Gravity and the Past

Working document v1.0. The second of two documents covering Virtualism's account of the temporal arc and the production of reality. The companion document, Change and the Present (`change_and_present_v1_0.md`), develops the quantum side of change: intrinsic values leaping where they can, the photon-Arc as transaction, King William the Wave (the wave function) as fact governing reality, and the present as intrinsically overdetermined reality. This document picks up where that one left off and develops the extrinsic side — when one changes, all change. How the universe propagates the consequences of each Arc. Why what we call time, gravity, and the speed of light are signatures of one underlying propagation. What the past is, given that the Arc itself takes no time. And how the cycle closes: how the past constrains what the next imminent future can become.

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1. Where Change and the Present left off

Document one ended with a photon-Arc producing one new present in an instant. Alice loses Philip; Bob gains Philip; the universe's facts are updated to match. The Arc is structurally complete in itself. No time passes during it; no path is travelled; nothing intermediate exists between the Alice-with-Philip configuration and the Bob-with-Philip configuration. One present settles into the past, another emerges, and what was the imminent future — King William the Wave's domain of

possibility — has resolved by one tick.

But that update has consequences beyond the Alice-Bob pair, and those consequences do not propagate freely. Alice's loss of boost is automatic — it happens with the Arc. The fact that Alice is now somewhere different in regard to Dave, the universal centre, is also automatic. But the rest of the universe does not yet know about it. Charlie, far off, still bears his old relations to Alice; the constellation of facts that Charlie maintains has Alice where she was. The universe is, in this respect, momentarily inconsistent with itself. Some of it has been updated; some of it has not.

The reconciliation of this inconsistency is what this document is about. The consequences propagate, and the rate at which they propagate is finite, and what we call time and the speed of light and gravity are all signatures of that finite propagation. There is no separate time-keeping mechanism doing this work alongside the Arcs. The propagation *is* the time-keeping. Time is what the universe doing its updating *looks like* to anyone embedded within it.

This document develops six things in one closed exposition.

First, **the dynamics of mass, momentum, and gravity**. Document one established the structural identification — rest mass is symmetrical boost, momentum is lopsided boost, gravity is the process of unbalancing and rebalancing. Document two develops what that identification *does*: how momentum persists, how acceleration adds lopsidedness, how gravity-Arcs work in detail, how the worked geometry of the 4D hypersphere

supports it all.

Second, **why G is what it is**. Newton's constant of gravitation is not a brute fact about nature but the exchange rate between three vocabularies — rotation-content (kg), real-space distance (m), and Machian tick-rate (s) — that Virtualism identifies as projections of the same underlying paradox dynamic. Once the universe's own scales for any two of mass, distance, and time are fixed, the third — and therefore G — is determined. The inverse-square falls out of the geometry of how the virtual centre's constraint reaches its constituents through a 2D surface. None of this is put in by hand; all of it falls out of the same mechanism.

Third, **what Bob sees when Philip arrives**. By the time Philip reaches Bob, the universe is no longer in the state it was when Philip left Alice. Alice has been further repositioned by every other Arc that propagated to her during Philip's transit. Bob receives Philip with the information of where Alice *was* at Philip's emission, not where she is now. What he sees is the *apparent past* — real as a fact-of-reception, unreal as a description of where Alice currently is. The past is factual without being real, and the conceptual cornerstone of the document is the worked-out account of how that comes to be the case.

Fourth, **time as the visible signature of Machian-inertia-as-applied-paradox**. Inertia is being unable to race ahead. Each propagation of consequences requires paradox-resolution work that takes no time individually, but that cannot be skipped, and the cumulative pacing of that work is what we call time.

Clocks measure accumulated paradox-resolution. The speed of light is the rate at which the consequences of an Arc propagate outward through the present's 3D structure. Gravity is the same propagation, seen as how-things-now-move. Three faces of one mechanism.

Fifth, **the past as factual but not real**. What demerged from reality persists as fact. The classical waterfall of fact streams away from the present, and position — once settled — lives in that stream. Pure facts continue to exist after the realities they were facts about have demerged. This is the ontology of the past, and it has bearings on Spirit territory that will be flagged at the points where they arise but not developed here.

Sixth, **the Mandala cycle completed**. Document one developed the production cycle's forward half: water (distant future) into air (imminent future) into earth (present), with photon-fire as the carrier of the Arc. Document two develops the return half: earth into fire (present settling into past), fire feeding water (past constraining the new distant future), water shaping into air again — the cycle continuously turning. In document one, the temporal arrow and the production arrow ran in the same direction. In document two, they diverge. The production arrow still runs forward (past feeds future via Machian rearrangement), but the temporal arrow now runs backward (past is behind us, present here, future ahead). The two arrows that aligned in document one come apart here, and that divergence is the document's structural signature.

The document does *not* develop consciousness, soul, the

afterlife, or astrology, even where the past-as-eternal-fact material crosses into that territory. Material that touches Spirit or Iconism is flagged with a positioning paragraph at the point where it arises and the development reserved for those projects.

A note on naming, before proceeding. The cast inherited from document one stays in place. Alice, Bob, and Charlie remain three particles with mass. Dave remains the virtual universal centre — the timelike (imaginary) heart of the 4D hypersphere on whose surface the real lives. Philip remains the photon, the carrier of the Arc. Simon remains the spin-and-entanglement carrier, the 1D informational analogue of Philip's 3D energetic carriage. To these, document two adds three: *Eddie* and *Freddie*, two real masses used when the focus is pair-dynamics; and *Gigantic George*, the virtual centre of any particular pair of masses — the local analogue of Dave. King William the Wave, whom document one introduced as the wave function, has done his work by the time the photon-Arc fires: once the present is produced, William's domain — the imminent future of possibility — has resolved by one possibility, and the rest of his content has demerged with the Arc. William's role in document two is therefore mostly structural: he is what *was* before the Arc, the possibility-space whose collapse the propagation is now expressing. The document's actors are mostly the ones doing the propagating: the masses Alice-and-Bob, Eddie-and-Freddie; the centres Dave and George; the photon Philip carrying news.

2. The structural arc of the document

The document follows the production cycle's *return half* as its deep structure, with the propagation phenomena as the surface vocabulary. The reader meets the cycle as a sequence of familiar physical phenomena — propagation, apparent past, time, the past — and the Mandala cycle underneath supplies the architecture that makes those phenomena one story rather than six.

The arc has seven beats:

- **The Arc completed** — one new present produced, Alice and Bob updated, Philip gone. The question now: what about the rest of the universe?
- **Machian rearrangement** — extrinsic consequences of the Alice-Bob change propagate to every other object that bears a relation to either. Not real motion through real space, but virtual repositioning by virtue of altered relations to the changed centre.
- **What gravity costs to do its work** — Newton's G as the exchange rate between three vocabularies (rotation-content, real-space distance, Machian tick-rate) that Virtualism identifies as projections of the same underlying paradox dynamic. The inverse-square falls out of the geometry through which the virtual centre's constraint reaches its constituents.
- **The rate-limiter** — Machian inertia. Propagation of consequences requires paradox-resolution work. Each unit of work takes no time but cannot be skipped. The cumulative pacing is the speed of light.

- **What Bob sees** — apparent past. Alice has been further repositioned by every other Arc that propagated to her between Philip leaving and Philip arriving. Bob receives Philip with the fact of where Alice *was* at Philip's emission, not where she is now.
- **The past** — facts streaming away from the present. Where position lives once settled. Pure facts liberated from reality, persisting eternally without continuing to be real.
- **The Mandala completion** — fire-to-earth-to-air-to-water at the level of reality-production. How the past's facts constrain the next imminent future, closing the cycle that document one's forward half opened.

The reader can read the document straight through and meet the arc as a sequence of phenomena. The cycle is doing structural work below the surface, but the surface story is the physics story, and it stands on its own terms.

The temporal arrow and the production arrow diverge here, and the divergence is worth noticing. In document one the two arrows aligned: distant future into imminent future into present (temporal) ran in the same direction as water into air into earth (production). In document two they part company. The temporal arrow runs backward through the Mandala cycle — present into past, past behind us. But the production arrow continues forward — the past *feeds* the next imminent future via Machian rearrangement. The past constrains what the new distant future can become, and that constraint then tightens into the new imminent future. Looking at the temporal arrow, the past is behind; looking at the production arrow, the past is *upstream*. These are two different relationships, and the

divergence between them is, in part, what gives time its peculiar character — running in one direction at the level of description, but functioning as constraint on the *next* moment's becoming.

3. The dynamics of mass, momentum, and gravity

Document one §7.5 made the structural identification. Rest mass is symmetrical boost — imaginary rotation balanced around the rotation axis. Momentum is lopsided boost — imaginary rotation greater in one vector than its symmetric counterpart. Gravity is the process of unbalancing or rebalancing — the Arc-mediated alteration of boost-shape. This is the *what*. Document two takes up the *how*.

3.1 Why momentum persists

A particle with lopsided boost stays lopsided absent a re-symmetrising Arc. This is a stronger claim than it might appear, and it is the foundation of Newton's first law as Virtualism understands it.

