Shift-symmetry in Einstein's universe: Part C: Time-symmetry

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Part of a series. In this paper we look at Einstein's demand (supported by Eddington) that the fundamental equations of physics be time-symmetrical.

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1. Introduction

This is the fourth of a series of papers [1] [2] [3] [4] [5] [6] exploring Einstein's concept of shift-symmetry.

In this paper we look at **time-symmetry**: we are taught in the lecture hall that mathematical physics *must* be time-symmetrical, and since the only relativistic equations that *are* time-symmetrical are those of Lorenz aether theory and special relativity (and "relativity plus time-symmetry" gives SR), if time-symmetry *really was* a fundamental aspect of reality, the SR equation-set would be unavoidable and undeniable.

Under Einstein's vision for theoretical physics, physical law is completely symmetrical with respect to time. This is a feature of the SR equations used in his special and general theories, and is intimately linked to his approach to energy-conservation.

> **Eddington (1929):** [7] " Time's Arrow. ... [the] primary laws of Nature which, as we have seen, are indifferent to a direction of time. "

> **Einstein (1938):** [8] " … such equations as those of the gravitational and of the electromagnetic field are actually invariant under a reversal of the sign of time … "

> **Richard Feynman (1964):** [9] " … it's easy to prove that the law of gravitation IS time-reversible. And the law of electricity and magnetism? Time-reversible. The laws of nuclear interaction? Time-reversible, as far as we can tell. The laws of beta decay … also time reversible … (but we shall see … I don't know). "

But in the real world our universe is quite obviously NOT time-symmetrical. The fact that we all seem to share a common concept of the "normal" default direction of time that requires no explanation, and the fact that that (after the concept of reversed time has been explained to us) we still have no trouble in our daily lives differentiating between the two directions, suggests that there is something very deeply asymmetrical about timeflow physics ... even if we find it difficult to identify exactly what this difference is.

The failure of theorists to adequately model or explain observed time-asymmetry using only fully time-symmetrical components, applied symmetrically, has been one of the long-standing problems of theoretical physics in the Twentieth Century, to the extent that it has been argued that perhaps a theory that does *not* show time asymmetry fails a basic test by not corresponding to reality. [10] [11] [12]

In this paper, we show that a range of effects are fundamentally time-*asymmetrical* at the level of the most basic laws and foundation equations, breaking Einstein's "symmetrical" world-view.

The more speculative elements of these arguments have been split off into a separate paper, "*On microgravitational waves*" [13]

2. Overview

2.1 Reality is not time-symmetrical

Our universe distinguishes between "forward" and "reverse" time directions. Although some philosophers have attempted to pass this off as an unphysical quirk of the human mind, there is nothing about timeflow that requires human intelligence or consciousness: if we keep a notebook, then the book's state "now" will "remember" things that we wrote in the past, but nothing from the future. The notebook is not required to be either conscious or intelligent for this to work, merely *persistent*.

Similarly, a library's book collection will exclusively contain books published before the current date, and the fossil record will contain imprints of creatures that lived many millions of years ago, but nothing from what will follow us. A telescope trained on deep space will show events from the distant past, but nothing from the future. These asymmetries are physical, and quite real. When mathematically-inclined philosophers attempt to dismiss timeflow asymmetry as some invention of the human brain, it is an admission that they cannot replicate these behaviours symbolically, but do not want to admit the possibility that they might be using a wrong set of symbolic logic.

Since the human brain is not immune to the laws of physics, and must operate within them, even if our perception of timeflow *was* somehow a quirk of human consciousness, there would still have to be some asymmetry in the actions of the brain's biochemistry or physics to explain how it was that we all ended up experiencing timeflow in the same direction.

2.2 Eddington, revisited

Eddington said in his 1927 Gifford lectures [1] [7] that criticisms of special relativity for not having an arrow of time were unfair, because the same lack of directionality had also existed in every other previous classical theory, SR's impropriety being merely that it had made the absence of an arrow more *obvious*. [i]

While this is a powerful-seeming defence of special relativity, it is also terribly wrong: as a simple example, the Doppler prediction under $C19^{th}$ Newtonian theory for a body receding at half lightspeed is $E'/E = (c-v)/c = 0.5$ … but in reversed time, an apparently-receding body whose velocity is half lightspeed instead has a recession redshift of $E'/E = c/(c+v) = 1/1.5 = 0.666'$ – a physically different result. In a Newtonian universe, we can check whether we are experiencing time forwards or backwards by checking the Doppler relationships. [14]

In a relativistic theory such as Newton's, the Doppler relationships need to be the same for everyone, and need to be a simple function of different bodies' relative motions. If we generalise the continuum of all possible potential relativistic equations, we find that the LET/SR set is the only one that shows time-symmetry. [15]

> Within relativity theory, the basic equations were historically *asymmetrical* with respect to time, until the advent of Lorentzian electrodynamics and special relativity.
>
> The absence of an arrow of time (within relativity) is an LET/SR innovation. [15]

i **Eddington (1927):** [7] " *… Objection has sometimes been felt to the relativity theory because its four-dimensional picture of the world seems to overlook the directed character of time. The objection is scarcely logical, for the theory is in this respect no better and no worse than its predecessors.* "

Doppler relationships in reversed time

In "absolute" non-relativistic aether theories, we can usually obtain E'/E = 1 over a round trip by using different Doppler relationships for the two different shift stages, according to how each observer moves through the aether. [i]

Relativistic theories are not allowed to do this: they must apply the same Doppler formula to all observers. SR textbooks usually give legacy "aetheric" descriptions accompanied by Lorentz corrections, generating the same final composite recession relationship for everyone, of $E'/E = \sqrt{(c-v)/(c+v)}$ [ii] [16].

