

Where $E = mc^2$ Comes From

A foundations note: a bridge from the wave/radiation sector, not from RealQM or Newton

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July 2, 2026

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Abstract

$E = mc^2$ is *foreign to both RealQM and Newton* — it must be imported. It enters from the *wave/radiation* side (matter and light as waves), it is the *one bridge* between the electric-energy sector (RealQM / RealNucleus / Radiation) and the gravitational-mass sector, its factor c^2 is a *unit convention*, and the single non-conventional fact is that the exchange rate *is the speed of light* — because matter and light are the same kind of wave.

1 It is foreign to RealQM and to Newton

RealQM is the *static, non-relativistic* Coulomb structure: energies in Hartree (Coulomb attraction plus the kinetic term $\kappa|\nabla\psi|^2$), with **no c and no rest energy**; nothing in it produces mc^2 . Newtonian mechanics has only $\frac{1}{2}mv^2$ and potential energy — **no rest energy at all**. So $E = mc^2$ is not derivable within either; it is genuinely **added from outside** the matter-structure sector.

2 Where it does come from

Not from the matter-structure side — from the **wave/radiation** side, where c lives.

- **Standard route:** special relativity (Lorentz invariance) — which this program declines to use as the derivation.
- **In this program (Many-Minds Relativity):** from the wave picture — but this route is itself largely *definitional*. The **physical input** is $P = E/c$, the momentum of a wave (radiation pressure); the step $m := P/c$ (i.e. $P = mc$) is a **definition of mass** — a convention, not a theorem; and then $E = Pc = mc^2$ follows algebraically. So the MMR “derivation” is **one physical fact ($P = E/c$) plus one definitional convention ($m = P/c$)**.

So $E = mc^2$ appears exactly when the static Coulomb structure is made **dynamic and radiating**: it is a statement about the **Radiation sector**, not the RealQM/atom sector — and its derivation is, as just noted, mostly convention.

3 The content, though, is empirical: energy really is mass

Convention governs the *derivation* and the *units*; the physical claim — that all internal energy contributes to mass — is **empirical and confirmed**:

- **The proton is the proof.** Its mass is $\sim 99\%$ the internal kinetic + binding energy of its quarks and gluons (only $\sim 1\%$ quark rest mass). A system's mass *literally is* its internal energy — $E = mc^2$ read backwards, and measured.
- **Nuclear binding is a weighed mass defect.** A deuteron weighs *less* than a free proton + neutron by $2.224 \text{ MeV}/c^2$ — bind (cool) the system and it weighs less, directly on the scale.
- **So a cooling body does lose mass and become easier to accelerate.** Hot = more internal energy = more mass = more inertia = harder to accelerate; cooling $\rightarrow$ lighter $\rightarrow$ easier. Real — but for ordinary *thermal* energy, tiny: heating 1 kg of water by 100 K adds $\Delta E \approx 4 \times 10^5 \text{ J} \rightarrow \Delta m \approx 5 \times 10^{-12} \text{ kg}$ ($\sim 5 \text{ ng}$), $\sim 10^{-12}$ of the mass, far below direct weighing. The *confirmed* cases are nuclear (mass defect) and the proton.

4 Is it “only a convention”? — half yes

- **The c^2 factor is a unit convention.** In natural units ($c = 1$), $E = m$: mass and energy are the *same quantity*, and c^2 is only the exchange rate that appears because mass (kg) and energy (J) are historically measured in different units. The *number* c^2 is a currency rate.
- **The equivalence it encodes is not conventional.** That a bound system *weighs less* (the mass defect), that mass and radiation interconvert (annihilation, nuclear energy) — that is empirical.
- **In this program it is the postulated bridge.** $E = mc^2$ is the coupling *axiom* tying the electric-energy sector to the gravitational-mass sector — not derived from either. It plays the role of a **conversion rule in a conserved-energy ledger**, where energy runs *electric* (Coulomb) $\leftrightarrow$ mass (gravitational) $\leftrightarrow$ radiation, conserved overall, with c^2 the exchange rate.

So “a convention in a game of constant energy with two forms” is a fair description of its *function* — provided one keeps the physical equivalence (empirical) separate from the unit factor (conventional).

5 The one non-conventional fact: the rate is the speed of light

c enters the program **only here** — and it is the **same** c as light's wave speed. That identity is the real content: the mass-energy exchange rate equals the speed of light because **matter and light are both waves in the same arena, with one characteristic speed**. The units (c^2) are arbitrary; that the rate is c *rather than some unrelated constant* is not — it is the statement that matter and radiation share one wave medium. Remove that shared-wave picture and $E = mc^2$ would be a bare convention; with it, the c is forced.

6 Its role in the program

$E = mc^2$ is the **seam where the Coulomb sector couples to gravitation**. Gravity never sees electric charge directly; it sees only **energy**, and $E = mc^2$ turns the Coulomb sector's energy (binding, kinetic, radiation) into **mass**, the gravitational charge. The coupling is **realized in matter** (each cloud carries both a charge and a mass) and **manifested in the mass defect** (Coulomb binding lowers the energy, hence the mass; the difference radiates). It is also the **only place** c **enters** an otherwise c -free, non-relativistic construction — the relativistic seam of the whole program.

In one line. $E = mc^2$ is not from RealQM or Newton but imported from the wave/radiation side ($P = mc$); its c^2 is a unit convention and it functions as the conversion rule in a conserved-energy

ledger between the electric and gravitational forms — the one non-conventional fact being that the rate *is* the speed of light, because matter and light are the same kind of wave.