Each new present that emerges from an Arc-elsewhere is *another* present in which the same lopsidedness obtains. Freddie, who was moving northwards before some other particle's Arc, is still lopsided in the imaginary-northwards direction after that Arc. The Arc that fired elsewhere has updated the universe's facts in the manner the Arc demanded — Alice has lost Philip, Bob has gained him — but nothing in that update has touched Freddie's intrinsic boost. Freddie's lopsidedness is intact, and

the lopsidedness produces the same extrinsic shift it always produces: a small displacement of Freddie's apparent position in the direction his boost is asymmetric toward.

We see this as Freddie "continuing in straight-line motion." We say it that way because the geometry of his successive apparent positions traces out a straight line and his apparent speed between adjacent positions is constant. But there is no inertial law to invoke. The particle's intrinsic boost-shape is doing what the boost-shape does, turn after turn. Each turn is a fresh present, each turn finds Freddie still lopsided in the same direction, each turn produces the same small extrinsic shift. Joining the dots gives the straight line.

The diary's clearest single statement of this is from D060C, 4 June 2025 — *"one side plastered with photons"* — for the lopsidedness mechanism, and D060B, 6 May 2025 — *"it is boost that points their path closer"* — for momentum-as-boost-pointing. The picture is that momentum is not a separable attribute that Freddie has *in addition to* his mass. It is the shape his mass takes. Rest-mass-Freddie has it shaped one way (symmetrically); moving-Freddie has the same imaginary content shaped another way (lopsided toward the vector of motion). The quantity of content is conserved; what changes between the rest case and the moving case is the *symmetry* of the content's imaginary rotation.

3.2 Why momentum has a vector

The lopsidedness has a direction in the imaginary 3D, and that direction's projection into the real 3D is what we see as the

velocity vector.

This is the *Fast Freddie* passage from D060A, 16 April 2025: *"Fast Freddie's direction of momentum is 3D but imaginary, in addition to his real 3D properties, so is a vector."* Three remarks fall out.

First, the direction is real *as a direction in the imaginary*. It is not a fiction the observer constructs; it is a fact about Freddie's boost-shape. The asymmetry of his rotation is greater along this particular axis than along its perpendiculars; the axis along which it is greater *is* the direction of his momentum.

Second, the projection into the real is what observers and instruments engage with. We do not see Freddie's imaginary rotation directly. We see its consequence — the displacement of his apparent position turn after turn. That displacement has a direction (the direction of the asymmetry's projection), and so we say Freddie has a velocity vector pointing that way.

Third, this is why Freddie has three momentum components rather than just a speed. The imaginary 3D in which his lopsidedness lives is itself 3D, and the projection of a 3D vector into a 3D real space gives back three real components. Momentum is a vector because rotation in 3D is a vector. Speed (the magnitude of the vector) is just the size of the lopsidedness, irrespective of direction.

3.3 Why acceleration is paradox-driven response

Acceleration occurs when there is a state of paradox between the subjective and the objective — between the internal parts of the accelerating thing and the external relationship it has with whatever is "accelerating" it. The mountain and Muhammad, in D064A's worked example (23 April 2025): if Muhammad cannot move the mountain and the mountain cannot move Muhammad, then the system as a whole is in paradox. Both have determinate positions; the system requires those positions to be consistent; the requirement and the facts cannot all hold simultaneously. The resolution: the objective usually has greater power because the objective is just larger, so Muhammad goes to the mountain — but the mountain also goes a little way towards Muhammad. The acceleration is the paradox-driven response of both parties together, in the proportions their respective rotation-contents permit.

The mathematics behind this is straightforward once the structural identification is in place. Each acceleration-event adds more lopsidedness to the boost. The rate of addition is the magnitude of acceleration. The direction of addition is the direction of the resulting velocity-change. Acceleration is not, structurally, a different kind of thing from rest mass or momentum; it is *the process by which lopsidedness is being added at a particular rate*. Where momentum is a settled asymmetry, acceleration is asymmetry being added. Where gravity is the universe's whole repertoire of paradox-driven boost-adjustments, acceleration is the rate at which any particular boost is being adjusted.

The worked illustration is the booster-stage example, from D062A, 7 November 2025. When a rocket detaches from its stage-1

boosters, two things happen at once. The rocket loses the *mass of the boosters* — a real loss of internal boost, because those boosters were carrying rotation-content that was part of the total rocket-plus-boosters system. But the rocket *retains the velocity the boosters imparted* — a lopsidedness that was added to its own boost during the powered phase and that persists absent a re-symmetrising event. The rocket is lighter (less total boost) and still moving at speed (the boost it retains is shaped lopsidedly in the direction the boosters were pushing).

What the example shows is that rest mass and accelerated mass are two facets of one boost-load, distinguished by symmetry of rotation rather than by being separate quantities. The boosters *added rotation* during the powered phase. Some of that rotation was symmetric (the rocket's overall mass increased slightly because its energy content increased — the relativistic contribution that becomes significant at high acceleration) and some was lopsided (the velocity component, which is rotation asymmetric toward the direction of acceleration). Stage separation removes the symmetric part along with the boosters themselves. The lopsided part stays with the rocket because it was rotation *added to the rocket's own boost*, not rotation borrowed from the booster's boost. The asymmetry is a fact about the rocket, and facts about the rocket go where the rocket goes.

This subsection has done the dynamic side of the structural identifications inherited from document one. Mass, momentum, gravity, acceleration: the same paradox dynamic seen at four different moments — at rest, in motion, in adjustment, in adjustment-at-a-rate. The unifying picture is that *rotation

into the imaginary is the only basic operation*, and everything else is its symmetric-or-asymmetric, static-or-changing expressions.

4. Gravity-Arcs as the mechanism of un-balancing

If mass is rotation and momentum is lopsided rotation, then gravity is the process by which one becomes the other or becomes more of the other. A gravity-Arc is the event that does that adjustment. It is *as virtual as* the photon-Arc — no particle is exchanged, no force is transmitted, no path traversed. Some quantity is subtracted from one configuration and added to another, and the universe's facts are updated to match. The mechanism is structurally identical to the photon case. The difference is what is subtracted and added.

In the photon case, *energy-square* — the photon-quantum itself — is subtracted from Alice's intrinsic content and added to Bob's. The change is intrinsic. Alice has less energy than she did; Bob has more. Their identities as the particles they are remain unchanged, but their intrinsic facts have altered.

In the gravity case, *mass-position* — extrinsic facts about who is where in relation to what — is subtracted from one configuration and added to another. The change is extrinsic. Eddie has not gained or lost any rotation-content; his intrinsic state is identical before and after the gravity-Arc. But his extrinsic relations have shifted. Where he is in relation to Dave (the universal centre) has changed by a tiny amount; where he is in relation to Freddie (the other mass)

has changed by a tiny amount; the position-fact about Eddie has been updated. *Where the photon alters intrinsic facts, gravity alters extrinsic facts hence the whole object.*

This is the structural identity. Neither event involves real motion through real space. Both are *as-if* paths constructed post-hoc from the extrinsic positional facts of the event. Looking back on a photon's "trajectory," we see Philip having "travelled" from Alice to Bob — but the trajectory is a construction from the start-fact and the end-fact, not a path that Philip's continuous presence ever traced. Looking back on a gravity event, we see Eddie having "fallen toward" Freddie — but the trajectory is again a construction, this time from a sequence of positional facts each of which represents a single Arc's worth of repositioning. The continuity is in the sequence's smoothness, not in any particle's continuous existence along the line.

4.1 Gigantic George — the virtual centre of any pair

For any pair of masses Eddie and Freddie, there is a virtual centre — Gigantic George — that, as the sum of their boost, is more rotated than either. Because George is more rotated, the system Eddie-Freddie-George rotates further into the imaginary as a unit, and rotating further into the imaginary appears as *closing the real-space distance* between Eddie and Freddie.

This is gravity in action without a gravitational force. There is no exchange of anything between Eddie and Freddie. There is no graviton emitted by one and absorbed by the other. The

mechanism is that the pair-as-a-whole has a virtual centre, and the centre, by virtue of summing the pair's rotations, is more rotated than either of them. For the pair to be consistent with its centre, the pair must do what the centre is doing — and the centre is rotated further into the imaginary, which means the pair must be rotated further into the imaginary, which means the real-space distance between Eddie and Freddie must close.

This is the deep mechanism. It is not metaphor; it is the same parts-and-wholes structure document one's foundational note set out. The pair is a whole; the centre is the heart of the whole; parts must be consistent with their whole; the whole's rotation into the imaginary forces the parts to rotate further than they otherwise would.

The diaries develop this in several passes. D060A, 16 April 2025; D060B, 6 May 2025; D060C, 4 June 2025; D063B, 7 February 2026. The 4 June passage is the most concentrated, asking *"why masses have this tendency to move towards one another"* and answering *"G as the virtual sum of A and B has the mass of both of them, so G is boosted more than either A or B."* The February 2026 passage adds the explicit denial of a graviton: *"This gives a non-force-mediated mechanism for gravity that does not require a graviton."*

What needs to be added to the diaries' formulations is the ontological grounding. George does not exist as a particle. He is a virtual fact — a fact-about-the-parts, not a part himself. But he is no more or less virtual than Dave, who is the universal version of the same thing. The parts-and-wholes

structure runs all the way through: every whole has a centre, every centre is virtual, every centre constrains its parts. Gravity is the universal expression of that constraint.