To time-reverse a Doppler relationship, we invert the right-hand ratio (which represents the ratio of the outcome values "before" and "after"), and also reverse the ± polarity of the velocity values, to reflect the fact that time-reversal turns recession velocity into approach velocity, and vice versa.

With Newtonian theory, this converts the recession redshift formula from

$$E'/E = (c-v)/c \quad , \textit{to} \quad E'/E = c/(c+v) \; .$$

With special relativity, this converts the recession redshift formula from

$$E'/E = \sqrt{(c-v)/(c+v)} \quad , \textit{to} \quad E'/E = \sqrt{(c-v)/(c+v)}$$ ... no change

The SR shift equation-set is time-symmetrical: the Newtonian set is not. [iii] [14]

How Eddington managed to make this mistake is not obvious: perhaps he liked special relativity so much, and felt that its scheme of things was so natural, that he simply assumed that this *ought* to be correct default behaviour, without checking. Unfortunately, due to Eddington's reputation as one of the few people on the planet who *really understood* relativity theory, [17] nobody else seemed to check whether his characterisation was realistic, and there are now over three hundred research papers that cite the Eddington piece, without anyone seeming to have noticed the mistake.

If we believed Eddington, we would think that time-symmetry was a fundamental and universal property of classical physics, and this would lead us naturally to treat the SR equations as the only logical possibility (and to then go on to apply them within a general theory, giving GR1916). Since Eddington's mistake (plus relativity) makes Einstein's system logically and psychologically inescapable, the error may have inadvertently helped to cement Einstein's special and general theories into the research community's consciousness as theories that "couldn't be wrong."

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i Absolute aether theories did tend to give the appearance of being time-symmetrical for strictly two-body problems ... they would assign different equations to a fixed and a moving body, and under time-reversal, we could explain the flipped equations by saying that the aether was now stationary in the other frame.

ii Under SR, if we choose to believe that the speed of light is fixed in our own frame, we expect to see a propagation shift of $E'/E = c/(c+v)$, combined with a Lorentz redshift of $E'/E = \sqrt{1 - v^2/c^2}$

The theory's *uninterpreted*, *physical* prediction is then $E'/E = c/(c+v) \times \sqrt{1 - v^2/c^2} = \sqrt{(c-v)/(c+v)}$

Alternatively, if we choose to believe that the speed of light is fixed in the *emitter*'s frame, we expect to see a different propagation shift, of $E'/E = (c-v)/c$, combined with a Lorentz blueshift (due to our own time dilation) of $E'/E = 1/\sqrt{1 - v^2/c^2}$

The theory's *uninterpreted*, *physical* prediction is then, once again, $E'/E = (c-v)/c \; / \; \sqrt{1 - v^2/c^2} = \sqrt{(c-v)/(c+v)}$.

iii Although these examples use simple approach and recession velocities, similar calculations work for other angles.

3. "Statistical" time

Before we can start on exploring timeflow properly, we need to dispose of the subject of entropy, which is sometimes invoked as providing an important arrow of time.

Since Eddington, researchers tried hard to explain how it could be that a time-asymmetrical universe could be constructed from nothing but time-symmetric parts, a thankless (and, one might think, *technically impossible*) job.

In the approach invoked by Feynman, asymmetrical timeflow is blamed on **statistical behaviour**:

> **Richard Feynman (1964):** [9] " … the apparent irreversibly of nature does not come from the irreversibility of the fundamental physical laws; it comes from the characteristic that if we start with an ordered system and have the irregularities of nature bouncing, then the thing goes one way. "

Starting with a glass tank containing two types of molecule, nominally "black" and "white", then, if the individual molecules are free to move throughout the tank, and each type occupies a different side of the container at the start of the experiment (t=0), then the molecules' random walks will cause the two populations of molecules to gradually mix, and after a reasonably short period of time, the tank's contents should appear fairly uniformly grey. The **entropic arrow of time** is then the direction of time in which the state of the system becomes less specific and more generic, and according to Feynman, it is this *statistical* arrow that is responsible for time-asymmetry.

There are multiple problems with Feynman's argument:

1. Once the tank appears uniformly grey, we can no longer use mixing to keep track of further entropic timeflow. Has time stopped? No.
2. **Poincare's recurrence theorem.** If no information is lost from the system, the molecules should eventually return to their original positions and velocities. The counter-argument to this is that, as far as we know, nobody has ever seen such a vastly-improbable event to happen, and the amount of time needed for this cycling to happen *perfectly* might be many, many billions of years ...
3. ... However, on its way to cycling back to its original state, the molecules may pass through an inconceivably large number of *other* absurdly-improbable states, some of which might be *even more* improbable than the initial state. [i] So the "cycle time" calculation is not to be relied on.
4. We can also start with a highly contrived initial state, in which the molecules' initial positions and velocities are such that they mix and unmix in an oscillating cyclical pattern really quite quickly, until irregularities in the glass wall surfaces cause the oscillating system to become more blurred and to tend towards uniform greyness. At each oscillation, time is not running backwards.
5. The entropy argument is a measure of statistical drift from a predefined state. If the labels "black" and "white" assigned to molecules are purely nominal, and the molecules are all identical, then we are free to change the labels and define the

i … for instance, if the molecules might suddenly spell out the name and home address of the experimenter, that might be considered even more improbable.

system as going through any number of improbable states, purely through definition. The arrow disappears. If we choose to define the nominally "separated" state as the state that exists two hours *into* the experiment, the tank is defined as moving from a "grey" state at t=0 to a "separated" state at the two-hour mark, showing us the reversed-entropy behaviour that supposedly never happens.

