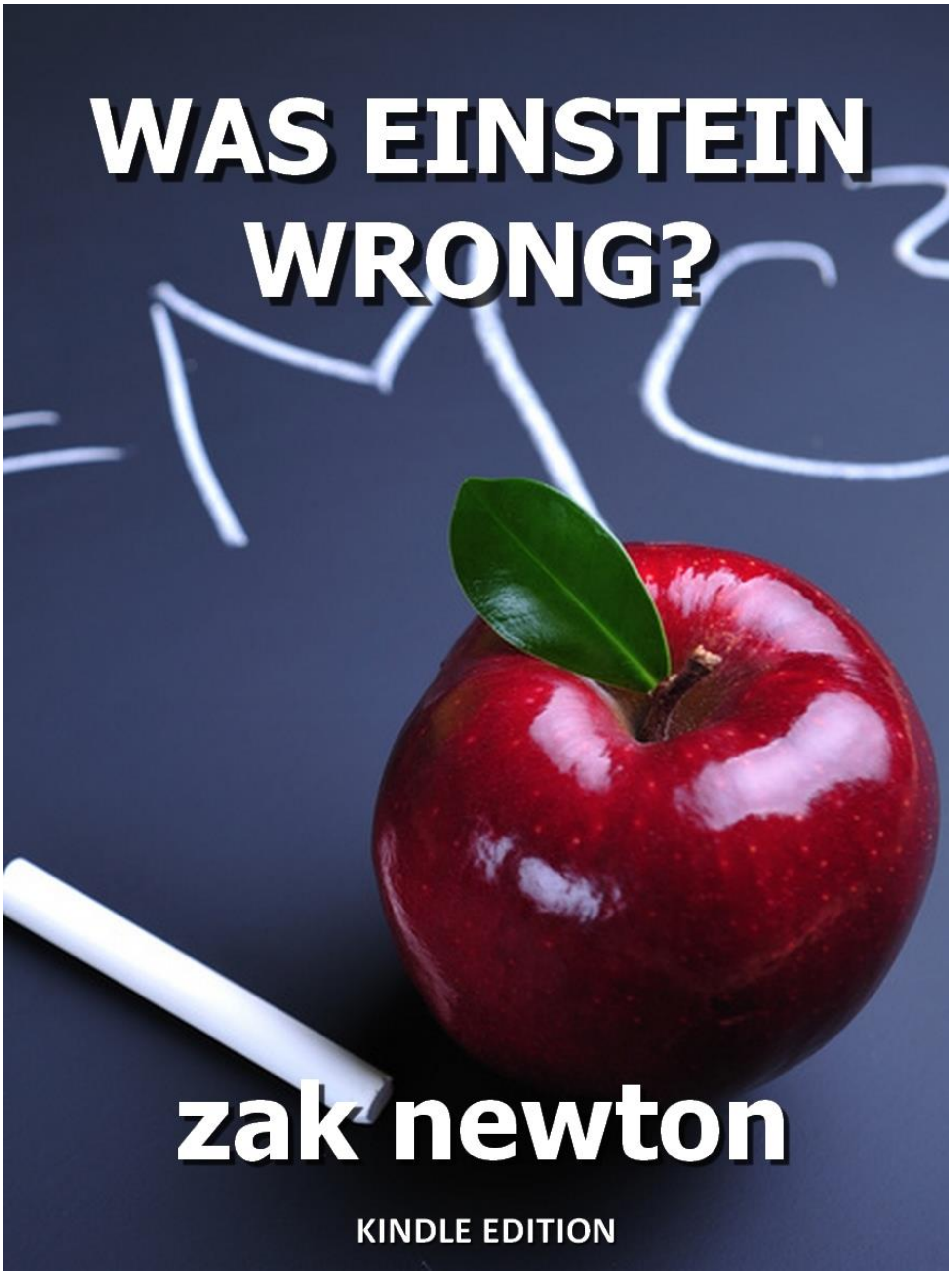
WAS EINSTEIN
WRONG?
zak newton
KINDLE EDITION

WAS EINSTEIN WRONG?

ZAK NEWTON

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END OF SAMPLE

‘Due to my position I prefer not to be identified at this time.
That’s why I have chosen to publish using a pen name.’

Zak Newton - October 2012

One - Introduction

Hello. Thank you for choosing this book: I hope you enjoy it.

Please have ready a comfy chair, a nice cup of tea (or beverage of your choice) and a willingness to invest just a couple of hours in understanding one of the greatest mysteries of the last hundred years: Einstein's Relativity, in all its ghastly (and undeserved) glory.

But first, let me assure you that you will *not* need to be expert in advanced mathematics or Physics. I *promise* you will find this an easy read: you'll need only a tiny bit of maths ('One plus One equals Two', yes? Good) and some really easy stuff like Newton's 'Distance = Speed x Time' and that's about all. (And even without that, you'll still get most of this, honest!)