4.2 Why this is structurally identical to the photon-Arc

Subtract-and-add. Some quantity is removed from one configuration and added to another. The path between is not travelled; the as-if path is constructed post-hoc from the extrinsic positional facts. The difference is what is subtracted and added:

- In the photon case, *energy* is subtracted from Alice and added to Bob. The intrinsic energy-content of each particle changes.
- In the gravity case, *position* is subtracted from one configuration of Eddie-and-Freddie and added to a different configuration. The extrinsic relations of each particle change.

The mechanism is the same. Both are paradox-driven Arcs. Both update the universe's facts in a single instantaneous event that has no internal duration. Both leave the as-if appearance of a continuous path that can be reconstructed after the fact. Both are foundational to how the universe's facts get updated from one present to the next.

That gravity-Arcs operate on extrinsic facts rather than intrinsic facts is what makes gravity feel different from the quantum events. Quantum events change *what something is*; gravity events change *where something is*. The former feel

discrete and individual; the latter feel continuous and universal. But this difference is in what is changing, not in the mechanism of change. The mechanism is the same in both cases: paradox-resolution via subtract-and-add, with no real motion involved.

5. Why G is what it is

A structural account of Newton's gravitational constant.

The argument that follows is not a derivation of G's numerical value, which would be impossible without a derivation of the universe's own scales for mass, distance, and time, and Virtualism does not claim to derive those. The argument is an account of *what kind of quantity G is* and why, on Virtualism's terms, it cannot be a brute fact about nature. The standard position treats G as a free parameter discovered by measurement and lacking further explanation. Virtualism's position is that G is *structurally determined* once any two of the three relevant scales are fixed — and that this is a substantially stronger claim than "G is just what it is."

5.1 Framing the question

The Hossenfelder checklist (positioning_verlinde_and_emergent_-gravity.md §3) demands that any successful emergent-gravity account derive the inverse-square behaviour of gravitational attraction *as a consequence*, not as a target. Verlinde's entropic-gravity programme fails this test because his derivation reverse-engineers Newton from thermodynamic premises

that already contain gravitational acceleration. The calculation, when audited, was found to use the very phenomenon it was supposed to be explaining. The inverse-square came out because it was put in.

Virtualism's account, by contrast, gets the inverse-square *for free* from the geometry of how the virtual centre's constraint reaches its constituents, and gets the *kind* of quantity G is from the three-vocabulary structure the gravity-Arc mechanism requires. This subsection is where Virtualism cashes the checklist's most important item. The $1/r^2$ is not an input; it is a consequence of the geometry. And G is not a free parameter; it is the exchange rate that the geometry requires.

5.2 The Eddie-Freddie-George geometry, recapitulated

To see why G is what it is, we need the worked geometry of the pair-and-centre situation in slightly more detail than §4 gave.

Eddie has rest mass. Symmetric imaginary rotation. Eddie is numerically the same man he would be without rest mass, but his content is partly absorbed into the imaginary axis, so the real-projected Eddie occupies less real space than the unboosted Eddie would. Equivalently — and this is the way the geometry of the 4D hypersphere encodes it — Eddie is further from his neighbours in the 4D measure while occupying the same real-space point. This is the *stretch*: a mass-bearing thing is, in the 4D measure that includes the imaginary axis, more distant from its neighbours than its real-space proximity to them would suggest. It is occupying a real-space point but it is also reaching into the imaginary, and the reach is part of

what it is.

Freddie has mass and momentum. Lopsided rotation, greater in one vector. Freddie has even less apparent real-space distance along his vector of motion — he is *more* stretched along that axis. This is, incidentally, the structural origin of length-contraction; it falls out of the rotation-shape rather than being put in by hand. A moving Freddie, viewed by a stationary Bob, appears foreshortened along his direction of motion because the imaginary rotation that constitutes his motion has absorbed some of his apparent extent along that axis. The factor is not specified here as a number; what matters is the structural origin of the effect. The diaries' picture is that length-contraction is the same phenomenon as the imaginary rotation that *is* the momentum, viewed from another angle.

George is the virtual centre. Because George sums Eddie's and Freddie's rotations, George is more rotated than either. George is further into the imaginary than his parents. There is no real-space point that is George; George is a fact about Eddie and Freddie taken together. But George is a *real fact* about them — the centre-of-mass is exactly where it is, with no Heisenberg uncertainty attaching to it, because it is a virtual fact rather than a real particle. This is a deep point that the diaries return to repeatedly (D060A, 9 April 2025; D044, 20 June 2021): *the centre is not subject to the rules that govern the particles*. The particles are subject to quantum uncertainty because they are real; the centre is not, because it is virtual.

The constraint. Eddie and Freddie are held in relation to

George — they *make* him; they cannot be inconsistent with him. George is further into the imaginary than they are. To maintain consistency with George, Eddie and Freddie must rotate *more* into the imaginary than they would on their own, which closes their real-space separation by exactly the amount the additional rotation requires. *That closing is what gravity is.* Not a force; a paradox-resolution that closes real-space distance because the virtual centre demands it. The pair-as-a-whole is rotating further into the imaginary than its parts were, and the parts must catch up, and catching up appears, in the real-space projection, as the parts moving toward each other.

This is the geometric mechanism of attraction, with no force involved.

5.3 The keyhole — where $1/r^2$ comes from

Gravity's mechanism lives in the 4D rotation. But the constraint from George does not reach Eddie and Freddie through the 4D bulk. It reaches them through the 2D surface of the sphere at radius r — the surface whose centre is George and on which Eddie and Freddie both live (at their respective r-values from George).

This is the geometric origin of the $1/r^2$. Twice as far from George, four times the surface area over which the same constraint must be distributed. So 1/4 of the closing-pressure per patch.

The inverse-square is not a force-law decree. It is what

spherical distribution of a constraint means geometrically. Any constraint that emanates from a point and distributes over the surface of a sphere has its intensity at any point on the surface falling as $1/r^2$. Light intensity from a point source follows the same law for the same reason: the same photon-flux is distributed over an increasing area. Electric field strength from a point charge follows the same law for the same reason. Wherever a constraint emanates from a point and distributes spherically, the inverse-square is what comes out.

The "keyhole" is just the 2D shell over which the constraint distributes — the 2D real-space surface through which George's 4D-rotation constraint reaches the particles it constrains.
The 2D-ness is essential. If gravity's geometric reach were 3D rather than 2D, we would have $1/r^3$; if 1D, we would have $1/r$. The actual law — $1/r^2$ — tells us that gravity's reach is 2D, which is what we should expect for a constraint that lives in the bulk but distributes over a sphere.

The diaries' single line for this is from D044, 20 June 2021: *"gravity has no uncertainty"*. The reason gravity has no uncertainty is that the centre that imposes it is a virtual fact, and the geometry through which it reaches its constituents is 2D and deterministic. There is nothing probabilistic about the constraint; it is exactly what the geometry requires.

5.4 The mass-product

The remaining piece of the Newtonian formula is the $m_1 \cdot m_2$. Why does the gravitational interaction between Eddie and

Freddie depend on the product of their masses, rather than (say) the sum?

The answer is in how the rotations compose in George. Eddie's mass-rotation and Freddie's mass-rotation combine in George multiplicatively in the appropriate limit. The joint rotation is not the sum of the two rotations (which would give a G-rotation proportional to $m_1 + m_2$); it is the product. This needs care in the worked derivation but is not mysterious. It is the geometry of how two rotations compose into a virtual centre. If George were the simple sum of his parents' rotations, the gravitational interaction would depend on $m_1 + m_2$. Because George is what you get when the two rotations compose multiplicatively in the relevant limit, the interaction depends on $m_1 \cdot m_2$.

The $m_1 \cdot m_2$ falls out of the geometry. It is not put in by hand.

5.5 G as the exchange rate between three vocabularies

Now to the substantive question. *What is G?*

G has dimensions $m^3/(kg \cdot s^2)$. This is the standard SI formulation, and it is the clue. The three vocabularies that the formula brings together are:

- *Imaginary rotation content*, the thing mass *is*. Counted in kilograms when projected into the scale we use for matter.
- *Real-space distance*, the thing being closed by gravity. Counted in metres.
- *Universal tick rate*, the Machian pace at which paradox-

resolutions accumulate. Counted in seconds.

G is the conversion factor between these three. *Not a free parameter.* The exchange rate the three vocabularies have with each other, because the three vocabularies are not independent — they are projections of the same underlying paradox-driven dynamic.

This is the structural claim. Once the universe's own scales for any two of mass, distance, and time are fixed, the third — and therefore G — is determined. G is not a constant of nature in the sense of being a free parameter that could have been otherwise; it is whatever number expresses the ratio that the three units happen to have to one another, given the universe's single underlying dynamic.

This is significantly stronger than the standard physicist's position. Standard physics treats G as a brute parameter that we discover by measurement and have no further explanation for. The Newtonian framework needs a constant because the units of mass, length, and time are independently chosen, and a dimensional bridge is required to make the inverse-square law come out with the right magnitude in those units. Standard physics treats the bridge as just a fact about nature. Virtualism's account makes the bridge *necessary*: given that mass-rotation, position-closure, and tick-rate-accumulation are three vocabularies for one underlying dynamic, the exchange rate between them is structurally determined. There is no "choice" of G that the universe makes; there is only the exchange rate that the three projections are mutually consistent at.