6. If the universe has never been seen to spontaneously separate out a gas into "black" and "white" molecules, then we can ask where our pre-separated tank came from. If we track the "initial" velocities and positions of the molecules at t=0 *backwards*, through the period *before* t=0, we will have a description in which, for the previous few hours, a tank of "grey" gas *did indeed* separate out, the separation completing at t=0.
   On the other hand, if we say "*humans did it!*", then the separation of gases *still* happens, thanks to the statistically-improbable actions of *Homo sapiens*.

3.1 Entropy and selection bias

Feynman's argument rests on **selection bias**, on how we select an "initial" reference-state, and on the decision to only track changes away from that state in the forward-time direction. Suppose that we placed a hiker on the top of Mount Everest: we could say that, if they walk North, their altitude above sea level will always *tend* to decrease (on average), and that therefore we can show a significant statistical correlation between northward travel and reduced altitude, analogous to our association between entropy and timeflow.

But this correlation is artificial – if we place the hiker ten miles *south* of Everest, then initially, the further North they walk, the *higher* they get. Or we could have them start at the same peak and walk due South, or West, or East, and still find as good a correlation. [i]

3.2 The uniformity problem

With our gas-tank, and with our hiker, the increase in mixing and the decrease in altitude are both *statistical trends*, which allow local variations and brief polarity-reversals (for instance, the descending hiker may find themselves sometimes climbing up smaller peaks or clambering over large rocks on their Northward descent). But our personal experience of timeflow is that we *never* see it running backwards.

The answer to how time-symmetrical statistics could produce a time-asymmetrical universe seemed to be *fluctuation*: In any random system there will be statistically rare events where order seems to suddenly appear, and it could be argued that our entire universe consists of a statistical fluctuation. But it is uncomfortable, if we are using statistics to explain an arrow of time, to also have to reject statistical probability and invoke a huge, *cosmologically improbable* fluctuation as the basis of everything, presumably also invoking the anthropic principle to argue that this is "necessary".

Once we allow the intrusion of the anthropic principle, statistics become moot because the principle can always be used to selectively override statistical behaviours that we dislike or find unhelpful. If we allow overrides, the subject of statistical mechanics loses legitimacy.

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i In this analogy, if the hiker were to walk once around the entire circumference of the Earth and return to their original position, this would be the counterpart of Poincaré recurrence.

The Earth's surface need have no *inherent* relationship between "Northwardness" and reduced altitude, but we would have *manufactured* a correspondence by (a) artificially choosing the highest part of the Earth's surface as our start-point, (b) placing the hiker at that position without explaining how they got there, (c) only looking at the path Northward and studiously ignoring paths leading away from the "initial" position in other directions, and (d) refusing to look at paths long enough to include other significant mountain peaks, or long enough for recurrence.

3.3 The teacup problem

Another common way of expressing the entropy issue to to say that although we see teacups being dropped, and breaking, and sandcastles eroding on sandy beaches and being blown away in the sea breeze, leaving featureless sand, we never see teacups and sandcastles *forming*. [9] But this begs the question, **where do all these teacups and sandcastles *come* from?** Does the universe start off with an initial stock of teacups and sandcastles, which steadily decreases as the universe ages? If we say that teacups are not seen to simply "happen" all by themselves, then someone who works in an automated robotic ceramics factory might disagree, and if we inspect CCTV coverage of our sandy beach, we will see sandcastles indeed forming, by the agency of small children armed with buckets and spades.

At this point, the arguer will usually make a distinction between "artificial" and "natural" causes, and say that teacups and sandcastles and divided tanks of molecules are created *artificially* by humans, and that entropy relates to *natural* processes. But humans are not Gods, immune to entropy and timeflow and physical law. In the study of entropy, humans are just another part of Nature, another part of the larger mechanism.

Perhaps the creation of teacups and sandcastles is such an important job that the universe has allowed humans to evolve specially to be able to carry out this critical work.