In the following pages I hope to explain why

- Sunlight doesn't kill you instantly (although according to Relativity it *should)*

- Light itself can travel at Lightspeed (although according to Relativity it *shouldn't)*

- Travelling at high speed really *won't* make you gain mass or shrink in size

- We really *really* ***COULD*** travel faster than light if we wanted (and some things – might be doing so already)

'- Mass' and 'energy' are *not* interchangeable

- We may find that light itself can travel faster (or slower) than we thought

- But time-travel still isn't possible. (Sorry about that.)

Because Einstein's Relativity is pure illusion: quite literally, just a trick of the light.

I will prove it all this with Einstein's own words and his own equations. I will show that just about every word ever spoken or published on the subject of Einstein's Relativity needs to be reconsidered. I will also show you *why* we've believed in Einstein for so long.

I will show you that Einstein actually *redefined* ‘motion’, ‘time’ and ‘distance’ to replace those familiar concepts with illusions. Quite simply, his ‘Relativity’ deals only with the *appearance* of things in motion rather than with that motion itself.

This is not a spoof or the work of a crank. This is serious, pure science. All it asks of you is your attention. Science geeks please note: this *is* the simplified version. Don’t write in to tell me I missed a bit. I know.

Off we go, then.

Tea ready? Good. Take a *deep* breath: we’re about to rewrite the history of Science --

I dare you to read on.

Two - The odd effects of Special Relativity

In this book I will be concentrating (mostly) on Einstein's Theory of Special Relativity – with occasional detours around the fun bits of the General Theory (and there *are* some, I promise.) In this chapter I want you to think about some of the implications of the predictions Einstein makes in his Theory.

OK – let's start with the name of it. What's so special about '*Special* Relativity'? Well, as we'll see, Einstein's first papers on his new idea dealt with a very restricted range of circumstances: objects moving in a straight line without changes of speed, direction or anything else – what is known as 'uniform motion'. When Einstein went on to develop a wider theory, without these limitations, that first theory became known as 'Special Relativity'. ('Special' in the sense of 'being a specific case of', OK?) The later *unlimited* version became 'General Relativity'.

So that first theory is just a part, a 'special case', of the latter, all-embracing theory?

Well – not quite: it's actually much more important than that. Why so? Because *all* of Einstein's later work depends on the ideas and formulae developed at that first stage. If the theories of Relativity's foundations are wrong, it is *all* wrong.

Right, then: Einstein's Relativity. You know a lot about it, already: of course you do! Even if you probably haven't studied his books (see references at the end of the book for a couple of goodies) you know that nothing can travel at the speed of Light (or any faster, either), that mass increases and length *decreases* the faster you move and that time runs more slowly the faster you move as well. As an object's speed nears Lightspeed (300,000 kilometres a second) its mass nears 'infinity' and its length diminishes to a point.

You may even have heard of the 'Space-Time Continuum' and the idea that we now have a fourth dimension of the Universe. Yes? (No? Don't worry – that bit *is* a little obscure.) And of course you know that the speed of Light is a constant. There's more to the theory than that but we'll leave it there for now. All that is true, isn't it? Sure?

Then it's time for my first question.

Why don't we all die of Sunstroke?

'Infinite mass'. What a tremendous idea that is. If it's right then if even *one* speck of matter achieves that speed then it would carry more mass than the *entire Universe*. If an object gets even *close* to Lightspeed its mass should be greater than that of our Solar System, greater than our Galaxy. So – how does Light itself manage to achieve that speed? How much mass does Light itself have? Why don't we all get smashed into nothing by all that 'infinitely massive' sunlight out there? Why doesn't the simple act of striking a match obliterate the whole planet? And how does CERN manage to accelerate particles to 99% of Lightspeed without the terrific increase in mass pulling the Moon out of its orbit – or at least causing an Alp or two to fall over?

Ah, but Einstein was a *genius,* wasn't he – so there *must* be a good explanation, yes? Next question -

How can I keep young and beautiful?

You'll have heard the one about the man who travels at really high speed and then returns to find that his stay-at-home twin brother has aged far more than he himself has, yes? Wow. How does that actually – *work*? The ageing process is a well-understood phenomenon and although the effects vary a little from person to person we do have a fair idea what to expect. Degradation of body tissue, lose of flexibility, changes in brain function, increased tendency to mutter to yourself (particularly about the younger generation), acquisition of a killer-instinct at Jumble Sales (that one is for females only)

You *know* it's coming: you *know* you'll grow to love comfy clothing (with elasticated waistbands) and large-print books. How does speed of travel *actually* affect the rate of these changes in your body? *What happens to make it so?*

Next question – and this one is a *goodie* -

Will there be a bigger sandwich?

According to Einstein, if an object is moving it will gain mass and lose length by an amount determined *only* by its speed - regardless of how much mass or length it had to start with or how much resistance any of it might normally put up. And all that extra mass and lost length come back again when the object slows down again. That's right: according to the Theory of Relativity objects lose their extra mass and regain their lost sizes at slower speeds. Where did it all get to? (Don't worry: if you didn't know Einstein said that, I'll show you further on.)

Extra mass! What an amazing prospect. Incredible! Let's see *how* incredible -

So here I am, travelling on a super-fast plane – just me as passenger, a cheese sandwich and a cup of tea (milk and two sugars, please). Now - exactly *what* gains the extra mass? My body? My clothes? The sandwich? Is there now more sugar in that tea? Or does *all* of it gain extra? And where does this extra stuff come from?