5.6 The honest qualification

Virtualism does *not* derive G's numerical value (6.674×10^{-11} in SI units). That number depends on the units we use for kg, m, and s, and Virtualism cannot derive those without deriving the universe's own scales from first principles, which it does not claim to do. What Virtualism claims is that G is *the kind of quantity that is structurally determined once any two of the three scales are fixed*, and that this is a stronger claim than the standard *G is just what it is*.

The dimensionless ratios in which G appears — such as the ratio of gravitational to electromagnetic force between two electrons, of order 10^{-39} — are the truly fundamental numbers, and even those, standard physics treats as brute facts. Virtualism's position on these dimensionless ratios is a question for further work. The framework supports the *kind* of answer that would be appropriate (the ratio reflects the relative weight of two different paradox-dynamics in the universe's overall economy), but the work of cashing that into a number is reserved.

What this subsection establishes is the kind of claim Virtualism makes about G. It is not a derivation of G's value; it is an account of G's nature. And the account is that G is a constant of bookkeeping, not a constant of nature.

5.7 Does it hold at relative velocities?

The Newtonian picture has G as a constant of bookkeeping between three vocabularies. But the Newtonian picture is the non-relativistic limit. What happens to the account when one of the masses is moving fast?

Yes, the account holds — and without extra machinery.

Fast Freddie's lopsided rotation makes George lopsided in Freddie's direction. Recall §3.2: Freddie's momentum is a lopsidedness in his imaginary rotation, projected as a velocity vector in the real. George, being the sum of Eddie's and Freddie's rotations, inherits the lopsidedness from Freddie's side. George is no longer a symmetric centre; he is rotated preferentially in the direction of Freddie's motion. The constraint George imposes therefore becomes anisotropic — more closing-pressure along Freddie's direction of motion, less perpendicular to it.

This is *exactly* what general relativity says happens to a fast-moving mass: its gravitational pull is enhanced longitudinally relative to its rest-frame Newtonian pull. The factor of enhancement (γ^2 in GR, where γ is the Lorentz factor) falls out of the lopsidedness of George when one of his parents is rotation-asymmetric. The G that appears in Einstein's field equations is the same G — doing the same conversion work between the same three vocabularies. What changes at high velocity is not G but the rotation-content of the source. Fast Freddie has more imaginary rotation than slow Freddie; he contributes more rotation to George; George is therefore more strongly rotated and the closing-pressure correspondingly greater.

The relativistic correction is *the same mechanism* as the Newtonian gravity. It is what Virtualism's account predicts when the source is rotation-asymmetric. General relativity captures the same effect with metric machinery and a more complicated formalism, but the physical content — that gravity's source is the rotation-content of mass and that asymmetric rotation gives asymmetric gravity — is shared between the two accounts.

5.8 The co-determination of rotation and position

A point that surfaces in the working-out of the dynamics: when a gravity-Arc occurs, the change in rotation and the change in real-space position are not sequential. There is no "first the rotation changes, then the position adjusts." Both update in the same Arc.

Following the intrinsic/extrinsic distinction sharpened in §4, rotation here is Eddie's *extrinsic* relation to Dave (the universal centre), and position is Eddie's *extrinsic* relation to Freddie (or any other mass). Both are extrinsic facts about Eddie, and the gravity-Arc updates extrinsic facts in a single event. The two updates are not two events but one Arc seen from two angles: rotation-vs-Dave and position-vs-Freddie. *This is also why Eddie's intrinsic content is untouched by a gravity-Arc — what we ordinarily call "Eddie moves" is the extrinsic fact-set updating, not Eddie's interior changing.*

The co-determination is what makes the picture consistent. If rotation and position updated sequentially, there would be a

moment when one had changed and the other had not, and the universe's facts would be inconsistent. There is no such moment. The Arc is one event, the update is one update, and what we analyse as "rotation-change" and "position-change" are two descriptions of one fact-revision.

5.9 Aphorism candidates

The argument of this section yields two formulations worth preserving:

> G is not a constant of nature but a constant of bookkeeping —
> the exchange rate three vocabularies have for the same
> underlying rotation.

> G is the bill the universe charges when you want to count
> mass in kilograms, distance in metres, and time in seconds.
> It's the same paradox in three currencies; G is the bill.

These are candidates for placement in the Acta Analytica paper or other publication-ready material. The first is the philosophical formulation; the second is the everyday version.

6. What Bob sees when Philip arrives

This is the cornerstone of the document. The picture established in §3–§5 has the universe doing two distinct kinds of work in each present-producing cycle. The Arc itself — photon or gravity — instantaneously updates the universe's facts for the pair of objects directly involved. The

consequences of that update then propagate to every other object that bears a relation to either, at the rate Machian inertia permits. The first kind of work is instant; the second is finite-rate. The combination is what produces the apparent past — the most counterintuitive feature of the picture, and the feature that makes Virtualism's account of time qualitatively different from anything in standard physics.

6.1 The setup

Philip leaves Alice. The Arc fires. Alice loses Philip's energy-content; Bob (the eventual receiver) is determined in the same Arc as gaining it; the universe's facts are updated. Alice immediately has less boost than she did. Alice's position-in-relation-to-everything-else has shifted as a consequence of the boost change — her relations to Dave and to every other massive object are slightly different because her rotation-content is slightly different.

So far, so simple. The Arc is complete. Alice is now in her new state.

But Alice's new state is, momentarily, *known only to Alice and to Bob*. The rest of the universe still bears the relations that obtained before the Arc. Charlie, sitting at his post across the room, has Alice's pre-Arc rotation-content in his fact-set; he has not yet been updated. The reconciliation — the bringing of Charlie's fact-set into line with Alice's new state — has to propagate to Charlie via further Arcs, at the rate Machian inertia permits.

How long does this take? It takes, for any particular other object, a number of ticks proportional to the propagation distance. *Ticks* here are not abstract durations; they are the count of paradox-resolutions the universe has performed since the Alice-Bob Arc. Each tick is a fresh Arc somewhere in the universe, doing its instantaneous work. The accumulation of ticks is what reaches Charlie eventually.

6.2 Bob receives a photon, not a status report

Now consider what Bob, in particular, receives when Philip arrives. Philip carries the information that *Alice lost a photon's worth of energy*. Philip does not carry the information that *Alice is currently in such-and-such a state*. The Arc that fired between Alice and Bob fired at the moment Philip left Alice. At that moment, Alice had her pre-Arc content minus the photon, and Bob had his pre-Arc content plus the photon. That was the Arc. The Arc has not been re-fired; Alice's subsequent history is not in Philip; what Bob receives is the fact of *Alice-as-she-was-when-Philip-left-her*.

By the time Philip reaches Bob, Alice has been further updated by every other Arc that propagated to her during Philip's transit. Alice's actual current state is determined by all of those subsequent updates, none of which Philip is aware of. Philip's content is from the moment of his emission; he is not a continuously-updated messenger.

So what Bob sees, on receiving Philip, is the universe-as-it-was when Philip was emitted — but only with respect to Alice. Bob's other relations have continued to update through the

intervening time, so Bob is in his current state with respect to Charlie and Eddie and Freddie and everyone else. But with respect to Alice, Bob's information is *out of date by the amount of Philip's transit time*.

This is the structural source of the apparent past.

6.3 The past Bob sees is not a real past

A key clarification: when Bob sees Alice "in her past," there is no past Alice anywhere that Bob is seeing. Alice's earlier state — the state she was in when Philip was emitted — does not exist anywhere in the universe any more. It demerged with the Arc. The only place it persists is *as a fact*: the fact that, at the moment of Philip's emission, Alice had such-and-such a rotation-content and was in such-and-such a position. That fact is in Philip's content. Bob receives the fact and treats it as if it were a current state-report about Alice. It is not. It is a fact about Alice that was true at the moment of Philip's emission and is now part of the universe's record.

This is the diary's framing from D060A, 4 April 2025 — *"the distant always appear to be as they were, placing them in a past that paradoxically does not exist."* The paradox is that we treat Bob's perception of Alice as a perception of how Alice is *now*, and we therefore locate Alice's perceived state in a past. But Alice's past does not exist. It is gone. What exists is the fact, in Bob's reception, of how Alice was when Philip emitted. The apparent past is *factual without being real*.

This formulation has several consequences worth drawing out.

First, the apparent past is *not a window into a real past*. It is a fact-of-reception. Philip carries with him the fact of Alice's state at the moment of emission; Bob receives that fact; Bob is now in possession of a fact about Alice's earlier state. That fact is real in the way facts are real — it is true, it is in the universe's record, it is consistent with everything else — but it does not pick out a region of reality where Alice's earlier state continues to exist.

Second, the apparent past does not bring with it anything that the universe is currently *doing*. Alice is not currently doing what she was doing when Philip emitted. The current Alice — wherever she is in her trajectory — is doing whatever she is doing now. The fact of her earlier state, in Bob's reception, is just a fact; it is not a causal influence streaming out of the past into the present.

Third, this is why Virtualism's account is compatible with the *Markovian* structure of physical law (cf. Builes and Impagnatiello on Presentism): the past influences the future only through the present. The fact of Alice's earlier state, sitting in Bob's reception, is part of the *present's* fact-set. It is a present fact, even though it is a fact about an earlier state. The past does not reach forward into the present through any other channel. Everything that is happening now is happening as a function of present facts, including the present-fact of past-Alice-as-perceived-by-Bob.

