of gravitation have the same form: two amounts multiplied, divided by the square of the distance, with a constant in front that carries a factor of 4π. We argue that this is not a coincidence, working from the premise of the four universal motions that there is no such thing as charge. In that framework only particles in motion exist, at infinitely many levels of scale. An atom is a nucleus holding a population of far smaller G1 particles in orbit, and what holds them is gravitic motion one level down: the random motion of still smaller and faster G2 particles, which the nucleus and each G1 partly block. A collisionless sea of randomly moving particles pushes any two partial blockers toward each other with a force $F = (\rho/4\pi)\, S_1 S_2/d^2$, where ρ is the sea's momentum-flux intensity and S_1, S_2 are the blocking areas. Read in the G1 sea this is Newton's law, with $G = \kappa^2 \rho_{G1}/4\pi$. Read in the G2 sea it is Coulomb's law, with what has been called charge being a count of G1 particles, each blocking the same G2 area, so that $1/4\pi\varepsilon_0 = \rho_{G2}(s_e/e)^2/4\pi$. The inverse square, the product of the two amounts, the equality of action and reaction, the 4π, and the exact steps in which charge comes all follow from one mechanism. The paper claims the form of the law and the anatomy of its constant, not their numbers: matching Coulomb's constant fixes $\rho_{G2} s_e^2 = e^2/\varepsilon_0 = 2.90 \times 10^{-27}\ \mathrm{N\,m^2}$, one relation in two unknowns. We state what remains open: the settled count of each atom, the size of the bundle atoms trade, and how a full atom's population leaves no net effect, which the framework assigns to magnetic motion.

Keywords: Coulomb's law; electric charge; push gravity; Le Sage; atomic structure; four universal motions

1 Two laws with one face

Newton's law of gravitation [1] and Coulomb's law of the electric force [2] are usually written

$$F_{\mathrm{N}} = G\,\frac{m_1 m_2}{d^2}, \qquad F_{\mathrm{C}} = \frac{1}{4\pi\varepsilon_0}\,\frac{q_1 q_2}{d^2}. \tag{1}$$

The resemblance is complete. Each is a product of two amounts, one belonging to each body. Each falls off as the inverse square of the distance. Each acts equally and oppositely on the two bodies. Each has a single constant in front. The standard account offers no reason for any of this. Gravity is said to be the curvature of spacetime and the electric force the exchange of photons between charges, two pictures with nothing in common, and the shared form is left as a fact to be noted and not explained. The factor of 4π in Coulomb's constant is described as a bookkeeping artefact of "rationalised" units.

When two laws wear the same face there are two possibilities: coincidence, or one mechanism seen twice. This paper takes the second, and builds it from the four universal motions [3–5], a physical model in which the universe contains nothing but particles in motion. The model's starting point for electricity is the one that makes the argument possible and that most readers will find hardest to accept: **there is no such thing as charge.** Nothing in the model carries a sign. Particles collide or they do not, and every effect we observe is the result.

The argument in one paragraph is this. An atom is not a nucleus with charged electrons around it. It is a nucleus holding a large population of far smaller particles, called G1 particles, in orbit. What holds them is not an attraction between opposite charges. It is the same thing that holds the

Moon around the Earth, gravitic motion, operating one level down: a rain of still smaller, faster G2 particles moving at random, which the nucleus and each G1 partly block. A body in a random rain is pushed toward anything that shadows it. The shadowing law has the form of Newton's law at our level and the form of Coulomb's law at the level below, because it is one law. What physics has called charge is a count of the G1 particles a body holds, and since every G1 blocks the same amount of G2 rain, that count is also a blocking area in the G2 sea.

Section 2 states the premises. Section 3 derives the shadowing law, and Section 4 reads it at level 1 as Newton's law. Section 5 reads it at level 2 as the law that holds an atom together, and Section 6 shows that the count of G1 particles is what Coulomb's law measures. Section 7 sets the two laws side by side term by term. Section 8 gives what the match fixes numerically and what it does not. Section 9 says why the question of attraction and repulsion is not one this law has to answer, Section 10 lists what is not yet derived, and Section 11 places the work.

2 Premises

The following are the four universal motions' claims, taken as given [3]. This paper does not test them; it asks what follows from them for the form of Coulomb's law.