According to Einstein's Relativity the steel and aluminium of the plane, my flesh, my bones, the cheese in the sandwich, the tea……*all* of it gains mass *by exactly the same amount.* And then loses it again when we slow down. Speed – and speed alone – spins me a bigger cheese sandwich and then takes it back again. Wonderful!

And that is not all. Remember that time is supposed to run slower the faster you go? If time really does go slower the faster you go then it must also go slower for the physical reactions going on in the engines that sustain the plane's motion, mustn't it? So – how do we keep that plane moving *at* that speed? How does it stay up? If *I* have extra mass so must the plane which should mean that it needs *extra* oomph to stay up there but its engines are burning fuel more slowly so how….?

I sense it's time for my next question.

How do you squeeze water?

Einstein tells us that objects lose length the faster they move. Any object, regardless of what it is. Even my cup of tea, back there, becomes a slightly *shorter* cup of tea –

Hang on, aren't liquids supposed to be virtually impossible to compress? Isn't that the basis of every hydraulic system ever built? But there it all is, expanding and contracting just as a result of our speed. *All* of a moving object loses length when moving. That means that all of its component parts must also lose length – exactly the same amount of length – whether they are solid, liquid or gas, dense or hollow, fragile or resilient.

Now then: Classical Physics (all the pre-Einstein stuff: we still use it all day-to-day) knows a *lot* about how materials behave under pressure, under stress, when heated, cooled, pushed into or through other stuff or bounced off things. We know what structures will collapse readily and which won't; we know why some things crumple, some bend, some bounce and others shatter – and *lots* more.

One thing any engineer will tell you is that all materials behave *differently*. Hit a lump of iron and then a lump of chalk: different result. Freeze water: it expands: freeze iron and it contracts (and becomes surprisingly brittle). Don't build a bridge out of tissue paper: steel and concrete are better. And so on.

Try to make a hollow cube out of cling film: it won't stand up. Try the same thickness of tinfoil: better but it will sag, even when quite still. Try a similar thickness of iron: fine!

And *shapes* matter. An object with a pointy end moves more easily through just about anything (air, water, a brick wall..) than one that just has blunt bits. *And* that air, water or brick is pushing *back, resisting* the motion. And because of *that* most materials get *distorted* in motion. Aircraft and ships shorten a little, bullets and rubber balls flatten on impact – and so on. Some materials can recover their shape, some cannot. The ball will bounce back to its original shape but the bullet won't.

If *structures* matter, so does flexibility. Here's an example I rather like. Ever heard someone refer to the flight of an arrow as 'straight to its target'? Everyone knows that an arrow flies straight, don't they. Or maybe in a gentle curve, up a bit, along a bit and down a bit? We've all *seen* Robin Hood, haven't we?

That's not how it goes at all. An arrow in flight looks more like a snake on Speed. The body of the arrow contorts into an S-shape at the start of its flight and travels through the air whipping from side to side as its backside makes a determined effort to overtake the sharp end, only deterred by the flexibility of the arrow itself. Welcome to the 'Archer's Paradox' (I didn't make that up: this phenomenon actually *is* called that.)

It doesn't take much to see *why* this happens. Here you have the arrow, minding its own business on the ground, when some fool picks it up, sticks its feathered end onto a bit of string, heaves back on the bow and –

Delivers an almighty dose of acceleration to that unsuspecting rear-end. Off it goes with a yelp (or that could have been me as I caught my thumb again), heading straight for the target. But the sharp end is still stationary: *it* hasn't received any acceleration yet – and it won't either, until the 'push' from the rear is transmitted along the length of the arrow.

If the body of the arrow was more fragile or the air it was moving through offered more resistance this 'rear-end shove' would simply crumple up the arrow (and indeed the arrow *does* suffer a little compression in flight). But an arrow is necessarily made of strong material: it has to be or it could never penetrate a target. Traditionally it was made of wood, taken *along* the grain (have you ever tried to compress a tree?). (Modern arrows tend to be made of duralumin (the same material used to build the Zeppelins, as it happens…….) which behaves in the same way.) Its nature is therefore to resist lateral compression. The only *other* thing it can do is bend.

And so it does. First to one side and then the other, as the forces imposed by that 'rear-end' shove fight the arrow's attempt to return to its original shape.

Classical Physics has explanations for all these effects and *lots* of fancy names and formulae to help you calculate them. Einstein doesn't say whether his new effect is added on to all of these known ones or what changes are going on in the moving thingy to *make* it happen. The object's *other* dimensions don't change – there is no bending or flattening -

I repeat, Einstein says is that moving objects become shorter, purely as a result of their speed **regardless what that object *is*.** That is, regardless of how dense it is, whether it has a strong or a weak structure; regardless, too, of what it is moving *through* – a plain vacuum, air or water or another stronger or weaker substance; regardless of its *shape* –

In short, regardless of all the stuff we thought we knew about Stuff, a moving object shortens by an amount determined **only** by its speed. A bar of iron or column of water contracts by *exactly* the same amount as a balloon or paper dart – just as a result of its speed.