The diary's clearest single statement of this from D063B, 7

February 2026: *"the change to Alice and Bob appears like the passage of time, but Bob is only 'aware' of the fact of Alice's prior position, not her current one, and there is a big difference between facts of the past and facts of reality."*

6.4 How far back Alice appears to Bob

How far back does Alice appear to Bob? Not by any abstract universal time, but by the number of paradox-resolution ticks that have accumulated during Philip's transit.

D063B's simple-universe-vs-real-universe contrast, 16 February 2026, is the cleanest formulation. *In the simple universe*, where nothing else is going on, Philip takes one tick to go from Alice to Bob: one Arc, one update, Bob sees Alice as she was one tick ago. *In the real universe*, ticks are the count of all other changes happening in the universe during Philip's transit. A photon crossing a light-year takes a year because a year's worth of changes occur in the universe during the transit. The "year's worth of changes" is not a separate counter being maintained; it is the actual number of paradox-resolutions happening everywhere, summed up.

A light year, therefore, is *the distance Philip can span while one year's worth of changes occur in the universe*. This is not a relabelling of the standard definition; it is a substantive metaphysical claim. The speed of light is not a free parameter that the universe happens to have; it is the rate at which the consequences of an Arc propagate outward, set by the rate at which the universe's overall paradox-resolution work proceeds. If the universe's work proceeded faster, Philip would seem to

travel faster; if slower, slower. But the rate is uniform because the propagation mechanism is uniform.

This also means that any observer necessarily sees the other in their own past, and disagreement about *how far in the past* is irrelevant to the question of what the present is. The point is from D064B, 1 May 2025: *"any observer necessarily sees the other in their own past, so disagreement about how-far-in-the-past is irrelevant to the Presentism question."* The Presentism question is whether the present is what exists; the disagreement about how-far-in-the-past concerns the bookkeeping of perception, not the ontological status of what exists. Virtualism is Presentist in the substantive sense — only the present is real — while accepting that each observer's perceptions of distant others necessarily place them in those observers' own past.

6.5 The conceptual cornerstone

The apparent past is the conceptual cornerstone of this document because it locks together everything the picture has established up to this point.

It depends on the Arc being instantaneous (because if the Arc had a duration, Philip would carry information continuously updated through the duration, and there would be no fixed moment-of-emission). It depends on the consequences propagating at finite rate (because if the consequences propagated instantaneously, Bob would always see Alice as she currently is). It depends on the propagation being via further Arcs rather than via a continuous medium (because the Arcs are the mechanism by which the universe's facts get updated, and there

is no other channel through which Alice's current state could reach Bob). And it depends on the past being factual-but-not-real (because what Bob sees is a fact, not a continuing reality, and the difference between fact and reality is what allows the universe to keep its accounts straight without storing an indefinitely-many parallel pasts somewhere).

The picture of time that emerges is qualitatively different from anything standard physics offers. Time is not a dimension the universe is moving through. Time is not a parameter the universe is keeping track of separately from the events that constitute it. Time is the visible signature of the propagation work — the count of ticks, the rate of paradox-resolution, the accumulation of facts in receivers — and nothing else. The fact that observers perceive distant things in those things' own past is not a peculiarity of perception but a structural feature of how the universe updates itself.

7. Inertia as the rate-limiter on change

Section 6 has the apparent past depending on consequences propagating at finite rate. This section says *why* the rate is finite. The answer is Machian inertia, understood not as a property particular objects possess but as the universe's relational structure of *being unable to race ahead*.

7.1 Inertia as the inability to race ahead

Inertia is the phenomenon that affects the rate of change in comparison to other change, and ultimately to all contemporary

change. Hence it is Machian. *Inertia is being unable to race ahead.* Each value-difference between objects requires the repeated application of paradox to shift, and that repeated application is what *takes time* in the sense of preventing everything from updating simultaneously.

This is a stronger Machian claim than the standard one. The standard Machian thought — Ernst Mach's, taken up later by Julian Barbour and Mark Lange in their different ways — is that inertial effects are determined by the distribution of distant matter. The familiar consequence is that there is no absolute inertia; what counts as "moving" or "at rest" is relative to the rest of the universe. Virtualism takes the Machian intuition further: inertia is not just *defined relative to* the distribution of matter; it is *the rate at which propagation through that distribution happens*.

The universe is not standing still while particular objects move around within it. The universe is *updating*, continuously, Arc by Arc. Every Arc anywhere requires paradox-resolution. Every paradox-resolution requires a specific amount of work. That work cannot be skipped — there is no shortcut through the paradox, no way to update facts without doing the resolving. And because the work cannot be skipped, the universe cannot update everything at once. Some things update before others; the sequence of updates *is* the universe's history; the rate at which the sequence accumulates *is* time.

The diary's clearest formulation of the Machian picture is in D060A, 4 April 2025, where Mach, Barbour, and Lange are explicitly invoked. The question — *"Why is there a tendency to

move at all?"* — is answered by the Machian principle that every change shifts the centre of everything. Every Arc anywhere updates Dave's location. Dave's update propagates as a constraint on every massive object. The constraint takes a certain amount of paradox-resolution to satisfy. The rate at which the satisfying gets done is what we observe as the universe's pace.

7.2 The universe does not need a separate time-serialiser

A consequence of the above: the universe does not need a separate time-serialiser. It has Machian inertia, and inertia is the serialiser. Nothing can update without paradox-resolution work; the work cannot be skipped; therefore nothing can race ahead; therefore the universe updates at a pace, and the pace is what time is.

This is structurally important. Standard physics has time as an independent variable — a dimension things move through, or a parameter clocks measure, or a coordinate the field equations are written in terms of. Time, in standard physics, is *given* and the dynamics happens against the background of time. Virtualism inverts the picture. Time is not given; time is *produced* by the dynamics. The dynamics is the universe doing paradox-resolution work, Arc by Arc. The accumulated work is what we observe as time having passed.

There is no clock in the universe other than the universe's own working. Real clocks — atomic clocks, pendulums, water clocks — are instruments that count regular paradox-resolutions of their own and convert that count into a time-reading. They

work because *the relative rate* at which they accumulate ticks is in a stable proportion to the relative rate at which the rest of the universe accumulates ticks. They do not measure an external time; they measure their own local share of the universe's overall paradox-resolution rate, and that local share is in fixed proportion to the global rate.

This is consistent with the standard observation that clocks slow down when accelerated or in gravity wells. The acceleration or gravity is adding lopsidedness to the clock's own boost-shape. The lopsidedness changes the clock's local paradox-resolution rate relative to the surrounding universe. The clock runs slow because *its* tick-count accumulates more slowly than distant clocks' tick-counts. There is no separate "dilation of time" happening; there is just the clock's own local rate being out of step with the surrounding universe's rate. The relativistic phenomena are consequences of the universe being its own time-keeper rather than time being external.

8. The speed of light as the rate of inertia-pacing

The speed of light is not a velocity in the ordinary sense. It is the rate at which consequences of Arcs propagate through the present's 3D structure, limited by Machian inertia. The photon does not travel at *c*; *c* is the rate at which what the photon did propagates outward.

8.1 c as the rate, not the speed

This is a subtle point that bears unpacking. In standard

physics, the speed of light is the speed a particular kind of particle (the photon) moves through space. The number — about 3×10^8 m/s — is the photon's velocity in the usual sense: distance traversed divided by time elapsed.

In Virtualism's account, the photon does not move through space in the usual sense. Philip departs Alice and arrives at Bob; the path between is *as-if*, constructed post-hoc from the two factual endpoints. There is no continuous trajectory in real space along which Philip is at a particular position at a particular time. So what is "the speed of light" the speed *of*?

It is the rate at which the consequences of the Alice-Bob Arc propagate outward from the Alice-Bob pair, expressed as a distance-per-tick. The propagation is not Philip travelling; it is the universe's Machian rearrangement reaching successively more distant objects. The rate of that reaching is what *c* is.

D063B, 7 February 2026: *"a light year is the distance Philip can span while one year's worth of changes occur in the universe."* This is the substantive content of *c*. A light-year is not a distance in some abstract sense; it is the relationship between a particular kind of paradox-resolution work (the propagation of one Arc's consequences) and the universe's overall rate of doing that work. The number we measure is the ratio.

8.2 The Wolfram contrast

A useful contrast: Stephen Wolfram's *Physics Project* has time-dilation as *computation being used up*. The idea is that when

something is moving fast, its computational resources are diverted to maintaining its motion, leaving less computational capacity for the internal processes that constitute its own time-experience. Slow clocks because slow computation.

Virtualism's version is structurally similar but ontologically distinct. D060A, 16 April 2025: *"momentum is simply more curvature due to more imagination."* Time-dilation in Virtualism is imaginary rotation absorbing real change. A fast-moving thing has its boost-shape lopsided into the imaginary; the lopsidedness means that some of its rotation-content is oriented along the imaginary axis rather than along the real axes; the rotation along the imaginary axis does not produce real-space change. So less of the fast-moving thing's intrinsic activity converts into real-space dynamics, and the thing's local clock runs slow.

The difference is that Wolfram's picture has a computational substrate doing the work — a fundamental computer to which "used up" is a meaningful description. Virtualism has no such substrate. The "absorption" is not a resource being consumed; it is the rotation-shape being asymmetric. There is nothing the imaginary rotation is doing in *addition* to itself; it is just what the rotation looks like when it is lopsided. The slow clock is not the result of a depletion; it is the natural consequence of where the rotation-content is pointing.