P1 — Particles only. The universe consists of physical particles in motion. Every force is the result of particles striking, or failing to strike, other particles. There is no action at a distance and no property such as charge that acts without contact.

P2 — Four motions. A population of particles can be moving in four ways: at random (gravitic motion), in orbits (magnetic motion), in a directed flow (electric motion), and in formation (luminic motion, light). Each name refers to a kind of motion, not to a kind of substance.

P3 — Levels without end. Every particle is made of smaller particles, and the space between particles of one level is filled with free particles of the level below. The levels are written G1, G2, G3, ... downward. At our level, a random sea of G1 particles fills space and its motion is what we call gravity. One level down, a random sea of G2 particles fills the space between G1 particles. Each level is faster than the one above it: G1 particles travel at exactly the speed of light, $v_1 = c$, and $c = v_1 < v_2 < v_3 < \cdots$, because the particles of each level must be fast enough to bend the paths of the particles above them.

P4 — A collisionless rain. The particles of a random sea do not collide with one another. Each flies straight until it meets a body, which may deflect it. A deflected particle is not stopped; it leaves in a new direction, and the body it struck is pushed along the particle's original line.

P5 — The atom. An atom is a nucleus of nucleons holding a large population of G1 particles in orbit around them. The G1 particles are the same particles that make up light, that flow in a wire as current, and that rain through everything as gravity. What holds the population in place is G2 gravitic motion. What shapes it into the lobed orbitals of chemistry is G2 magnetic motion, the circulating G2 particles about each nucleon [3, ch. 12]. Each kind of atom settles at its own number of G1 particles.

P6 — No charge. No particle at any level carries a charge, and nothing has a plus or minus built into it. The electron is not a particle. It is a bundle: a population of G1 particles that an atom takes on and gives up in units of a characteristic size [3, ch. 13]. What has been called the charge of a body is the number of G1 particles it holds compared with the number it settles at [3, ch. 10].

The question for the rest of the paper is whether these premises, with no charge anywhere in them,

give a law of the form $q_1 q_2/d^2$, and if so, what q is and what the constant in front is made of.

3 The shadowing law

This section is written for a generic level. It speaks of a sea of G particles and of bodies that partly block it, and never of a particular scale. Everything in it holds at level 1 and at level 2 alike.

3.1 The rain

Let a sea contain n particles per unit volume, each of mass m_G, moving at speed v in random directions (P3, P4). The number of particles per unit volume moving within a small solid angle $d\Omega$ about a direction $\hat{n}$ is $n\,d\Omega/4\pi$, and each carries momentum $m_G v$. The momentum they bring per second across a unit area held square to $\hat{n}$ is therefore

$$dI(\hat{n}) = \frac{n\,m_G v^2}{4\pi}\,d\Omega \equiv \frac{\rho}{4\pi}\,d\Omega, \qquad \rho \equiv n\,m_G\,v^2. \tag{2}$$

We call ρ the *intensity* of the sea. It is the momentum delivered per second per square metre, so it is measured in newtons per square metre, the same unit as a pressure. It is the only way the sea enters the force law. The 4π is the solid angle of the whole sky: the rain's momentum is shared out evenly over every direction.

3.2 One body alone

A sphere of radius R presents the area πR^2 to every direction. The momentum it receives per second from directions within $d\Omega$ is $(\rho/4\pi)\pi R^2\,d\Omega$ along $\hat{n}$, and over the whole sky the pushes cancel, because $\int \hat{n}\,d\Omega = 0$. A lone body is struck equally from all sides and goes nowhere. Any force must therefore come from rain that is *missing*.