Oh – and don't forget that all these changes and effects undo themselves as the object slows down.

It was Lewis Carroll's White Queen who set herself to believe six impossible things before breakfast: she would have got on really well with Einstein.

Next question –

Do you have the time?

Time slows down? *Time -?* Wow. Now that *is* odd. Because Time doesn't actually exist. We invented it. Purely for our own convenience. Don't agree? OK, try to *find s*ome Time - not a measure of it: the thing itself. Any luck? Thought not: we really *did* invent the whole idea - and then devised ways to measure it. The Universe we inhabit couldn't care less what time it is or even what we mean by the idea: all the Natural World has is a system of Consequences. Cause and effect.

Neither animals nor plants react to any clock or natural calendar. Instead they respond to changes in the warmth of the air and the earth – and to lengthening hours of sunlight when they can see it. Where there is a seasonal shift at all (ie outside the Tropics) it is notoriously unpredictable. We know this all too well: bad weather in March and April means the flowers that bloom in the Spring (tra-la) probably *won't…*

Modern-day primitive societies (and by that I mean those in a 'first-state' of development: a *prime* state) don't bother with any time-keeping at all. It's a safe bet that our distant ancestors didn't, either. We don't really know when 'time' began to matter to our forebears. The earliest real sign of time-watching occurs quite late in our development: a water-clock, for example, or something very obviously intended for a sundial.

But here's a funny thing: not every culture or period of history had the same idea about the slicing-up of the day. In the Roman Empire, for example, available amounts of daylight and night-time were chopped into 12 lumps each, regardless of how long or short each bit was. An 'hour' in winter was one twelfth of the daylight hours in winter; an 'hour' in summer was one twelfth of summer daylight, a *lot* longer.

'Time' is what we make it to be: it is *entirely* our invention. In our European culture we chop up our years into months (*moonths:* now *there's* a hint) of unequal length – presumably just to be awkward – happy in the knowledge that a year equals one Earth-orbit and the Moon whizzes around us at a constant rate.

Well, no, actually: the Earth is slowing *down* in its orbit and the Moon is drifting further off as a result. Come back in about a million years or so and it really *will* be a good idea to start Christmas shopping in July.

And, of course, other cultures and civilisations have chopped time differently to us. For example, why *do* we have 60 minutes in an hour and 60 seconds in a minute? (Answers on a postcard, please, to the Royal Observatory at Babylon.)

Ah, the *second.* Wonderful thing, isn't it? It *used* to be defined as 1/86,400 of one rotation of the Earth – until they found out that bit about the Earth slowing down. *Now*, it's 'the duration of 9,192,631,770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the Caesium 133 atom'. (Honest! The so-called Atomic Clock was created by the NPL in 1955 just to count this stuff.)

Does anyone care about that sort of accuracy? Oh yes! Because Science tends to be very careful with our (Western European) idea of Time. In a Physics dictionary you will find it defined as 'the duration of an event' and quite a lot of what scientists do depends on a precise knowledge of how long things actually take to happen. The likes of NASA, busy buzzing rockets off hither and yon, need to be *very* precise: when the Apollo missions called for a three-second 'burn' on the engines they didn't mean '*roughly'….*

But Einstein claimed that this human invention is somehow part of a Universal 'dimension' and that time goes slower the faster you go (actually it is more complicated than that: I'll get back to what he *really* said in a bit).

If you find all that easy to accept, here's a *really* tricky one for you –

How massive do I look from over there?

According to Einstein, all motion is 'relative' and dependent on 'observation'. Where you stand and how you move determines how another object's motion will look to you - and there are an almost limitless number of such reference-points. Each one will give a different view - and a different value – of its speed, yes? (And, yes – I *will* go into all that later.)

But Einstein *also* says that 'speed' determines an object's energy *and* that energy is *also* 'relative'. Therefore **energy** *also* has an infinite number of 'viewing points', each of which will deliver a different reading. And *all* these infinite readings of its energy occur at the same time. Every object in the Universe has every possible value for its energy at any instant in time. Including each one of us.

He says the same about 'mass': Einstein says that 'mass' is just another way of expressing 'energy' and vice versa. Therefore, every object in the Universe has no mass/ some mass/ infinite mass and infinite energy/ some energy/ no energy (and all the infinite possibilities in between) all at the same time, *all* the time.

We all know ***that*** *equation –*

Don't we just! That $E = mC^2$ thing has impressed the heck out of all of us for a century. But – e'rm – that's just a normal(ish) equation, isn't it? That is an 'equals' sign, in there. Which everywhere *else* means a calculation. You work out the numerical value of the stuff on one side and it gives you the numerical value of the stuff on the other. The two sides have equal value. That is why it is *called* 'the equals sign' and the thing it is in an *equation.* A mathematical balancing act: nothing more, nothing less.

So – how come Einstein declares that it means mass *becomes* energy? That the two are actually the same stuff?

And if they *are,* what triggers a change-over? Why isn't the mass of that carpet, down there, changing into a blur of energy even as I write? (Check that formula: says nothing about any need to move, at all, does it?)