3.4 Reversing entropy doesn't reverse time

a) Oscillating systems

We can contrive to build a mirrored container in the form of an elongated hollow ellipsoid with a mirrored inner surface, and set off a burst of light at one of the two focal points, "**A**". The light spreads out within the volume, becoming more dissipated, until it reflects off the mirror and reflects to converge on the second focus, "**B**". Becoming more and more intense, it creates a momentary new point of energy at **B**, and then passes through and away from **B** as a new expanding wavefront, that is then reflected and refocussed back to **A**, the process continuing indefinitely (at least, until the wavefront degrades due to imperfections in the shape of the mirror). Although the energy is repeatedly dissipating and refocusing, producing repeated reversals in the direction of the entropic arrow of time, what we *think* of as time does not reverse or cycle. [i]

Replacing the lightrays with molecule paths, we could set off explosions of "white" and "black" particles at the two focii, and if there were not too many particle-particle collisions, after an intermediate "grey" mixing state, the molecules, following simple trajectories, would then tend to separate out again at the two focal points, and then repeat the process.

b) Systems with energy input

We can also take the case of our Earth, which is the beneficiary of net energy-input from the Sun. Entropy on Earth runs backwards: rather than its information degrading and becoming more difficult to read, the Earth's information-content *increases* with time: the geological record becomes increasingly complex, plants and animals evolve increasingly complex systems requiring more DNA, energy is stockpiled in the planet's crust as fossil fuels, and the internet gets bigger rather than smaller. We build sandcastles and manufacture teacups. And yet, somehow, time on Earth does not run backwards compared to the outside universe.

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i As far as we know! At least, we do not *expect* the direction of timeflow to oscillate in the chamber.

3.5 Feynman's summary

Richard Feynman's summary of the problem in mainstream fundamental theory in the early 'Sixties, based on theory largely inherited from or influenced by Einstein's work, still seems to apply today:

> **Feynman (1964):** [9] "… it is obvious to everybody that the phenomena of the world are evidently irreversible …

, but,

> **Feynman (1964):** [9] " In all the laws of physics that we have found so far there doesn't seem to be any distinction of the past and the future.
>
> This obvious distinction between what happens, the past and the future, and this obvious irreversibility of all phenomena, you would think … its interpretation … that there's somewhere in the works, some kind of principle … and that this one-way business of the interactions of things is the thing that makes the whole phenomena of the World seem to go one way. And yet we haven't found it yet.
>
> That is, in all the laws of physics that we found so far there doesn't seem to be any distinction of the past and the future."

In other words, we still didn't seem to really understand what was going on.

Feynman's conclusion, surprisingly, was that, instead of rewriting our physical laws so that they *do* explain reality, we should accept that law and reality don't seem to agree, and to blame this on the complexity of the hierarchy of intermediate emergent structures that lie between fundamental law and the human experience.

> **Feynman (1964):** [9] " Although we've been talking in these lectures about the fundamentals of the physical laws, I must say immediately that one does not obtain an understanding of anything much … Nature as a matter of fact seems to be so designed that the most important things in the real world seem to be a kind of complicated accidental result … ".
>
> "… an understanding of the physical laws doesn't give you an understanding of the world in any way. "

Feynman blames,

> " … *the hierarchy of complexity* … Today, we cannot — and there's no use making believe we can — draw carefully a line all the way from one end of this thing to the other.

But blaming hierarchy doesn't work. If timeflow was simply an emergent statistical-thermodynamic behaviour, then we should expect fluctuating anomalies in the direction of time at all scales, and should also be able to reverse time by reversing energy-flow. We cannot insert a new behaviour into the hierarchical "stack" of laws, that cannot be derived from fundamental law, without it being, itself, another fundamental physical law.

The objective test of physical law is *supposed* to be how well it corresponds to reality. Our existing time-symmetrical laws are either incomplete or wrong, and if they do not let us derive the missing law, then they are probably incomplete ***and*** wrong.

3.6 Statistical time: the verdict

We cannot blame uniformly-forward timeflow on statistical behaviours and trends that are time-symmetrical. Even if we isolate a broad regional trend associating increased entropy with forward timeflow by selecting a statistically-unlikely state as a starting-point, and showing that the system will (initially) tend to move away from that state as time progresses, if the selected "initial" state is truly a *maximum*, the period directly *before* that state must have been increasing *toward* the maximum, and the exact behaviour that we have said is never seen to happen in real life, *must have just happened* in order for the experiment to exist.

We can get around this in cosmology by specifying a defined initial state that really *is* an initial state and has no previous time (a "Big Bang") ... but over smaller scales, a statistical explanation will tend to encourage us to expect fractal-style polarity-inversions at all scales. We can point out that Hubble expansion skews the statistics … but in this case, perhaps it is then *the expansion itself* that is the root cause of time-asymmetry in our region. [i]

Statistics is not enough: there must be some other explicitly time-asymmetrical behaviour at work, and this additional behaviour must either be built into existing fundamental laws, or must be an additional fundamental law itself.

i A discussion of cosmological issues to do with timeflow will be given in **Part D**. [5]

4. Gravitomagnetism (GM) destroys time-symmetry

4.1 Gravitomagnetism is impossible under SR-based systems

The special theory of relativity tells us that the effects of acceleration and rotation are **absolute**. If inertial physics is seen as a flat-spacetime problem, the relative velocity of masses is not supposed to be associated with any metric deviation from flatness. We can then go further and calculate the effects on an accelerating observer, who seems to feel a gravitational field ("gee-forces"). Since the path of a forcibly-accelerated spaceship can be broken down into a stream of arbitrarily-small velocity-differentials, and SR can model composite shifts with the use of its velocity-addition formula, if SR is correct for constant-velocity problems, it should also be valid for acceleration problems. [18] The intrinsic curvature due to an accelerated mass is then calculable from the aggregated distortions associated with all the individual velocity stages along its journey … which under SR, is zero.