3.3 Two bodies

Place a second sphere, radius R_2, at distance d from the first, radius R_1, and let both deflect every particle that meets them. Seen from body 2, body 1 covers a cap of sky of angular radius $\theta_{\max}$, with $\sin\theta_{\max} = R_1/d$. Rain that would have reached body 2 from inside that cap has been turned aside by body 1. Body 2 is still struck from the opposite side, so it is pushed toward body 1 by the push it no longer receives. The size of the missing push, taking the component along the line of centres, is

$$F = \frac{\rho}{4\pi}\,\pi R_2^2 \int_{\text{cap}} \cos\theta\,d\Omega = \frac{\rho}{4\pi}\,\pi R_2^2 \cdot 2\pi \int_0^{\theta_{\max}} \sin\theta\cos\theta\,d\theta = \frac{\rho}{4\pi}\,\pi R_2^2 \cdot \frac{\pi R_1^2}{d^2}. \tag{3}$$

The integral equals $\pi \sin^2\theta_{\max} = \pi R_1^2/d^2$ exactly, for every $d > R_1$. No approximation for distant bodies has been made.

The bodies need not be opaque. If a body turns aside only part of the rain crossing it, what matters is its *blocking area* S: the area that, if perfectly opaque, would turn aside the same amount. Replacing πR_i^2 by S_i,

$$\boxed{F = \frac{\rho}{4\pi}\,\frac{S_1 S_2}{d^2}} \tag{4}$$

Body 1 is pushed toward body 2 by the identical argument with the labels exchanged, and the expression is symmetric in $1 \leftrightarrow 2$, so the two pushes are equal and opposite. Nothing pulls. Each body is pushed toward the other by the rain the other does not block.

3.4 Why the inverse square cannot be avoided

Equation (4) has three factors, and each has a physical meaning. The rain brings $\rho/4\pi$ of push per steradian of sky. A blocker of area S_1 at distance d removes S_1/d^2 steradians from the other body's sky; that is what a solid angle is. The second body collects the shortfall over its own area S_2. The distance enters only through the solid angle, and solid angle in three dimensions falls as $1/d^2$ because the surface of a sphere grows as d^2. A random, collisionless rain in three-dimensional space can produce no other distance law.

The collisionless condition (P4) is essential. In a sea whose particles struck one another, the shadow would be filled in from the side within a few collision lengths and the force would be short-ranged. That is what happens to large spheres in a fluid of small ones, where the same shadowing gives a force that dies within one small-sphere diameter [6]. A sea that does not collide with itself keeps its shadows sharp over any distance.

3.5 Blocking areas add

If a body is transparent enough that its parts do not shadow one another, its blocking area is the sum of the blocking areas of its parts. A body made of N identical parts, each with blocking area s, has $S = Ns$. This is the property that matters most below. It holds exactly in the transparent limit, and the first correction when the parts begin to shield one another is known [7].

4 Level 1: Newton's law

At our level the sea is the G1 sea, of intensity $\rho_{G1} = n_1 m_{G1} c^2$, and the bodies are ordinary matter. Ordinary matter is very nearly transparent to G1 particles: almost all of them pass through the Earth undeflected. In that case each bit of matter turns aside rain in proportion to how much matter there is, and the blocking area is proportional to the mass,

$$S = \kappa\, m, \tag{5}$$

with κ, in square metres per kilogram, the opacity of matter to the G1 sea. Substituting in (4),

$$F = \frac{\kappa^2 \rho_{G1}}{4\pi}\,\frac{m_1 m_2}{d^2}, \qquad G = \frac{\kappa^2 \rho_{G1}}{4\pi}. \tag{6}$$

This is Newton's law. Its constant has three factors: one over the solid angle of the sky, the intensity of the G1 sea, and the square of the opacity that turns a body's amount of matter into a blocking area. The identification of G in this form has a literature (Section 11). Measured bounds on gravitational shielding limit κ from above, and through (6) they set a floor on ρ_{G1}; that is not needed here.

The point to carry forward is what the "amount" m in Newton's law is. It is not a primitive property that reaches across space. It is the reason a body casts a shadow in the G1 rain.

5 Level 2: what holds the atom

Now go down one level (P3). The sea is the G2 sea, of intensity $\rho_{G2} = n_2 m_{G2} v_2^2$ with $v_2 > c$. The bodies are the bodies that live in that sea: nucleons and the G1 particles. A G1 particle is a body at this level. It is made of G2 particles, and it sits in a rain of free G2 particles, exactly as a stone is made of atoms and sits in a rain of free G1 particles [3, ch. 4].