Wow, this is some theory! Oh, yes – I can hear you. No need to shout -

But he was a Genius, we just have to trust him!

OK – not a question, but something I seem to keep hearing: maybe you have, too. Something along the lines of 'if we don't understand *how* things work under his theory we just have to have faith in him: he was *such* a genius, we poor dimwits can't hope to understand him'.

Sorry – no, that won't do. This is Science: 'trust', 'faith' and 'belief' are fine things, I agree, but they belong in Religion. Not here. If Einstein's theory doesn't make sense we *are* entitled to ask why. We are *supposed* to challenge ideas, to question – and demand sensible answers.

Be very careful: if anyone ever asks you simply to take a scientific idea on trust – don't! Inspect it very, very carefully. Check it for yourself.

- *and he proved it all, didn't he?*

There *is* proof that he was right, surely? Lots? Actually – no, there isn't really *any* proof – quite the reverse. I'll take more space on this later on. For now please just note that Einstein said that his effects would only be detectable at extremely high speeds, near to Lightspeed itself; that at more normal speeds the old 'classical' theories would yield results indistinguishable from his.

Which would be fine were it not for the awkward fact that nearly every bit of evidence cited in his favour relates to low-speed motion while the *very* high speeds achieved by the CERN Particle Accelerator don’t seem to deliver the huge increases in mass he predicted. Near-infinite mass? Where?

There is also the awkward point that all the proofs offered for Relativity are capable of *other* explanations, based on long-established Classical physics. All but one, that is: the secret of Nuclear power – and that deserves a chapter all by itself.

Three -The weird world of General Relativity

I said I would take the occasional detour from ‘Special Relativity’. Here comes one: we are about to dip a tentative toe in the murky depths of ‘General Relativity’ just for a moment. Special Relativity’ nests within the General theory – or, if you like, the General Theory completes or rounds off the more limited ‘Special’ version. Therefore, if you snipe at one you inevitably wound the other. But the General Theory has weaknesses all on its own. For example –

Well, well, well – gravity and others

The new ‘General’ theory allowed Einstein to claim a new explanation for the phenomenon of gravity. In particular, his theory claimed to offer a new explanation of why it is that all bodies falling under the influence of gravity fall at the same speed, regardless of their mass.

Newton’s view of Space was that it was an inert, impersonal or passive place: nothing could affect it or be affected by it. Einstein’s new theory was radically different. He argued:

- that the presence of matter *curves* Space around it and

- that Space would not exist if there were no matter in it. That in fact Space is *created* by matter (as is Time)

The latter idea is a matter for Philosophy students. A Scientist should ask ‘how can you tell?’ But that *first* idea – Wow!!

The Curving of Space

According to Einstein’s General Theory, objects in Space modify that Space. He argues that Space is not ‘uniform’ in its character – that is, it isn’t the same all over – but is distorted by the presence of mass. And it is this distortion that creates the effect we refer to as the ‘force of gravity’.

All space is distortable in this way and *all* bodies, no matter how small, provide distortion. If you have a problem visualising that idea, have a lie-down: see if that helps. Comfy? Notice the way your body ‘distorts’ the bed as you lie on it? According to Einstein, that is how any object distorts the parts of Space around it. *Any* object – including the Sun, Moon, Earth and all the rest of it down to the smallest speck of dust – distorts Space in the same way.

(Well, not *exactly* the same: there aren't any crumbs or lost socks in Space but you get the idea.)

And as objects 'approach' such distortions, they naturally follow the same distortion – down towards the body causing it: the way a biscuit dropped in bed always rolls down to end up underneath you.

Nice image, isn't it? We all understand that sort of idea, even if we don't quite get the hang of the maths. There are problems with it, though: quite a few, actually.

We now know that Gravity isn't a uniform force. We *treat* it as if it were uniform to make the calculations easier but actually evidence shows that a body exerts gravity *unevenly,* depending on its physical qualities. 'Shape' and 'density' are the main things to check. The Earth, for example, is a flattened sphere – slightly flattened at the two poles. And it is quite lumpy – all those untidy mountains and stuff. Lots of dense stuff like granite. In short, Earth is a bit uneven in its shape and make-up.

And whaddya know - Earth's gravity is also uneven. Not by a lot but it *does* vary. The force of gravity you will feel – and therefore your own weight - actually depends on whether you are standing at the poles (heavier) or at the equator (lighter) or near a lump of something really dense like Scotland (heavier). Sorry about that, Scotland – must be all those deep-fried pizza suppers.

So it can't just be 'mass' that warps Space: we need to get *density* in there as well. To be fair, Newton's version has a similar problem: he, too, needs to get 'density' into it, somehow. But the real problem for Einstein is that *his* 'density' would have to be 'relative', dependent like everything else in his work, on how it *looks.* And good luck with *that* one. ('From over *here* does that rock look dense to you……?')

But we have another problem with Einstein's vision of bendable Space and this time it's a problem Newton's theory *doesn't* have. Look back at our example and think about it. Anything strike you? If I lie on a bed, my mass compresses the mattress – pushes it *down* – and displaces the air around me – pushes it *away*. Fine, so far: there are those definite substances for my vast bulk to dent or shove aside. And the displaced/compressed substances have been fully accounted for.

