Charge Below, Gravity Above:
Coulomb for the Small, Newton for the Large

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Written in respectful cooperation between Claes Johnson and Claude (Anthropic), with Claude contributing a balanced, neutral view.

Abstract

RealQM with Coulomb's law describes matter at small scales — the electron and the nucleus as charge clouds, atoms and molecules as their binding — with inertia the energy content E/c^2 and no primitive mass [1]. Gravitation plays no part there: between two protons it is $\sim 10^{-36}$ of the electric force. It becomes the ruling force only in the large, and for a clean reason: charge comes in two signs and screens itself away in neutral bulk, while mass/energy is one-signed and only *accumulates*. So the two forces occupy almost disjoint domains — electromagnetism, direct and screening, *below*; Newtonian gravitation, weak but cumulative, *above* — joined by a single mechanics ($\mathbf{F} = \dot{\mathbf{p}}$) and a single inertia ($E/c^2$), one force reading charge and the other mass. We keep strictly to what Coulomb and Newton can say, and mark — without pursuing — the extreme regimes (strong gravity, the highest energies) where more would be needed.

What is new, and what is standard. The physics is standard: Coulomb's law and Newtonian gravitation, the screening of charge and the accumulation of mass, the equality of gravitational and inertial mass, and the local (field and potential) character of force. No new empirical fact and no new mathematics is claimed. What is the author's is the framework — RealQM, with charge clouds for atoms and (RealNucleus) for nuclei — and the synthesis: a single contrast, direct and small (charge) against cumulative and large (gravity), rooted in the one asymmetry that charge is $\pm$ while mass is $+$. The note keeps to non-extreme physics and is foundational and conceptual.

1 Two forces, two regimes

The whole picture rests on a single contrast between the two forces, each a local response to a field:

	Coulomb (charge)	**gravity (mass)**
character	direct, fundamental	weak, cumulative
scale	small (microscopic)	large (macroscopic)
between two particles	real, $1/r^2$	negligible (matters only in bulk)
charge sign	$\pm$: screens (local)	$+$: accumulates (cumulative)
in RealQM	built in	not needed at this scale

Charge acts *directly* between individual particles and cancels itself over neutral bulk; mass gravitates only *cumulatively* and never cancels — so electromagnetism rules the small and gravitation rules the large. The rest of this note unfolds this one contrast.

It is worth being exact about what "range" means. Each force is *local*: a body responds to the field — an electric field, or a gravitational potential — at its own position ($a = -\nabla\varphi$ there); nothing reaches across space to act on it. What is far-reaching is the *field*, sourced by distant matter. Both fields fall off as $1/r^2$ in principle, yet their *effective* reach is opposite: the electric field is screened to short reach in neutral matter, while the gravitational potential, unscreened, reaches long. So the range belongs to the field, not to the force, and the two occupy almost disjoint territories: electromagnetism governs the small and the charged — atoms, molecules, chemistry, materials, light; gravitation governs the large and the neutral — apples, planets, stars, galaxies. The boundary follows from two facts, one on each side.

First, *gravity is extraordinarily weak*. The gravitational attraction between two protons is about 10^{-36} of their electrostatic repulsion; between two electrons, about 10^{-43}. At the scale of an atom gravity is not merely small, it is irrelevant to any digit anyone measures. Second, *electromagnetism screens, and gravity does not*. Charge comes in two signs and bulk matter is neutral, so over macroscopic bodies the electric forces cancel; mass comes in one sign, so gravity never cancels — it *accumulates*. Aggregate enough neutral matter and electromagnetism has quietly removed itself while gravity has been adding up, until, at planetary scale, the weakest force in nature is the only one left standing.

So "electromagnetic below, gravitational above" is not a modelling convenience but the way the two forces are organised: weakness keeps gravity out of the microscopic world, and screening keeps electromagnetism out of the macroscopic one.

2 One inertia, two forces

Underneath the two regimes there is a single mechanics. RealQM describes the microscopic world with *no mass as a primitive* [1]: the energy of matter is computed from charge and a geometric scale, and inertia is the energy content,

$$\mathbf{p} = \frac{E}{c^2}\,\mathbf{v}, \tag{1}$$

the measured relation of the Penning trap [1]. Newton's second law, in its original form $\mathbf{F} = \dot{\mathbf{p}}$, governs the response. In the small, the force is electromagnetic, $\mathbf{F} = q\mathbf{E} + q\mathbf{v} \times \mathbf{B}$, coupling to *charge*. In the large, the force is gravity, coupling not to charge but to the same energy E/c^2. The economy is worth stating plainly:

	couples to	inertia (response)
electromagnetism	charge q	E/c^2
gravitation	mass/energy E/c^2	E/c^2

One mechanics ($\mathbf{F} = \dot{\mathbf{p}}$), *one* inertia ($E/c^2$), *two* forces reading two different properties of the same matter — its charge and its mass. Nothing here needs a separate primitive called mass; "mass" is the name of the inertia, and the inertia is energy.