This is a real point of contention with Wolfram's approach, not merely a difference of vocabulary. Wolfram is committed to ontological substrate (the computational fabric) doing the work; Virtualism is committed to *no* underlying substrate

beyond the paradox-dynamic itself. The substrate-free version is stronger because it does not require positing a fundamental computer the universe runs on.

8.3 The cosmic microwave background as worked case

The cosmic microwave background photon, in standard cosmology, left its source about 13.8 billion years ago and has been travelling ever since. Virtualism's version: the CMB photon was *emitted in an Arc* whose other end is *here, now*, at the detector. The "13.8 billion years of travel" is the number of the universe's ticks that have accumulated between the emission-end of the Arc and the reception-end. The photon is not aging during this time; the photon is not even *existing* during this time in any sense that has a duration. The emission-fact propagates outward from the source, and the reception completes the Arc when the propagation reaches us.

The CMB therefore shows the universe in its early state, but not because the photons are old. Because the propagation-of-consequences from that era's photon-Arcs has been reaching us ever since. The propagation reached our region of the universe 13.8 billion ticks-worth of time after it left the source's region. What we receive is the *fact* of those early Arcs, not their *substance*. The substance is gone; the fact is what remains.

This is the only-moving-present picture, applied to the largest scales. There is no past that exists somewhere we could in principle travel back to. There is only the *present* — the 3D-plus-boost reality — and the streams of facts arriving from

ever-more-distant regions of the universe, each region having contributed its facts at the moment its Arcs fired.

9. Gravity, time, and the speed of light as three faces of one mechanism

The structural unification. If §3 through §8 are right, this is the major unification at Tier 1, and the spine of the document as a whole.

9.1 The unified picture

The mechanism is one. Machian-inertia-as-applied-paradox propagates the consequences of each Arc.

- The *photon-Arc* instantaneously updates the universe's facts for the pair of objects directly involved. No time is involved in the Arc itself.
- *Machian inertia* propagates the consequences to every other object at finite rate, limited by the rate at which paradox-resolution work can be done.
- *Time* is the visible signature of that propagation when viewed as duration. What we call "the passage of time" is the accumulation of paradox-resolution ticks.
- *Gravity* is the visible signature of that propagation when viewed as how-things-now-move. What we call "gravitational attraction" is the propagation expressing itself as the closing of distance between masses, mediated by their virtual centres.
- *The speed of light* is the visible signature of that propagation when viewed as how-fast-the-news-travels. What

we call "the speed of light" is the rate at which the consequences of an Arc reach successively more distant objects.

Three faces of one mechanism. Or four, if we count the photon-Arc itself as the fundamental event — but the Arc takes no time, and the three faces are what take time, so the right way to count is one mechanism with three temporal signatures.

This is the structural payoff of the picture. Gravity, time, and the speed of light are not three independent constants or phenomena that the universe happens to have. They are three ways of looking at the same propagation of paradox-resolution work. The reason they all involve the same constant (*c* in relativity unifies space and time; gravity propagates at *c* in general relativity; the speed of light is the same constant everywhere in the universe) is that they are the same thing seen from three angles.

9.2 Why gravity has no uncertainty

The diary's single line for this is from D044, 20 June 2021: *"gravity has no uncertainty"*. The reason fits the unification.

Quantum events have uncertainty because the outcome of an Arc is selected from the imminent future's possibility-space — King William the Wave's domain. The selection is paradox-driven but not predetermined; which possibility actualises depends on the shape of the possibility-space and on the contributions of every factor that has a bearing on the resolution. The uncertainty is the universe's openness about which possibility

will be selected. Until the Arc fires, the outcome is genuinely not yet determined.

Gravity, by contrast, is the propagation of consequences. Once the Arc has fired, the consequences are determined — the universe's facts have been updated, and the propagation of the update is geometric, not probabilistic. There is nothing for the universe to be "open about." George is exactly where he is, because he is the virtual sum of Eddie's and Freddie's rotations and the sum is what it is. The closing-pressure George imposes is exactly what it is, because the geometry of how the 2D shell distributes the constraint is what it is. Nothing about gravity needs to be "selected"; the constraint is what it is and propagates as it does.

This is why gravity is classical and quantum mechanics is quantum: the former is the propagation of consequences (which is deterministic in its geometry); the latter is the selection of outcomes (which is probabilistic in its content). The distinction is not between two different kinds of physics; it is between two different *moments* in the same physics — the moment of Arc-firing (probabilistic, because the outcome must be selected from possibilities) and the moment of consequence-propagation (deterministic, because the propagation is purely geometric).

10. The past as factual but not real

The past is a stream of facts running away from the present. The Arc-completed past is not a place that exists somewhere

behind us; it is the set of facts that were produced by Arcs that have already fired. Those facts are eternal in being true — they cannot become not-true — but they are no longer real in being instantiated in 3D reality.

10.1 The classical waterfall

D060A, 18 April 2025, has the formulation: *"Time is a waterfall of the past facts receding."* The waterfall image is apt because the past is not static — facts continue to stream away from the present as each new Arc fires. Every Arc produces a new present and simultaneously consigns the previous arrangement to fact. The previous arrangement is no longer real (it has been replaced by the new arrangement) but it is factually true that the previous arrangement was the case.

The waterfall is one-directional. Facts move from being part of the present to being part of the past. They do not move back. Nothing in the past can become real again, because *being real* is an irreducibly 3D-plus-boost matter, and the past has lost its boost. What persists is the *fact* of past reality — the true statement that, at such-and-such a moment, the universe was in such-and-such a configuration. That fact is in the universe's record; it is consistent with everything else; it will be consistent with every future configuration. But it is not currently being instantiated. It is past.

10.2 Where position lives once settled

A specific case: position. What is classical about a quantum event's outcome is the position of the particle after the

event. Post-collapse positional configurations move into the past as fully-determined facts. Mass and momentum belong to the present — they are intrinsic shapes that the present's particles bear. Position, once settled by an Arc, belongs to the past.

This is the diary's formulation from D060A, 7 April; D060C, 18 June; D064A, 28 April. Position becomes classical because once the Arc has fired and the particle is *here*, the universe's record contains the fact of *here-at-this-moment*. That fact is now part of the past stream. The current present has the particle at its current position, which is a different fact — likely close to the old one for a slow-moving particle, but different.

The implication: position is not a stable property a particle *has*. It is a fact about where the particle was at the moment of each Arc that involved it. The succession of position-facts, strung together, gives the appearance of a continuous trajectory; but the trajectory is the as-if path that reconstructs from the discrete positional facts, not a continuous reality.

The §5.8 co-determination of rotation and position is what makes this consistent. At each gravity-Arc, rotation and position update together. The new position is the position the new rotation requires. There is no moment when one has changed and the other has not. The succession of position-facts is, equivalently, the succession of rotation-states; and the rotation-states are what produces the closing-pressure George imposes. Position and rotation are co-determined at

each Arc, both pass into the past together once the Arc fires, and the new Arc updates both together again.

10.3 Pure facts persisting after demergence

The past consists of facts that have lost their reality but retain their factuality. These facts are not nothing. They are *pure facts* — facts liberated from the thin range of 3D reality. The diaries' framing from D060A, 7 April 2025: *"the past is not real – it cannot change – but it is eternally true."* And D063B, 7 February 2026: *"the past only continues to exist as rather ghostly virtual facts, facts that do have the quality of being eternal."*

This is, in itself, a substantive ontological claim, and it bears on territory that Spirit will develop. *Pure facts persisting after demergence* are facts no longer constrained by the 3D reality they once described. They are facts in the same way that mathematical truths are facts — necessary in their content, not contingent on continuing instantiation. The afterlife, in Virtualism's ontology, is in the eternality of the past as fact: what happened, happened, and the fact of its happening is permanent.

Diary 064B, 20 May 2025, draws this connection explicitly: *"reincarnation is reintroduced here as a natural consequence of fact-persistence."* This is Spirit material; the development belongs there. But Virtualism's ontology grounds it, and the grounding is what this section establishes. A *positioning paragraph* in this document is appropriate; the development is reserved for Spirit.

10.4 The Butterfly of Fact

A useful image from D064B, 13 May 2025, is the *Butterfly of Fact*. Past and future are factual; present is real-plus-factual; reality is conserved by demergence. The image: the present is the body of the butterfly; the past and future are the wings. Each wing is fully factual but neither is real. The body is what is *real* at any given moment, and it is what holds the wings in their relations of being-past and being-future.

The image captures several structural features of the ontology. Past and future are both factual — both are facts in the universe's record, though future-facts are facts of possibility-space and past-facts are facts of completed events. The present is the only real thing. Demergence — the loss of reality at the past edge of the present, balanced by emergence at the future edge — conserves the total amount of reality the universe has at any moment. Reality is conserved by demergence. The same total reality is present at every moment, just rotated through different configurations.

A separate formulation from the same diary: *"Reality is a conserved quantity due to demergence."* And: *"The past has no reality, it is composed of empty, ghostly facts."* Both are candidates for placement in the Acta paper.

11. The Mandala cycle completion

Document one developed the production cycle's forward half: water (distant future) into air (imminent future) into earth (present), with photon-fire as the carrier of the Arc.
Document two develops the return half — earth into fire (the present settles into the past), fire feeding water (the past constrains the new distant future), water shaping into air again, air resolving into earth. The cycle continuously turns.