Take a nucleus and one G1 particle near it. The nucleus blocks some of the G2 rain, with blocking area S_N. The G1 particle blocks some, with blocking area s_1. By (4), read at level 2, the G1 particle is pushed toward the nucleus with

$$F = \frac{\rho_{G2}}{4\pi} \frac{S_\mathrm{N}\, s_1}{d^2}. \tag{7}$$

A G1 particle with sideways motion, pushed toward the nucleus in this way, goes into orbit around it, for the same reason the Moon goes round the Earth. A nucleus with a large population of G1 particles around it is a solar system one level down [3, ch. 12]. Figure 1 shows the arrangement.

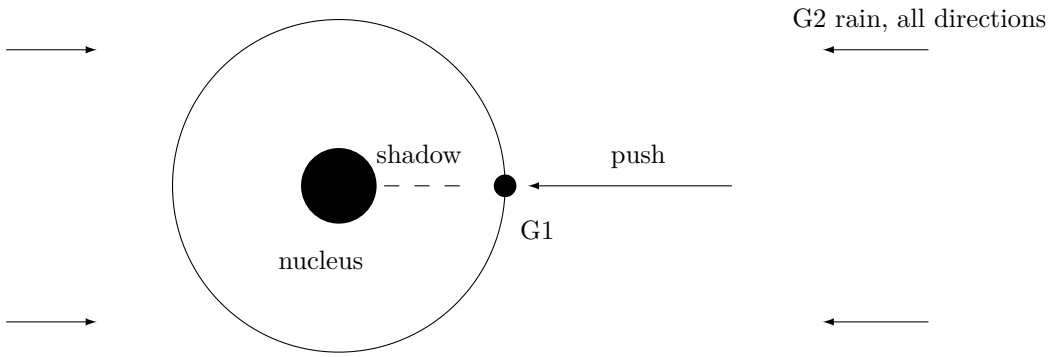


Figure 1: Gravitic motion one level down. The nucleus turns aside part of the G2 rain, leaving a shadow on its side of the G1 particle. The rain arriving from the far side is not matched and pushes the G1 particle toward the nucleus. With sideways motion the G1 particle follows an orbit (the circle), as a planet does around a star. Nothing in the figure carries a charge.

Three features of this picture matter for what follows.

First, the holding is done by a push, not a pull. The nucleus does not reach out to the G1 particle. The nucleus decides *where* the push comes from, by the shadow it casts; the G2 rain does the pushing.

Second, nothing in (7) refers to charge. The quantities in it are a sea intensity and two blocking areas. This is what physics has described as the electrostatic attraction between a nucleus and its electrons.

Third, the standard objection to orbiting electrons does not arise. A charged particle moving in a curve is required by classical electrodynamics to radiate continuously and spiral into the nucleus in about 10^{-11} s, and quantum mechanics answers by forbidding the orbits. Here nothing is charged, and a G1 particle held in orbit by the G2 rain is no more required to spiral in than the Moon is.

6 What Coulomb measured: a count

6.1 Charge as a count

Every atom settles at its own number of G1 particles (P5). An atom, or any body made of atoms, may hold more than that number or fewer. The four motions identify this difference as what has been called charge [3, ch. 10]:

- a body holding more G1 particles than its settled number is what we have called *negative*;
- a body holding fewer is what we have called *positive*;
- a body at its settled number is *neutral*.

This is Benjamin Franklin's original structure of 1747 — one kind of stuff and an amount above or below the usual — with the labels as history later fixed them. There is no negative quantity anywhere. A count starts at zero and goes up.

6.2 The count is a blocking area

Each G1 particle is a body in the G2 sea, and all G1 particles are alike, so each blocks the same G2 area s_1. Since blocking areas add (Section 3), a body holding N G1 particles beyond its settled number presents Ns_1 of extra blocking area in the G2 sea. The count and the area are two readings of one quantity, related by a fixed amount per particle [3, §10.7].