So special relativity lets us prove that there is no such thing as spacetime curvature due to forced acceleration. [19] [20] The accelerated observer's experiences are treated as being due to their *curved path through flat spacetime*, and an inertial onlooker sees the space as remaining flat. Since this lets onlookers decide absolutely who is "really" accelerating, acceleration under SR-based physics is an absolute property.

4.2 Gravitomagnetism is essential with general relativity

Under a general theory of relativity, acceleration and rotation are **relative**: the effects felt by an accelerating or rotating test mass are due to their relative acceleration or rotation with respect to background matter. Blaming these effects of relative motion of matter means that there should be **mutuality**: if an accelerated spaceship pilot feels a gravitational field due to the relatively-accelerating background stars, then nearby bystanders should in turn also feel a gravitational field due to the relative acceleration of the spaceship.

Since an accelerated (or rotating) body *feels* forces due to surrounding matter, it must also *exert* forces on that nearby matter, and deflect light ("back-reaction" / "democratic principle").

> **Einstein (1913):** [21] " ...
> 2. An acceleration of *K* induces an accelerating force acting on *m* in the same direction.
> 3. If *K* rotates, then a Coriolis field arises inside *K*, such that a pendulum set up inside *K* is influenced in such a way that its plane of oscillation is carried along. "

> **Einstein (1921):** [22] " The equations of motion, … show, now, in fact, that …
> 2. There is an inductive action of accelerated masses, of the same sign, upon the test body.
> 3. A material particle, moving perpendicularly to the axis of rotation inside a rotating hollow body, is deflected in the sense of the rotation (Coriolis field). "

> **Einstein (1922):** [23] " [Mach's] interpretation brings about the expectation that accelerated bodies have concordant accelerating action on other bodies (acceleration induction). "
>
> " … acceleration induction does indeed exist according to the gravitational field equations "

4.3 Accelerative and rotational GM require velocity-dependent GM

If we *need* accelerative GM in order to construct a general theory, and the application of the SR relationships prove that we *cannot have* accelerative gravitomagnetism, we know that, under a general theory, inertial physics cannot follow special relativity's narrative. [24]

4.4 Gravitomagnetism requires non-SR equations

This disagreement between special and general theories over gravitomagnetism shows at the level of the Doppler equations. If we use Doppler-shifted wavelengths of light as "rulers" to map space, then with the SR equations, the space around a moving star maps as being similarly "flat" regardless of the velocity of the star.

The Doppler relationships of SR/LET, carefully derived to be a *perfect fit* to flat spacetime, then also *enforce* flat spacetime. If we want the relative motion of stars to physically distort spacetime, as required by a general theory, we must use non-SR Doppler relationships. [20]

4.5 Gravitomagnetism requires time-asymmetry

We already know that the SR equations are the only set that support both the relativity principle and time-symmetry. Since we are deciding to keep the relativity principle, any theory of gravitomagnetism must have a Lorentzlike deviation away from the SR Doppler equations and must therefore be asymmetrical with respect to time. [25]

4.6 Gravitomagnetism requires energy-loss

Since the Doppler relationships describe the energy of a signal sent between two relatively-moving bodies, Doppler time-asymmetry manifests itself as an energy-asymmetry. Gravitomagnetism is not compatible with traditional energy-conservation, [i] and its time-asymmetry manifests as an energy-loss in forward time and an energy-gain in reverse time. [ii]

4.7 Gravitomagnetism forbids time-reversal

Since energy-gain is considered unacceptable in physics (the "no infinite energy machines" rule), gravitomagnetic theory must then also prohibit any physical observer from experiencing reversed time. While this would seem to be the strongest form of time-asymmetry possible, the restriction also seems to be in complete agreement with all known experimental evidence. We have, in the history of the human species, apparently never encountered any person or thing that experiences or has experienced time in anything other than the normal direction, we apparently have no credible evidence that any such thing has ever happened, and if such a thing was theoretically possible, we have nothing in mainstream physical law that would suggest to us how to make such a thing come about.

Since current theory does not have a proper arrow of time, or assign polarity to worldlines, it does not understand *even the concept* of a timeline running in the wrong direction.

This represents a big gap in our knowledge, and it is perhaps comforting to think that this theoretical void may exist for a reason: because the "missing" physics associated with physical time-reversal simply doesn't exist. [13]

4.8 GR and RG destroy time-reversibility

Lastly, since any valid general theory ("GR") or theory of relativistic gravitation ("RG") must use gravitomagnetism, and gravitomagnetism cannot use SR's flat, time-reversible equations, we know that *full* relativity and the relativity principle applied to gravity both require time-asymmetry, and forbid an Einstein-style system.

It is the a condition of validity that any proper general theory must be time-asymmetrical.

i .. but see sections 6 and 7 for how energy-conservation can be restored, by taking into account gravitational radiation.

ii More correctly, asymmetrical gravitomagnetic equations require energy-loss in *one* direction of time, and energy-gain in the other. We can then pragmatically choose to define "*forward time*" as "*the direction in which the energy-change is negative*".

5. The bouncing ball

Imagine a bouncing ball.