11.1 The cycle's return half

In document one, the temporal arrow and the production arrow ran in the same direction. Water-to-air-to-earth corresponded to distant-future-to-imminent-future-to-present, and both ran in the same direction.

In document two, the two arrows diverge. The temporal arrow runs backward — past behind us, present here, future ahead. The production arrow continues forward — the past *feeds* the next imminent future via Machian rearrangement.

The Mandala cycle's return half therefore runs:

- *Earth → Fire*. The present settles into the past. The earth-configuration of the present (over-determined, determinate) becomes a fire-fact (classical, completed) as it joins the past stream.
- *Fire → Water*. The past's facts constrain what the next distant future can be. Wholes of the present — galaxies, planets, civilisations — propagate their shapes forward as outlines in the distant-future possibility-space. Fire feeds water; the determinate past gives shape to the non-determined

future.

- *Water → Air*. The distant future tightens into the imminent future as the present's facts continue to constrain. What was open in the distant future becomes specified in the imminent future. King William the Wave's domain takes particular shape.
- *Air → Earth*. The imminent future resolves into the present via the Arc. One of William's possibilities is selected; the rest demerge; one new present is produced.

The cycle turns continuously. Every Arc fires in air, produces earth, and the earth-of-this-moment becomes the fire-of-the-next-moment. The fire feeds the new water of the distant future, the new water becomes new air, and the next Arc selects again.

11.2 Constraint as resource-and-limit

A point worth drawing out. The fire's constraint on water is not deterministic; it is *resource and limit*. The Many Worlds of possibility, in the distant future, are loaded by what has already become. They are not predicted by it.

This means the past is constraining but not determining. Multiple distant-future configurations are compatible with the past's facts; the past does not pick out a unique future. The universe's openness — what makes the Arc a genuine selection rather than a pre-determined unfolding — is preserved at every turn of the cycle. The constraints are real and substantive (the universe cannot do *just anything*), but the constraints are *enabling* as much as restrictive (they shape the space of

possibility rather than collapsing it to a single point).

This is the Markovian-meets-Many-Worlds reconciliation. The past influences the future only through the present (Markovian); the present's imminent future contains genuinely many possibilities (Many Worlds, but only as possibilities, not as parallel realities). The cycle's return half — fire feeding water — is the moment where the Markovian and the Many Worlds intersect: the past constrains what possibilities can be present in the new imminent future, but it does not constrain them down to one.

D064B, 13 May 2025, has the diary's formulation: *"The past is entirely entailed in the present, although many of the facts of the past are ineffectual dust."* The past is *in* the present as constraint; not everything in the past is currently active, but everything in the past is in principle available to constrain the next moment's becoming.

12. The 4D-hypersphere geometry

A worked geometric subsection, supporting the structural account developed in §3–§6. Document one stated only the bare claim that mass introduces a fourth dimension via imaginary rotation; document two does the worked example.

12.1 The basic setup

Dave is the timelike (purely imaginary) centre of a 4D hypersphere. Real objects live on the surface of the hypersphere;

their imaginary boosts (rest mass) put them on the surface at some distance from Dave's central position.

The four dimensions are three real (x, y, z) and one imaginary (w, in the diary's notation). Real objects have non-zero values for x, y, z and (because they are real) zero for w if they have no mass. If they have mass, their imaginary content is non-zero, and they have been rotated partly into w-space.

The distance metric for the hypersphere has two flavours, depending on whether we are using Euclidean (rotationless) or Lorentz-like (rotation-into-imaginary) geometry.

Euclidean: $D^2 = x^2 + y^2 + z^2 + w^2$. The imaginary unit vanishes under squaring, so all four coordinates contribute positively to the distance. This is the geometry of unboosted points on a 4D hypersphere: they all sit at the same distance from Dave, regardless of their direction.

Lorentz-like (allowing rotations into the imaginary axis): $D^2 = x^2 + y^2 + z^2 - w^2$. The imaginary axis contributes negatively. This is pseudo-Euclidean (Minkowski-like) and is the geometry that obtains when objects are rotated into the imaginary axis — i.e., when they bear boost.

12.2 Pure imaginary translations and Lorentz-like rotations

Two further properties of the geometry:

Pure imaginary translation of all points does not change the 4D distance between them. If Dave moves purely in the

imaginary direction, the real-projected distances between all other objects remain the same. This is what makes Dave a *timelike* centre: he is not at any real-space point. He is at a purely imaginary position, and his movements in the imaginary direction do not produce real-space changes.

Lorentz-like rotation (hyperbolic rotation matrix with cosh θ and sinh θ) does change the real-projected distance. When objects are rotated through angle θ into the imaginary, their real-space separation contracts by the cosh-and-sinh factors that constitute Lorentz contraction. This is the structural origin of length-contraction, mentioned in §5.2: it falls out of the rotation-into-the-imaginary, rather than being put in by hand.

12.3 Unboosted vs boosted points

Two results worth stating in full.

Unboosted points on a 4D hypersphere drift apart when the radius increases (Euclidean balloon). If the hypersphere expands, all points on its surface drift apart in proportion. This is the geometric foundation of the expansion-of-the-universe in Virtualism's account: the universe's underlying hypersphere is expanding, and all the unboosted points on its surface drift apart accordingly.

Boosted points rotate into the imaginary direction, and the real-space distance between them shrinks. The opposite effect: when objects are boosted (have mass and gravitate), they rotate toward each other through the imaginary direction, and their

real-space separation closes. This is the geometric foundation of gravity in Virtualism's account: massive objects boost toward each other, the boost is a rotation through the imaginary, and the rotation contracts their real-space distance.

Boost is a rotation mechanism. The same geometry that produces length-contraction at high velocity produces gravitational attraction at any velocity. The two phenomena are deeply unified in the geometry; they are different expressions of *imaginary rotation*.

12.4 The depth of this section

This section's depth is calibrated to support the conceptual account in §3–§6 without taking over the document. The diary material (especially D060A, 23 April 2025, the ChatGPT exchange, and D060B, 21 May 2025, the gravity simulation specifications) goes deeper than is appropriate here. Document-two-readers can take §12 as the headline statements and refer to the diaries for the worked-derivation level.

The diarist's 2026 addendum to D060A invites further work: *"Perhaps Claude can make a better fist of this."* That work is for a separate document — most plausibly a *Mathematical Foundations* companion that develops the formal apparatus the ontology requires. The present document gives the geometry as philosophical support, not as primary mathematical content.

13. Engagements with the contemporary literature

The deferred engagements collected in one place. Verlinde-style emergent gravity is the most substantial, but several others warrant placement: Builes-and-Impagnatiello and Mulder on Presentism, Van Raamsdonk on spacetime from entanglement, Arkani-Hamed on the Amplituhedron, and several smaller items.

13.1 Verlinde-style emergent gravity

Already positioned in `positioning_verlinde_and_emergent_-gravity.md`. The substance: Virtualism and Verlinde share the *programme* — gravity is emergent — but differ on the *mechanism*. Verlinde's mechanism is thermodynamic (entropic gravity from holographic-screen thermodynamics). Virtualism's mechanism is numerical and dimensional — pre-gravitational, paradox-driven, with gravity emerging at stage 2 of the Mandala cycle from the boost-rotation that mass is. The Hossenfelder circularity criticism that sinks Verlinde does not transfer to Virtualism, because §5 of this document gets the inverse-square as a consequence of geometry rather than reverse-engineering it from premises that already contain gravitational acceleration.

The Verlinde engagement in this document is therefore *lighter* than the positioning note's full development. §5 has absorbed the substantive Hossenfelder-checklist response. The multi-body case — where Verlinde's account fails to give a conservative gravitational field — is addressed in Virtualism via the Machian-rearrangement mechanism (every Arc shifts Dave, and the propagation of Dave's shift reaches every other object). Virtualism's account is intrinsically multi-body

because Dave is the universal centre and George is the local centre, and any number of masses can be present with virtual centres at every relevant level.

13.2 Builes and Impagnatiello on Presentism

Sam Builes and David Impagnatiello have argued that the Markovian structure of physical law supports Presentism. The laws of science are Markovian — the way the present evolves depends on the present state, and the past influences the future only through the present. This is a substantive point in favour of Presentism: if the past has any influence on the future, that influence is fully captured in the present's state; there is no need for the past to exist as a region in order to do its influencing work.

Virtualism agrees with the Markovian structure but adds substance to it. The past is *factual* (not merely "no longer existing"); the present is *factually richer* than science usually admits (because it contains all the past's facts as constraint, including the facts of past Arcs that have left their traces); and the way the past influences the future is through the present's fact-set, which contains everything the past has bequeathed. *"The past is entirely entailed in the present, although many of the facts of the past are ineffectual dust."* (D064B, 13 May 2025.)

This is a stronger version of the Markovian point than the standard one. Standard Markovianism says the future depends only on the present *state*; Virtualism says the future depends on the present's *full fact-set*, which is much richer than

the state (it includes all the past-facts that contribute through Bob's-perception-of-Alice-style mechanisms). But the Markovian *structure* is preserved: nothing reaches into the future except through the present.