But Einstein said that mass distorted *space* : what does that 'distortion' actually do to the affected bit of space? Make it denser, like my mattress? Push it aside, like the air? Where does it go?

And – look, the *real* problem with that so-simple example is that it only shows you the supposed effect happened in *one* plane. Here's our rubber sheet; here's the orange, making the sheet *bend* – fine! But if Einstein is correct we actually have to imagine not one but an **infinite** number of these sheets, each set at a fractionally different angle from each other and each one being bent by the orange. Because gravity operates in *all* directions and from all angles.

So, we have to imagine Space not so much being bent as being *wrapped* around each object in it: around the stars and the planets but also around each little particle and even around each one of *us.* Each little lump or 'stuff' is somehow managing to *repel* Space from itself. How?

And, and – what happens when the lump of Space-distorting stuff *moves?* As our Earth moves through Space does the bit of vacuum it just left get unbent with a twang and a new bit get twisted up or do we drag our twisted bit of Space around with us all the time?

But let's not try to second-guess the Master! How does Einstein himself explain this? How does he explain the workings of this phenomenon?

He doesn't. We are just supposed to believe his theory.

'Inverse Square' versus 'Bendy Space'

Remember Newton's formula for calculating gravity? That it was a force 'inversely proportional to the square of the distance' between the attracting objects? Also known as the 'Inverse Square Rule' by those who like to generate confusing mental images (howdja draw an inverse square?....)

In essence it means that the closer you are to an object the greater will be its 'pull' on you (and yours on it, of course). You may not be aware, right now, of the gravitational force of Jupiter, let us say, but it *is* exerting one on you. At *this* distance, you can easily avoid getting pulled in. The closer you get to Jupiter the greater the force you need to resist its gravitational pull. Get *too* close and you are goin' *down….*

Einstein's theory says nothing about the distance between attracting bodies, merely that mass 'bends' space and the 'gravity' of body is caused by the 'well-like' depression it creates. But this adds yet more problems to our list. He simply said 'mass bends space': he didn't say what could be *in* space that *could be* bent?

Remember: gravity acts on *all* objects, everywhere. That is, it works on those things in what we tend to call Outer Space (cue sci-fi music and bad acting) as well as all the stuff in our houses around us. Yes, madam, including that line of dust on that shelf, there. A particularly good candidate for bendiness, if ever I saw one.

Well, the air around us is *full* of stuff: we know that; we breathe some of it in and wipe the rest off the kitchen surfaces. So there is at least something there to bend (although of course each little bit of it is causing everything around *it* to bend even while it itself is bending around everything else ……. I think I have a headache….).

But Outer Space is supposed to be a vacuum. Nothing. Empty. Oh, OK – so they reckon now it's not *entirely* empty: there's maybe one whole atom to every cubic mile or so. But *mostly* empty. So – what, exactly, gets bent? That one lone atom is having to work hard, isn't it?

Sticking with Outer Space for a moment, *how* does this 'bending of emptiness' get greater as you approach a planet (and we know gravity's pull *does* increase as you approach). *And* why, when you are actually standing *on* a planet is gravity at its greatest? There isn't any 'space' between your feet and the ground so there would seem to be even less than nothing at all to bend. How about when you go potholing far beneath the surface? Where's the bendy stuff *now?* The rocks around you…?

Oh – get ON with it!

OK – so just saying ''relativity' makes things very, very odd' isn't enough to disprove it. Of course not. I have to do a lot more than simply point out some of the oddities. So let's get on with doing that. Just relax, put some soothing music on the player –

- and let me mess with your mind.

Four - The mysterious nature of Light: part I

Here's a question for you: one that is in fact the whole secret to Relativity. My question is this: can you tell me why *Light* is so important to Einstein?

To put it another way, why is the speed of *Light* the limit to all **motion?** How does Light get into that game at all? After all, it is arguably just a common-enough product of certain chemical reactions. Anyone with a couple of dry twigs (or a box or matches) can make it: what is it *about* Light that gives it such a starring role in Einstein's version of the Universe?

Before Einstein told us such things were impossible, the idea that something might travel faster than light never bothered us. No reason it couldn't: we simply knew we wouldn't see it. Rather in the way we can't hear outside a certain range of sounds: such sounds exists; some creatures can hear them; we can't. Simple.

But Einstein tells us that Light is very special. Very, very special. Light certainly *is* special to us, of course. Our dominant sense, our ability to see, depends on it. Some creatures have better hearing than we do, most have a better sense of smell, some appear to be able to detect magnetic fields - for us, the key to our survival has been sight.

Now, you know very well that for us to see any object – anything at all, whether it is a source of light (a match, a candle, the Sun) or just reflects the light of something else (the planets, ourselves and so on) - light has to travel from that object to the sensor-cells in our eyes, cause a signal to be transmitted to our brain for that signal to be interpreted there.

You know that: of course you do. But here's something you may have overlooked. Light is *amazingly* fast (300,000 kilometres a second or about 186,000 miles a second, if you prefer.) Yes, fast – but *not* instantaneous. Light takes *time* to reach our eyes.