Write the extra blocking area of body i as $s_i = N_i s_1$. The shadowing law at level 2 between two bodies is then

$$F = \frac{\rho_{G2}}{4\pi} \frac{s_1^2 N_1 N_2}{d^2}. \tag{8}$$

This has exactly the form of Coulomb's law, with the count N in place of the charge q. Requiring (8) to agree with Coulomb's law for every pair of bodies fixes the conversion between the two:

$$\frac{\rho_{G2}}{4\pi} \frac{s_1 s_2}{d^2} = \frac{1}{4\pi\varepsilon_0} \frac{q_1 q_2}{d^2} \quad \Longrightarrow \quad \boxed{q = \sqrt{\varepsilon_0\, \rho_{G2}}\; s = \sqrt{\varepsilon_0\, \rho_{G2}}\; s_1\, N} \tag{9}$$

What a coulomb meter reads is a number of G1 particles, multiplied by a fixed conversion factor. As a check on units, $\varepsilon_0 \rho_{G2}$ has units of $(\mathrm{C}^2\,\mathrm{N}^{-1}\mathrm{m}^{-2})(\mathrm{N\,m}^{-2}) = \mathrm{C}^2\,\mathrm{m}^{-4}$, so its square root times an area is a charge.

6.3 Why charge comes in exact steps

Millikan found that the charge on an oil drop is always a whole multiple of one smallest amount, e [8]. In the standard account the exactness of this step is an unexplained fact. Here it splits into two parts.

The first part is forced. Blocking areas of identical blockers add exactly, so a body holding N bundles of a given size blocks exactly N times what one bundle blocks, for the same reason that N identical filters cast N filters' worth of shadow. Nothing further is needed to make the multiples exact.

The second part is open. The step itself is the size of the bundle of G1 particles that atoms take on and give up [3, ch. 13]. If one bundle holds b G1 particles, the electron's G2 blocking area is

$s_e = b\, s_1$, and by (9)

$$e = \sqrt{\varepsilon_0 \rho_{G2}}\, b\, s_1. \tag{10}$$

Why atoms trade a bundle of that size, and what fixes b, is not derived here. Thomson's charge-to-mass ratio [9] is, on this reading, a property of the bundle, which is why it is the same whatever the gas and whatever the cathode: it is the same bundle of the same particles every time.

7 Why the two equations look alike

Set the two levels side by side (Table 1). Both rows are (4). Only the sea and the bodies differ.

Table 1: The shadowing law (4) read at two levels.

	Level 1 — gravity	**Level 2 — the electric force**
Sea	G1 particles at c; $\rho_{G1} = n_1 m_{G1} c^2$	G2 particles at $v_2 > c$; $\rho_{G2} = n_2 m_{G2} v_2^2$
Bodies	stars, planets, stones	nucleons and G1 particles
Amount	mass m	count N of G1 particles, or q
Blocking area	$S = \kappa\, m$	$s = s_1 N = q/\sqrt{\varepsilon_0 \rho_{G2}}$
Law	$F = \dfrac{\kappa^2 \rho_{G1}}{4\pi} \dfrac{m_1 m_2}{d^2}$	$F = \dfrac{1}{4\pi\varepsilon_0} \dfrac{q_1 q_2}{d^2}$
Constant	$G = \dfrac{1}{4\pi}\, \rho_{G1}\, \kappa^2$	$\dfrac{1}{4\pi\varepsilon_0} = \dfrac{1}{4\pi}\, \rho_{G2} \left(\dfrac{s_e}{e}\right)^2$

Term by term:

The inverse square is the same inverse square in both laws. A blocker of area S at distance d removes S/d^2 steradians of rain, and that is the only place distance enters.

The product of two amounts is the same product. One factor belongs to the body that casts the shadow; the other to the body that catches the shortfall. Mass and count enter in the same place for the same reason: each is what makes a body a blocker in its own sea.

Action equals reaction in both, because (4) is symmetric in the two bodies. It is obtained, not assumed.

The 4π is the same 4π. It is the solid angle of the whole sky, over which the rain's momentum was shared in (2). In Coulomb's constant it is not an accident of a choice of units; it is there for the same physical reason it would be in Newton's, had Newton's constant been written to show it.

The constants have the same anatomy. Each is one over the solid angle of the sky, times the intensity of that level's sea, times the square of what converts a body's amount into a blocking area:

$$G = \frac{1}{4\pi}\, \rho_{G1}\, \kappa^2, \qquad \frac{1}{4\pi\varepsilon_0} = \frac{1}{4\pi}\, \rho_{G2} \left(\frac{s_e}{e}\right)^2. \tag{11}$$

Two constants that resembled each other only because of a convenient choice of units would not decompose the same way.