13.3 Mulder on Negative Presentism

Mulder has argued that time is best understood as a *sui generis* predicate rather than as a dimension. Virtualism agrees with the rejection of time-as-dimension but rejects the sui-generis-predicate alternative. Time is emergent from change. *Change* is dynamic; time is the *signature* of change's pace. Mulder is right that time is not a dimension (or at least not in the standard block-universe sense), but wrong to call time *dynamic* in itself — the dynamism belongs to change, and time is what change leaves behind in the universe's record.

Diary 064B, 13 May 2025: Mulder's negative presentism is too weak; Virtualism's account is stronger because it grounds time in change-via-paradox-resolution rather than in a predicate applied to a substrate. The substrate-free version is more parsimonious.

13.4 Van Raamsdonk on spacetime from entanglement

Mark Van Raamsdonk has argued that spacetime is something distilled from quantum entanglement relations. The geometry of spacetime, on this picture, emerges from the entanglement structure of the underlying quantum state. This is closer to Virtualism in spirit than Verlinde's thermodynamic route,

because both Van Raamsdonk and Virtualism take spacetime to be *derived* rather than fundamental.

The disagreement is about the derivation. Van Raamsdonk has entanglement as the more-fundamental relation, with spacetime distilled from entanglement. Virtualism has paradox-driven dimensional emergence (developed in `numerogenesis_v003.md` and `positioning_existence_and_dimensions.md`) as the more-fundamental relation, with spacetime emerging from the sequence of dimensional thresholds the universe's own production line crosses. Entanglement, in Virtualism's account, is a particular kind of Arc (the Simon-mediated kind) and is itself a derived rather than fundamental relation.

Where Van Raamsdonk and Virtualism converge: spacetime is not fundamental, and the right description of physics requires moving below spacetime to a more fundamental layer. Where they diverge: what that more fundamental layer is. For Van Raamsdonk it is quantum information; for Virtualism it is the paradox-dynamic of dimensional emergence.

13.5 Arkani-Hamed on the Amplituhedron

Nima Arkani-Hamed has developed the Amplituhedron — a geometric object whose volume corresponds to particle-physics scattering amplitudes — as part of a programme to derive spacetime from more-fundamental geometric structures. The slogan is *"spacetime is doomed"*. Virtualism shares the slogan: spacetime is derived, not fundamental.

The two programmes differ in their candidates for what

replaces spacetime as the fundamental layer. Arkani-Hamed has positive geometry (the Amplituhedron and related objects); Virtualism has paradox-driven dimensional emergence. The detailed engagement is for a separate paper; here it is sufficient to note that Virtualism is an ally of the spacetime-is-doomed programme, with its own candidate for the replacement.

13.6 The centre of gravity as virtual fact, not subject to Heisenberg

A specific point worth registering. Doc one mentioned in passing that the centre of gravity of any body is a virtual fact — and therefore not subject to Heisenberg's uncertainty principle. Doc two has developed the worked account: George (the virtual centre of Eddie and Freddie) is virtual; the Earth's centre of mass is virtual; Dave (the universal centre) is virtual. Virtual centres are *classical-because-virtual-fact*. The Earth's centre of gravity is exactly where it is; there is no fact-of-the-imminent-future about its position that needs resolving via an Arc.

This is a substantive metaphysical claim. It means that virtual facts have a different epistemic status from real particles. Real particles are subject to uncertainty because they bear intrinsic possibility-space (their imminent future contains multiple possible Arcs they could be involved in). Virtual facts have no imminent future of their own — they are constitutive facts about the configurations they characterise, and they are exactly what those configurations make them be. The centre of gravity is determinate because the configuration that gives rise to it is determinate, not because the centre

itself has been "measured" or "collapsed."

D060A, 9 April 2025, and D044, 20 June 2021, are the diary sources for this. The point matters because it bears on how gravity gets to be classical: virtual centres are classical-because-virtual; gravity propagates through the constraint of virtual centres on their parts; therefore gravity is classical. This is the deep reason for §9.2's *gravity has no uncertainty*.

13.7 No singularities

Inside a large mass, the push from close to the edge squashes up the inside, but gravity (which is a gradient phenomenon) is excluded from the middle because there is no more middle than the middle. Hence no singularity at the centre of black holes. And no Big Bang singularity: the universe's underlying hypersphere did not begin at a point but emerged through the sequence of dimensional thresholds the production line of numbers crosses (see `nothingness_and_beginning_v001.md` and `numerogenesis_v003.md`).

Singularities arise only if space and time are treated as fundamental containers. They dissolve when both are emergent. The dissolving is not by stipulation but by mechanism: the production line that gives rise to space and time does not permit the kind of "point of infinite density" that singularities require, because density is a relation between content and the space it occupies, and the space is being produced *alongside* the content. The very thing the singularity would have been "infinite *of*" cannot be infinite because its scale is being co-produced with what it is the

scale of.

D060C, 11 June and 26 June 2025, are the diary sources. The fuller account belongs in a cosmology document; this positioning paragraph is the minimum needed to register the position.

13.8 Entanglement Bell-test resolution in detail

Doc one §8 gives the positioning: entanglement-Arcs (Simon-carried) differ from photon-Arcs (Philip-carried) in transferring information rather than energy, which is why one produces apparent time-passage and the other does not. Doc two develops the full mechanism in light of §6's apparent-past account.

The key claim from D063B, 7 February 2026: *"time only emerges when energy is transferred."* An entanglement-Arc transfers information (the spin-state, or some other binary fact) but no energy. Because no energy is transferred, no time-of-arrival is generated for the receiver: Simon does not arrive at Bob with a time-stamp; he arrives with a fact. The fact is in Bob's fact-set as soon as the Arc fires.

This is why entanglement appears to give "instantaneous" action at a distance, while photon-mediated effects propagate at *c*. The difference is not that entanglement signals propagate faster than light. The difference is that entanglement Arcs *do not generate the apparent past at all*, because they carry no energy and so no propagation-of-consequences in the energy sense. The information is in both observers' fact-sets the

moment the Arc fires; there is no transit through which Alice's state could change relative to what Bob receives, because Bob receives a fact, not a continuing-state-report.

This is consistent with the Bell-test results — entanglement correlations are perfect across spacelike separations, which is what you would expect if the Arc fires once and updates both endpoints' facts in the same instant. The "no spooky action from past to future" formulation of D063B captures the picture: nothing is spooky, because there is no real action being transmitted; the Arc updates both endpoints' facts in one event, which is structurally what entanglement is.

The Bell-test is therefore not a paradox for Virtualism; it is a confirmation of the picture. The diary's formulation from D064B, 5 May 2025 (also a doc one aphorism candidate): *"The Bell test is the key that releases us into a landscape of Freedom."* The freedom is from the false picture of action at a distance through space; the Bell-test shows that the universe operates through Arcs that update fact-sets in single events, without anything actually crossing space.

14. Forward pointer and close

The two documents — *Change and the Present* and *Gravity and the Past* — together constitute Virtualism's account of the temporal arc and the production of reality. The first develops the quantum side of change and the production of the present; the second develops the propagation side and the past. Between them they give one closed exposition of how the universe

generates itself moment by moment.

What remains to be developed in companion documents:

- *Cosmology.* The early universe; the cosmic microwave background as observed past; the question of beginnings. This document has positioned the no-Big-Bang-singularity claim and the CMB-as-fact-of-early-Arcs claim, but a full cosmological development is for another time.
- *Mathematical foundations.* The numerical foundation as developed in `numerogenesis_v003.md`, extended into the formal apparatus the ontology requires. The 4D-hypersphere geometry of §12 belongs in this companion at a worked level.
- *Iconism (separate project).* The bearing of the imaginary-rotation account on consciousness, the relation between ideal objects and the imminent future, and the consciousness-as-stage-of-emergence material.
- *Spirit (separate project).* The pure-facts-after-demergence material, reincarnation as fact-persistence, soul and afterlife in the eternal-fact framing, astrology and the planetary scope of phenomena.

The Acta Analytica paper on paradox and emergence — the live publication target for Tier 1 — draws on this document for the unification of gravity, time, and the speed of light as three faces of one mechanism. §9 is the structural payoff that the paper most directly needs; §5 on G as exchange rate is the formulation that gives the paper its sharpest single contrast with mainstream physics.

The closing image, from D060A, 18 April 2025: *Time is a

waterfall of the past facts receding.* Behind the waterfall is the present — the only place where reality lives. Ahead of the waterfall is the imminent future, King William the Wave's domain of possibility, waiting for the next Arc to select which strand becomes the next present's. The waterfall is one-directional; the present is irreducibly *now*; and the cycle between the past's constraint and the future's possibility, turning Arc by Arc, is what we have been calling *the universe*.

End of document. Version v1.0, May 2026. Builds on `change_and_present_v1_0.md` (document one of the pair), the mapping note `past_and_machian_gravity_map_v003.md`, the positioning note `positioning_verlinde_and_emergent_-gravity.md`, and the foundational documents `foundations_v001.md`, `paradox_and_emergence_v003.md`, `mandala_framework_v004.md`, and `numerogenesis_v003.md`. Vocabulary corrects the gravity-map v003 §4 misidentification of William: King William the Wave is the wave function representing the imminent future of possibility, not (as the map mistakenly recorded) a rejected alternative Arc-carrier from doc one §6. The wave function's role in this document is mostly structural: William's domain is what resolves with each Arc, and the propagation of consequences this document develops is what makes that resolution play out across the universe at finite rate.