- **In a simple, "naive" idealisation** in which the ball is assumed to be perfectly elastic, we can prove that, if there is no obvious energy-loss, the ball bounces to the same height each time. This is time-symmetrical, and produces results that look identical in forward and reversed time. [i]
- **In a more realistic idealisation**, the ball's repeated path-reversals due to gravity represent reversals of the ball's gravitomagnetic field, and these field-reversals must propagate into the surrounding space as gravitational waves. As well as these smooth reversals caused by the pull of gravity on the ball, there are also more violent and abrupt reversals when the ball hits the ground, and these events, too, can be taken as origin-points for the emission of gravitational waves. Since gravitational waves require energy, these energy-losses cause the ball to bounce slightly lower each time. [ii]
- **In the time-reversed version**, the ball bounces slightly *higher* each time, due to gravitational waves *arriving* at its location.

The waves generated in the second description propagate outwards as concentric sets of expanding spherical wavefronts, that are eventually absorbed by matter further away.

But in the time-reversed description, these distant interactions conspire to produce concentric *inward*-moving spherical wavefronts that transfer energy to the ball, synchronised with the ball's oscillations, in manner that seems to the human mind to be highly contrived and disturbingly well-coordinated.

Even if the mechanics of gravitational wave propagation were thought to be perfectly time-symmetrical, the overall behaviour in reversed time, of remote supposedly-uncoordinated events generating gravitational signals, that just happen to conspiratorially synchronise in such a way as to produce a concentric set of shrinking spherical wavefronts, timed and positioned in advance to be *just right* to give the future bouncing ball at their centre a nudge in the right direction at the appropriate point in its cycle, seems not just "spooky", but downright creepy.

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i Simple gravity is therefore expected to be attractive in both forward and reversed time. No matter whether we "run the film" forwards or backwards, we still see the ball's path being attracted downwards.

ii We also have other forms of energy-loss, such as the sound of the ball impacting the floor, and the heat generated within the ball's structure from the deformation of its molecules on impact.

6. Relativistic energy-loss and thermal redshifts

6.1 Recoil redshifts

The atoms in a hot gas must be constantly be changing direction and undergoing repeated accelerations as they bounce off each other. Under special relativity this – in a very idealised description – is not a problem: the light passed through a region of hot gas should emerge at the far side with exactly the same energy it started with, as the Doppler effects due to the different intermediate velocity-stages between atoms cancel perfectly, and because, with the SR Doppler relationships, there are provably no further shift effects due to acceleration. [18]

In a more considered model, we can also consider the effects of **recoil redshifts**, which can be thought of as further Doppler recession redshifts due to the recoil (and therefore assumed velocity-change) of the emitting atom on emission, and the recoil of the receiving atom on absorption. This recoil effect is difficult to derive, as the actual mechanics of the local recoil of a *part* of an atom during during the brief emission period is not obvious. [i] Recoil redshifts are also difficult to incorporate into the *fundamental* equations, as the velocity-change also depends on the quite-arbitrary masses of the emitting and absorbing bodies: a "bigger" atom might be expected to recoil less due to the same photon-transfer, and therefore show a smaller recoil redshift, then a smaller atom. [ii]

These are all difficult issues. In practice, experimental physics addresses them "pragmatically", by saying that since we *know* that SR is correct, when experimental tests of SR have a habit of reporting redshifts stronger than the SR predictions, that – whatever the difference happens to be between the SR prediction and the actual "redder" experimental data – this is necessarily due to recoil redshifts in the emitter, the receiver, and/or the intermediate optics. [iii]

In an SR-based model, we are supposed to be able to (effectively) eliminate this recoil redshift by using a crystalline material in which the recoil is shared across the whole crystal lattice (the Mössbauer effect [26]) – this should make any recoil velocity-change, and any resulting recoil Doppler redshift, arbitrarily small.

6.2 Gravitational-wave "taxation"

Using "recoilless" Mössbauer hardware, special relativity will predict that the redshifts and blueshifts of signals traversing the medium should then cancel out exactly ... no thermal redshifts. However, this is at odds with gravitational wave theory, which demands that momentum exchanges are associated with "microgravitational" ("µg"*)* wave events, [13] which should carry away energy.

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i The idea of recoil redshifts is conceptually difficult, as, if we treat the emission of a photon as a pointlike spacetime *event*, we are saying that the atom's back-reaction to the event (conventionally treated as *subsequent* to the event) changes the event's nature. This implies some form of causal "negotiation" *during* the event (then again, QM does have a habit us letting us "blur" sharply-defined geometries).

The counter-argument is that the emission of a full wavelength of light, or even a wavelike pulse with an identifiable period, must take a finite amount of time.

A third argument is that perhaps, if the interaction surface is changing velocity during the emission of a pulse, that the pulse waveform perhaps might be expected to affected, but with a time-variant distortion (wave-shaping), as the ejecting surface has different velocities during different parts of the pulse.

ii The energy absorbed in these "conventional" recoil effects presumably shows up in the energy-accounting as an increase in the material's average molecular speeds, as increased kinetic/thermal energy.

iii If recoil redshifts do NOT exist, then we can no longer invoke them to explain excess redshifts in experimental tests of SR, and a number of experimental validations of the 1905 theory transmute into apparent experimental disproofs of special relativity.

In this scenario, a hot gas is constantly radiating μ*g* waves, and since the energy for these must come from somewhere, there needs to be a form of momentum-and-energy "taxation" on a signal sent between two atoms, required to "pay" for the necessary generation of a μ*g* wave.