3 The sign of the charge

The two properties differ in one decisive respect, and it governs everything: *charge comes in two signs, mass in one.* Because charge is ± it can cancel — unlike charges attract, like charges repel, and bulk matter is neutral — so electromagnetism *screens*, and stays local and short-reaching. Because mass is one-signed and always positive, gravity's source cannot cancel: it can only *accumulate*, and it is always *attractive.* This single asymmetry is the root of the whole separation — screening removes electromagnetism over neutral bulk while single-signed gravity piles up — and it is why gravity, though the weakest force, is the one that only ever adds, and so comes to rule the large.

4 The nuclear scale: charge and energy, contracted

The small-scale layer reaches further down than the atom. RealNucleus [3] applies the *same* functional — charge clouds minimising Coulomb energy against a localisation cost — to the *nucleus*, with only the geometric scale contracted from the ångström and electron-volt of chemistry to the fermi and MeV of nuclear binding. One theory, one scale smaller, reproduces nuclear binding as Coulomb geometry: the He-4/deuteron binding ratio comes out ≈ 13 against an experimental ≈ 12.7, and the burning of hydrogen to helium appears as a rearrangement of protons and electrons. On this (unconventional) reading the "strong" nuclear binding is not a new fundamental interaction but Coulomb geometry contracted, so electromagnetism and nuclear binding become *one theory at two scales*, and the small-scale layer spans the nuclear and the atomic worlds alike.

Two scales, one relation. A cloud's size varies inversely with its geometric scale while its energy varies directly with it, so size and mass are linked: a contracted cloud costs more localisation and Coulomb energy and is therefore *heavier*, an extended one *lighter.* Electron and proton sit at the two ends — the electron big and light (atomic scale, ~ 0.5 Å, 0.511 MeV), the proton small and heavy (nuclear scale, ~ 1 fm, 938 MeV) — so "proton small, electron big" and "proton heavy, electron light" are one fact, not two. What is *not* supplied is the value of the ratio: the proton/electron size ratio $\sim 5 \times 10^4$, the same datum as the mass ratio m_p/m_e, is left open, as it is in every theory.

Its *existence*, however, is no idle fact. Were the atomic and nuclear scales equal, there would be no compact nucleus distinct from a diffuse electron cloud — no layered atom, no chemistry, no molecules, no structure. The separation of scales is a *precondition for complexity*, so any universe that supports structure, and hence observers, must exhibit it: an anthropic reason *why* the scales are separated, though not a derivation of *how far.*

5 Why the separation is clean

Because the two forces read different properties and inhabit different scales, they do not interfere where each operates. In the microscopic world gravity is 10^{-36} too weak to enter RealQM's Coulomb bookkeeping, so RealQM is *complete without gravitation*: atoms, bonds, spectra and the propagation of light are electromagnetic through and through. In the macroscopic world the constituent charges have screened to neutrality, so Newtonian gravitation is *complete without electromagnetism*: celestial mechanics needs no field of charge. The separation is therefore not a truncation imposed by hand but a consequence of *weakness* on one side and *neutrality* on the other. Only where gravity grows strong or energy runs unscreened do the two couple — strong-field astrophysics and the

highest energies — and that lies outside the non-extreme scope kept here.

6 Gravity in the large

Gravity is at once the weakest force, unscreenable, and coupled to the one quantity that never cancels — mass. These are exactly the properties of a force negligible between individual particles yet *dominant in bulk*: as neutral matter aggregates, the electric forces cancel and the tiny gravitational pull, adding up over every particle, is eventually all that remains. Gravity is thus effectively a *large-scale, cumulative* force, and it acts *locally through a potential*: a body responds to the gradient of the gravitational potential at its own position, $a = -\nabla\varphi$, where φ is sourced (Poisson, $\nabla^2\varphi = 4\pi G\rho$) by all the surrounding mass. The Earth is not *pulled* across space by the distant Sun; it rides the local slope of a global potential to which the Sun is the dominant nearby contributor.