No matter how physically close we are to something there will *always* be a delay before light can reach us from it.

We are quite used to the idea of this when we think of the distant stars: so many light-years away from us: so many years that light has had to travel to reach us – that we tend to forget what this means. That it is the *past* of that star we are looking at. The light reaching our eyes now left that star years ago. That star may not even be there any more. It may have moved, gone dark, exploded – anything. We won't know about it until the 'news' of it finally reaches here, carried by the starlight.

The light from that event brings us the news of that event. Until that news gets to us, whatever happened *has* happened – we just don't know about it. Lightspeed limits our ability to see: we cannot *see* 'faster than Lightspeed'.

We are used to this phenomenon of a time-delay on seeing stuff when it comes to dealing with the distant stars but we tend to forget that it *also* applies to everything else: our sun, our Moon, the man over the road, even the palm of our hand as we hold it right up to our face – light has to *travel* before we can see. We can never see the present: only ever the past. Look at that blade of grass: the light you see it by left it a sliver of time ago. If it was bending in the wind *then* it has begun to straighten up *now*. But you won't see that just yet.

Look at the Sun – carefully! The light that is filling your eyes left the Sun over 8 *minutes* ago. By all means watch a sunset – ah, *isn't* that pretty? But try to remember that the Sun actually set over 8 minutes ago. It's already gone – even as you watch that fiery disc slip below the horizon. What you are seeing *now* has already happened.

Still not sure? Look – the distance from the Sun to the Earth is around 149,597,870 km. Light from the Sun therefore takes about 499 seconds or about 8.3 minutes to get here. Earth rotates on its axis roughly 4 degrees of arc in that time. So when you *see* the light from the Sun, the Sun itself is 4 degrees lower in the sky than you *think* it is. OK?

The Moon is only about 384,400 km from the Earth so it's *almost* where it looks to be. But Jupiter, say, is five times further out from the Sun than we are, at about 778,000,000 km. If there was anybody on Jupiter watching their version of the sunset, they would see it happening over 40 minutes after it actually *had*. You see? We never see the *present* state of anything, only what it *did* look like when the light we are now receiving *left* it. We spend our whole lives looking at the past.

OK – so we cannot *see* faster than light can reach us: we knew that long before Einstein. But why should lightspeed *also* be the limit to movement?

To answer that one we'll need a bit of history – and the story of an experiment that astonished Science, way back in the 1880s. What happened then should have been utterly ***impossible…..***

Five - The mysterious nature of Light: part II

Light is marvellous stuff, isn't it? It has fascinated philosophers and scientists as far back as we have any written records. The Greeks were interested in it (they were interested in *everything*). What made Light *light* and what made colour and why it did what it did and why wasn't the night sky a lot brighter – these issues have intrigued man through the ages (and occasionally woman when she'd finished the washing up).

As a result of all this interest, by the late Nineteenth Century, people knew a *lot* about Light. It was known that light was obtained by raising suitable material to a certain temperature. It was known what materials would produce what colour of light – and at what temperature. It was known that light could be bent or focussed to a point but that, left to itself, light would travel in straight lines from its 'source'. And that the source for any light will emit light in all directions, simultaneously.

(It was Isaac Newton who first suggested that light travelled in straight lines, an idea he gained from observing the separation of light passed through a prism. He was also the first to suggest that 'light' consisted of a stream of particles (he called them 'corpuscles').)

And of course that you don't see with your eyes: you see with your *brain.* Your eyes convert an incoming Light pulse into an electrical pattern which gets sent along the Optic nerve to the brain. It is the *brain* that sorts a mass of such signals into a coherent idea, effectively saying 'oh yes, I recognise that: it's a banana. Yum!'

According to an Horizon programme (broadcast on BBC2 18/10/10) only 10% pf our power of sight (perhaps I should say 'recognition') derives from the input of our eyes. The rest comes partly from the contribution of our other senses but mostly from our brain's ability to deduce an answer to the question 'whassat??'

But – the brain can easily be fooled into 'seeing' what isn't there. I don't just mean 'mirages' and other optical illusions – although they are good examples of brain-foolery: I mean *all* sorts of things. Think of a beautiful painting: a Constable, say, or a Holbein. One so finely painted you could almost walk into it or speak to the sitters. You can't, of course. It's just a flat surface with some splodges of paint on it in an interesting pattern. And that is all your eyes transmit: that pattern of colours. It is your brain that responds 'Ah, Henry VIII ' or 'oh, pretty scenery'.

And that is also why we can see shapes in clouds or in ink-blots or a big smiley face on the Moon. Our brains *love* to make pictures for us – but beware: the thing you see may not actually *be* there. It may just be your brain playing about.

Last dollop of introductory guff coming up: you don't see Light *itself.* The retina in your eyes *react* to Light. There are a number of other light-reactive substances that we know of (for example, our atmosphere or the film in a camera) but Light *itself* is invisible. That's why Space is so dark, in spite of all the sun- and star-light pouring through it. (For a particle of Light to *be* visible it would *itself* have to emit Light – and it doesn't. Sorry.)