This problem was recognised by Einstein:

> **Einstein (1916):** [27] " Nevertheless, due to the inneratomic movement of electrons, atoms would have to radiate not only electromagnetic but also gravitational energy, if only in tiny amounts. As this is hardly true in nature, it appears that quantum theory would have to modify not only Maxwellian electrodynamics, but also the new theory of gravitation. "

> **Einstein (1918):** [28] " It has already been emphasized in a previous paper [27] that the end result of this investigation— which would require a loss of energy of bodies due to the thermal agitation—must raise doubts as to the general validity of the theory. It seems that a more complete quantum theory would also have to bring about a modification of the theory of gravitation. "

The reason why Einstein seems to have reacted with alarm to the suggestion of gravitational waves, is that *g*-waves and μ*g* waves wreck his neat SR-based system. Since the SR model already generates perfect energy-conservation *without* taking into account μ*g* waves, when we factor in the additional radiant energy of the waves, the total energy of a system and its surroundings are constantly increasing. On the other hand, if a photon with given characteristics sent between two masses with a particular relative motion only allows energy and momentum to be conserved when we *include* the outgoing μ*g* wave, then the receiving atom should presumably report the incoming signal to have less energy than SR predicts.

Special relativity then no longer has the right fundamental Doppler equations. To obey the principle of relativity, any deviation from SR must be "Lorentzlike", any Lorentzlike deviation from SR gives a Doppler energy-loss in forward time and an energy-gain in reverse time, we lose Einstein's shift-symmetry, we lose time-symmetry, and we lose special relativity (and Einstein's SR-centric attempt at a general theory).

If gravitational (and micro-gravitational) waves are real, then Einstein's guiding principles do not correspond to the behaviours of the universe that we live in.

6.3 Has the Einstein-violating thermal redshift already been measured?

When the Harvard group set out to measure gravitational redshifts (1959-1960s), [29] [30] their hopes of a comparatively simple experimental setup were dashed by the discovery that their Mössbauer equipment, which was supposedly recoilless, nevertheless suffered from an unpredicted thermal redshift effect that, according to the then-current theory, shouldn't have existed.

It is conceivable that the *experimentum crucis* for time-asymmetry may have been carried out by accident over sixty years ago, without anyone involved appearing to realise the result's potential importance.

7. Einstein *vs.* gravitational waves

In a universe that supports *g*-waves, every event that alters the energetic distribution of a system represents the creation-point of an *outgoing* gravitational wave, when seen in forward time: in reversed time every such redistribution culminates in an event that also represents the absorption of an *incoming* gravitational wave.

Einstein's distaste for the idea of *g*-waves can be seen in his 1938 attempt to arrive at the equations of motion using gravitational theory, using time-symmetry to argue that gravitational waves didn't happen:

> **Einstein, 1938:** [8] " Our method, in which the time direction is not distinguished, corresponds to the introduction of standing waves in the wave equation and cannot lead to the conclusion that in the circular motion of two point masses energy is radiated to infinity in the form of waves."

Gravitational waves were gone! The radiation of energy from binary stars is nowadays considered a theoretical vindication of Einstein's general theory, but as late as 1938, Einstein was still arguing that we knew that this class of behaviour did not happen, because we knew that the gravitational and electromagnetic fields' behaviours needed to be time-symmetrical.

> **Einstein, 1938:** [8] " In our theory, however, the equations to be solved at each stage of the approximation are not wave equations but merely spatial potential equations. Since such equations as those of the gravitational and of the electromagnetic field are actually invariant under a reversal of the sign of time, it would seem that the method presented here, is the natural one for their solution."

Einstein is using the assumed correctness of one of his three pillars (time-reversibility) to "prove" the correctness of another:

> **Einstein, 1938:** [8] " Actually, the only equations of gravitation which follow without ambiguity from the fundamental assumptions of the general theory of relativity are the equations for empty space, and it is important to know whether they *alone* are capable of determining the motion of bodies. … We shall show in this paper that the gravitational equations for empty space are in fact sufficient to determine the motion of matter represented as point singularities of the field. " [i]

A presumed time-symmetry is being used to argue that the motion of matter can be modelled using the field equations for empty space, echoing his 1905 assumption that the motion of matter can be described using a *light-metric* based on empty space, which in turn reinforces the idea that gravitomagnetic complications can be ignored in inertial physics, and that the correct equations are therefore the flat, time-reversible, non-GM set supplied by special relativity.

Einstein invokes time-symmetry to help "prove" that a rotating double-star does *not* emit gravitational waves. Our willingness to spend over a billion dollars on the LIGO programme, whose entire mission is to *detect and record* gravitational waves suggest some measure of confidence that Einstein's 1938 argument was wrong, and that gravitational waves *do*, in fact, exist.

Assuming that Einstein's logic was correct, and that only his assumptions were wrong, this then casts some doubt onto his assumption of time-reversibility.

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i Since the 1938 arguments presuppose time-symmetry, the principle of relativity plus time-symmetry *alone* should have been enough for Einstein to be able to declare immediately that the SR equations were correct, with no further calculations required.