The answer to the question in the title is therefore short. Coulomb's law looks like Newton's because it is the same law: gravitic motion, read in the G2 sea instead of the G1 sea. It is not an analogy between two forces. There is one kind of push, at two scales.

8 What the match fixes, and what it does not

Equation (10) fixes one combination of the level-2 quantities exactly:

$$\rho_{G2}\, s_e^2 = \frac{e^2}{\varepsilon_0} = 2.899 \times 10^{-27}\ \mathrm{N\,m^2}. \tag{12}$$

This is one relation in two unknowns, the intensity of the G2 sea and the blocking area of the bundle we call the electron. A choice of either gives the other. Table 2 shows what three familiar length scales would imply if taken as the radius of the electron's blocking area in the G2 sea.

Table 2: G2 sea intensity implied by (12) for three candidate electron blocking radii r, with $s_e = \pi r^2$.

candidate radius r	s_e ($\mathrm{m^2}$)	implied ρ_{G2} ($\mathrm{N\,m^{-2}}$)
classical electron radius, 2.82×10^{-15} m	2.49×10^{-29}	4.66×10^{30}
reduced Compton wavelength, 3.86×10^{-13} m	4.68×10^{-25}	1.32×10^{22}
Bohr radius, 5.29×10^{-11} m	8.80×10^{-21}	3.75×10^{13}

The candidates span seventeen orders of magnitude in ρ_{G2}, so the question of what charge is has been turned into the question of how large the electron's bundle is in the G2 sea. Those two questions are no longer independent, which is the kind of progress a physical model should make even before it makes a numerical prediction.

The same holds for the famous ratio between the two forces. For a proton and an electron the electric force exceeds the gravitational one by $k_e e^2/Gm_p m_e = 2.27 \times 10^{39}$; for two electrons the ratio is 4.17×10^{42}. Dirac regarded a pure number of this size as demanding an explanation [10], and none has been accepted. Dividing the two constants in (11), the two-electron ratio becomes

$$\frac{k_e e^2}{Gm_e^2} = \frac{\rho_{G2}}{\rho_{G1}} \left(\frac{s_e}{S_e}\right)^2 = 4.17 \times 10^{42}, \tag{13}$$

where $S_e = \kappa m_e$ is the bundle's blocking area in the G1 sea. The number is no longer a brute fact. It says that the G2 sea is far more intense than the G1 sea, or that the bundle blocks far more of the G2 rain than of the G1 rain, or both. These are claims about the sizes, speeds and numbers of particles on two adjacent levels, and in principle they are calculable. They are not calculated here.

9 Attraction and repulsion are not the question

The standard account introduces charge to explain two behaviours, attraction and repulsion, and a reader will ask how a model without charge produces both. The four motions answer that the question is put in the wrong terms.

In this model nothing attracts and nothing repels. There are only pushes, delivered by particles that strike. "Attraction" and "repulsion" are names for outcomes — two bodies ending up closer or further apart — and in the four motions those outcomes come from two different physical processes, not from one quantity carrying a sign [3, §8.5, §10.8]:

- **Shadowing** (gravitic motion). Each body is pushed toward the other by the G2 rain the other does not block. This is the process of Sections 3–6, and it is what holds the G1 population in orbit around the nucleons.

- **Deflection of orbiting populations** (magnetic motion). Where the orbiting G1 populations of two bodies meet, the direction of their traffic in the gap decides what happens. Populations moving the same way side by side shadow each other's G2 rain and are pushed together; populations running at each other are turned off course and carry their bodies apart. This is the circulation rule of the four motions (the Dinu rule) [3, §8.4].

The law this paper concerns is the first of these. Coulomb's law, as a statement about the size of the force and its dependence on distance and on the two amounts, is the shadowing law at level 2, and that is why it has Newton's form. Which way two bodies move under all the motions acting on them is a question about the direction of their orbiting traffic, and it belongs to magnetic motion. A shadow can only remove rain, so a model that tried to get two opposite outcomes from blocking alone would fail; the four motions do not try.