The charge that gravity acts on is the same energy content E/c^2 that gives inertia — gravitational mass equals inertial mass, tested to a part in 10^{13}, and every body carries it: a single neutron falls, and even forms quantised bound states in the Earth's field [5]. That equality is natural here rather than a coincidence, for gravity acts on the very energy that already *is* the inertia. What a lone particle does *not* evidently do is serve as a fundamental *source* of gravity for another lone particle — the $\sim 10^{-40}$ mutual pull between two electrons has never been isolated, and gravity as a source shows itself only when mass is gathered. Whether it is therefore a fundamental force or a collective effect of aggregated matter is a question Coulomb and Newton do not settle, and we do not press it; either way, in the large gravity is what draws neutral matter together.

7 The cosmological perspective

The contrast is written across the history of the universe, and it turns on the sign of the charge. Early on — hot and dense — matter is *ionised*: charge is unscreened, and Coulomb physics is the active force. This is when nuclei are assembled (the same charge geometry as RealNucleus, one scale down) and, later, when nuclei and electrons combine into atoms. At that combination — *recombination* — matter turns *neutral*: the $\pm$ charges cancel and electromagnetism screens itself out. That is the hinge. After it, only the single-signed, cumulative pull remains, and gravity takes over: small density excesses grow, drawing neutral matter into stars, galaxies and the cosmic web. The universe's own timeline thus stages the two regimes in sequence — *charge builds the small (nuclei, atoms) while matter is charged; gravity builds the large (structure) once it is neutral* — the handoff being the $\pm$-screens-to-+-accumulates transition of recombination. The direct force makes the constituents; the cumulative force assembles them.

The essence needs only *one* seed: a small-scale perturbation of *charge*. From it the two scales follow in turn, and only the charge is primitive.

At the small scale the charge seed yields charge of both signs and of different spatial extent — small dense positive (the proton) and large diffuse negative (the electron) — and, a contracted cloud being heavier, that extent *is* the inertial mass. This builds the whole charged world: nuclei, atoms, molecules, chemistry — all of RealQM.

At the large scale the energy of that charged matter is a mass/inertia density ρ — seeded entirely by the charges — and it is this ρ that sources gravitation, through the Poisson relation $\rho = \nabla^2\varphi$. Read about the mean, $\rho = \nabla^2\varphi$ carries *both* signs, so the gravitational source is two-fold:

an attractive part where the mass is positive and a repulsive part where it is negative. As they grow these separate and emerge into large-scale structure — great chunks of positive mass *interfoliated* with negative mass: the over-dense filaments and clusters that draw together, interleaved with the under-dense voids that push apart, the cosmic web. The negative side is *emergent*, a redistribution of the one charge-seeded ρ, not a second seed — only charge is put in.

So one charge seed gives both worlds. The small-scale mass is the *size* of a charge; the large-scale mass is the *curvature* of the emergent gravitational potential; and gravity is the large-scale shadow of the energy of the charged world. This is the cosmology of the companion essay *Proton–Electron Cosmology* [4], in its leaner form — charge the sole primitive, mass emergent as energy at the small scale and as potential-curvature at the large.

8 Conclusion

For the vast, non-extreme middle of physics — chemistry, materials, optics, mechanics, the motion of ordinary bodies — two forces on ordinary matter suffice. Electromagnetism, Coulomb between charges, is direct and rules the small: atoms, molecules, and (in RealQM) nuclei. Newtonian gravitation, weak but cumulative, rules the large: planets, stars, galaxies. They stay in disjoint domains because charge screens and mass does not — the direct force makes and binds the constituents, the cumulative force gathers them — and throughout, inertia is the energy content E/c^2, one quantity carried through both. Only where gravity grows strong or energy runs unscreened — strong-field astrophysics, the highest energies — would more than Coulomb and Newton be needed; that lies beyond the scope kept here, and is left, honestly, at the edge.

References

[1] C. Johnson, *Energy Without Mass: RealQM, Inertia, and the Penning Trap* (companion note).

[2] C. Johnson, *Real Quantum Mechanics* (book).

[3] C. Johnson, *RealNucleus*: nuclei as charge clouds in RealQM (submitted, *Physics Essays*).

[4] C. Johnson, *Proton–Electron Cosmology* (companion essay).

[5] V. V. Nesvizhevsky *et al.*, "Quantum states of neutrons in the Earth's gravitational field," *Nature* **415**, 297–299 (2002).