8. Einstein *vs.* wave theory

Einstein's objection to gravitational waves – that their bulk behaviour suggested that time was not symmetrical – was not restricted to gravitational signals. The same argument also held for *any other form of wavelike behaviour, whatsoever*. Our conventional view of causality, in which information's causal influence propagates outwards as a wavelike feature, suggests time-asymmetry, and according to Einstein's worldview, this meant that the wave description was suspect – perhaps the *very nature* of wave theory was fundamentally wrong?

> **Einstein (1909):** [31] " The basic property of the wave theory that gives rise to these difficulties seems to me to lie in the following. While in the kinetic theory of matter there exists an inverse process for every process in which only a few elementary particles take part, e.g., for every molecular collision, according to the wave theory this is not the case for elementary radiation processes. According to the prevailing theory, an oscillating ion produces an outwardly propagated spherical wave. The opposite process does not exist as *an elementary process*. It is true that the inwardly propagated spherical wave is mathematically possible; however, its approximate realization requires an enormous amount of emitting elementary structures. Thus, the elementary process of light radiation as such does not possess the character of reversibility. Here, I believe, our wave theory is off the mark. … "

Einstein seems to have been placated by the subsequent further development of quantum mechanics, as a photon-based description appeared to transfer mass-energy and information between emitter and absorber as a point-to-point transfer that looked the same in reversed time. However, it is interesting to realise that Einstein's belief in a *totally* time-symmetrical universe was so strong that at one point he was prepared to consider getting rid of classical wave theory in order to achieve it.

But even these extreme measures would not have solved Einstein's problem, as we would still have quantum mechanics' *probability* waves to deal with, and of course, if we dropped a lump of bread into a duck-pond, the same circular radiating water-waves in forward time and troublingly-"conspiratorial" converging waves in reversed time, would still quite obviously happen. Trying to define waves out of existence *mathematically* does not change the obvious realities of daily life.

9. Summary

- **Reality is not time-symmetrical.** We all agree as to which direction in time is considered to be "forwards".

> ⚠ *Time-symmetry is not a recognisable property of our universe.*

- **Statistics and entropy do not explain timeflow.** The way that we measure time does not obviously depend on entropy.

> ⚠ *Entropy can slow or reverse without time running backwards. The arrow of time is not based on entropy.*

- **Gravitomagnetism ("GM") breaks time-symmetry.** The SR relationships require light-geometry to remain perfectly flat as a function of bodies' relative velocities, while gravitomagnetism requires it to curve – SR and gravitomagnetism cannot coexist. To lose SR but retain relativity, any deviation from the SR relationships must be *Lorentzlike*, but any Lorentzlike deviation from SR introduces time-asymmetry.

> ⚠ *Gravitomagnetism gives time-asymmetrical equations.*

- **Relativistic gravitation *generates* gravitomagnetism.** Relativity applied to gravity requires a finite speed of gravitational signals. [32] A finite c_g plus relative motion distorts the shape of gravitational fields, giving gravitomagnetism.

> ⚠ *Relativistic gravitation gives time-asymmetrical equations.*

- **General relativity *requires* gravitomagnetism.** Gravitomagnetic effects are needed to "relativise" accelerational and rotational effects, and accelerational and rotational GM cannot exist unless there is also a velocity-dependent gravitomagnetic effect, again invalidating SR.

> ⚠ *The general principle of relativity gives time-asymmetrical equations.*

- **Gravitomagnetism is "lossy" with respect to energy.** In the gravitomagnetic equations, time-asymmetry presents as an energy-loss in forward time.

> ⚠ *The fundamental equations must lose energy in forward time to accommodate gravitomagnetism.*

- **Gravitational waves remove energy from a system.** This must be paid for, somehow.

> ⚠ *The fundamental equations must lose energy in forward time, to pay for the cost of g-wave production.*

10. Conclusions

Einstein's concept of perfectly time-reversible physics is mathematically "neat and tidy", but incompatible with any workable relativistic theory of gravitation. The time-reversible 1905 equations are geometrically incompatible with gravitomagnetism, which is necessary for both simple relativistic gravitation and for any valid general theory of relativity.

Further, as Einstein pointed out, simple physical events are associated with the creation of outgoing gravitational waves in forward time but the absorption of incoming *g*-waves in reversed time, producing a functional bulk asymmetry and a form of **causal convergence** that sits badly with normal ideas about causality. In reversed-time physics, apparently-unconnected events conspire over great distances to create huge contracting wavefronts that shrink towards anticipated future events, and the present contains records of the future. [i] Information-flow behaves asymmetrically with respect to time. [13]

Gravitomagnetism enforces an "energy tax" on system changes, and the radiation of that energy as gravitomagnetic waves creates continual energy-losses in thermal systems at the level of the most basic particle interactions. This prevents systems from achieving equilibrium, and causes a bias toward exothermicity that creates a thermodynamic arrow of time at the smallest scales.

If we live in a GR universe, or a universe in which stars and planets obey the principle of relativity, or a universe in which gravitational waves are real, then the fundamental equations of physics must not be symmetrical with regard to time.

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The next paper will look at the results of Hubble expansion on Einstein's system

i In forward time, a telescope pointed at a distant supernova shows us a record of a past explosion. In reversed time, the image that we feed *into* the telescope causes photons to be emitted that contribute to the future implosion of the star. The image contains a clear imprint of a future event. Vast numbers of other interactions, scattered over many lightyears also conspire to emit signals that contribute to the implosion.

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