10 What is not yet derived

The argument above gives the form of Coulomb's law and the anatomy of its constant. It does not give the following, and they should be stated plainly.

The settled number. Each kind of atom settles at its own count of G1 particles. Nothing here says what sets that number or how large it is. It should follow from the arrangement of the G2 gravitic and magnetic motion around the nucleons, which has not yet been worked out [3, ch. 12, 15].

The size of the bundle. The step e is the size of the bundle atoms trade, b G1 particles in (10). Why it has that size, and why it is the same to many decimal places, is the same question as Millikan's quantum and is open.

The full population and the deficit. Coulomb's law depends on the difference between what a body holds and its settled number, but a neutral body still holds its whole settled population, every member of which blocks G2 rain. By shadowing alone, neutral bodies would push each other together strongly, and they are not observed to. Likewise, a body short of its settled number has a smaller blocking area, not a negative one. The count accounts for both directions symmetrically; the blocking area by itself does not [3, §10.8]. The four motions assign the cancellation to the organised, orbiting state of the settled population — magnetic motion — and the account of how a settled population leaves no net G2 effect at a distance is the most important open item for this paper.

Transparency at level 2. Exact additivity of blocking areas requires the bodies to be very nearly transparent to the G2 sea, as ordinary matter is to G1. The neutrality of bulk matter has been checked to about one part in 10^{21}, so any shielding among the G1 particles of a body must be smaller than that.

Numbers. Equation (12) relates two unknowns; it does not fix either. A measurement of the size of the electron's bundle in the G2 sea, or of the G2 sea's intensity by any independent route, would fix both.

Simulation. The shadowing law at level 1 has been checked by direct simulation of random impacts. The magnetic process of Section 9 has not, and it is the natural next test: two orbiting populations in a collisionless G2 rain, run in both senses, with the outcome counted.

11 Relation to previous work

The shadowing mechanism is Fatio's and Le Sage's [11, 12], and its classical objections are reviewed by Edwards [13]. The identification $G = \kappa^2\rho/4\pi$ in the transparent limit has been published in equivalent forms by Fedosin [14] and by Nali [15], and the shielding function for partly transparent bodies goes back to Majorana [7].

The idea that the electric force is the same flux mechanism at a smaller scale, within an unbounded hierarchy of levels, was developed by Fedosin [16, 17]. Two differences are worth recording. In Fedosin's treatment charge remains the ordinary count of elementary charges, a property of bodies, and the vacuum field has charged components of both signs, which supplies repulsion directly at the cost of a field that responds to the bodies' charges. In the four motions there is no charge in any form: the amount in Coulomb's law is a count of G1 particles, the count is a blocking area because the particles are identical, and exact quantisation follows from counting identical blockers. Direction is carried by magnetic motion rather than by a signed component of the sea. The atom as a nucleus holding a population of uncharged G1 particles by G2 gravitic motion, with the electron as a bundle rather than a particle, is the four motions' own [3]. Jeff Yee's simulations of electron clouds produced orbital-like structures from particle interactions without charge, and were an early sign that such structures can arise in a model of this kind [3, §12.7].

12 Conclusion

Coulomb's law has the form of Newton's law because it is the same law one level down. A random, collisionless rain of particles pushes any two partial blockers toward each other with a force proportional to the product of their blocking areas and the inverse square of their separation. In the G1 sea the blockers are ordinary matter and the law is Newton's. In the G2 sea the blockers are nucleons and the G1 particles they hold in orbit, and the law is Coulomb's. What has been called charge is a count of G1 particles compared with the number an atom settles at, and since every G1 blocks the same G2 area, that count is a blocking area.

From that one premise, with no charge anywhere, follow the inverse square, the product of the two amounts, the equality of action and reaction, the 4π as the solid angle of the sky, the shared anatomy of the two constants, and the exactness of the steps in which charge comes. The atom needs no charge to hold together and no rule forbidding its orbits from collapsing. What remains is specific: the settled number of each atom, the size of the bundle atoms trade, the way a settled population leaves no net effect at a distance, and the numbers ρ_{G2} and s_e, of which only the product $\rho_{G2}s_e^2 = e^2/\varepsilon_0$ is fixed. Each is a definite question about particles in motion, which is the kind of question a physical model should leave.

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