OK? Good. You see? Over the centuries, scientists had come to know *lots* about Light. But *not* what Light actually *was.* Was it a stream of particles, as Newton thought, or a series of waves? 'Who cares', you ask? Well, I'll change the question, then. How does Sunlight or Starlight *get* here at all?

Particles or Waves?

By the 19th Century, Science had hit a *major* problem with the original idea that Light was formed of streams of particles. Somewhat awkwardly, Light had been caught behaving more like a wave than a particle–stream. For instance, it had been shown that light-beams bend slightly as they pass the edge of an object and that the shadow cast contains bands of light and dark (a little like the rings of Saturn in appearance). A particle-stream shouldn't behave like that but a wave-series *would.*

Light had also been observed to undergo 'interference' in much the same way that water-waves interfere with each other. We know how water does this (more or less) but how light could be achieving this was a bit of a puzzle.

And then James Maxwell came along (who he? Patience, patience!). He had the bright idea of applying Faraday's principles of 'electrodynamics' …….

Oh, you haven't heard of him either? Alrighty…..

In the early part of the 19th Century Michael Faraday had shown that a moving magnetic field would generate electricity while electricity could generate a moving magnetic field. It was this theory that Maxwell used to show that light could indeed behave like a wave (and if you want to know more than that get a bigger book).

So we should be thinking of Light-waves and not Light-streams? OK - but a wave is fundamentally different from a particle-stream: it cannot exist alone; it has to be *in* something. It needs a 'medium' to carry it. No, not one of the 'is there anybody there' variety. A 'medium' in Physics means something like water, air, jelly – whatever the wavy thing is being wavy *in.* And there *must* be something there or the wave can't do its stuff.

Let me put this alarm clock on this table and set it off. Can you hear it? No? *I* can – because I am close enough. In this example the medium is the air all around the clock. Sound waves are shaking that air, sending those waves to my ear. A wave is nothing more than the shaking of the molecules of its medium. When we speak of a wave *travelling* what we mean is that each molecule in the medium carrying it is being made to vibrate, each molecule reacting in turn, in a kind of 'nudge, nudge, pass it on' sequence.

In my example, the sound waves will only travel a little way: air *resists* being shoved about and will eventually absorb all the energy in the wave, putting a stop to it. OK. But suppose there was *no* air there? Suppose I put my clock in a jar and pump all the air out, leaving a vacuum (you may have seen this experiment done at school: you *could* get close to copying it at home with a vacuum cleaner hose and a jug but you'd need a very quiet machine and a lot of sticky tape). *Now* the clock works its hardest but I hear *nothing.* Waves can't travel through emptiness: they *need* something there.

Now do you see the problem? If Light is a stream of particles, generated by the Sun, it is easy to see how they could travel across the vacuum of space but if Light is a series of *waves* we have a problem. If space really *is* a vacuum it should present an absolute barrier. Waves *can't* travel in a vacuum. Remember that film-tag 'In Space no-one can hear you scream'? Because sound *is* a wave and waves really *can't* travel across the emptiness of Space. If Light is *also* a wave, then we should add 'and no-one will be able to see you, either' for exactly the same reason. We could make Light here on Earth but there shouldn't be any Sunlight, Moonlight or Starlight or even Day or Night. The sky should be utterly black – *all* the time.

The coming of the Ether

So the Nineteenth Century really needed there to be something 'out there' if they were to accept the 'light as waves' idea. Space could not *really* be a pure vacuum. And being inventive chaps (and they mostly *were* chaps: the gals were still at the washing-up*)* before long they came up with an answer: the idea of the 'Ether'.

'Ether' was reckoned to be an invisible substance present throughout the universe. As such it presented the ideal medium for light-waves to travel from any point in the Universe to any other. It was Maxwell himself who proposed this solution. And what a neat, simple idea it was *and* it solved the immediate problem: Light could indeed consist of waves because Space was full of 'ether' which allowed those waves to 'travel' to us from the sun and stars. Great! Solved that one, then.

But there was one *tiny* problem with this idea, however neat it seemed. No-one could prove that this mysterious substance, 'ether', actually existed. Its advocates insisted that it *must* exist but all attempts to measure or weigh it failed. It didn't seem to react with anything or cause anything else to react *with* anything else. If this new substance was so thoroughly undetectable was it actually *there* at all?

If we leap ahead of ourselves a little we can see a little more of how this 'wave or particle' debate panned out. Einstein produced papers in favour of *both* ideas (that is, he supported both sides at various times) but then produced the 'dual-nature' theory suggesting that light could actually be both.

Later, in 1924, De Broglie suggested that *any* moving particle could display wave-like behaviour and this has been borne out by experiment. (Who? Don't worry: he was an Important Scientist but we don't need to know about him for this book. Just forget I mentioned him.) It seems that the image we should be holding for Light is that of a stream of particles that can *cause* waves in suitable media but which does not *need* that media to exist. Consider the example of a ship at sea. The ship is most definitely a 'thing'- a 'particle', if a rather large one - but its motion through the water *creates waves*. If by some trick one could render the ship totally invisible, its presence and exact position could still be detected simply by analysing the patterns of disturbance in the water.

But that is the benefit of hindsight. The Nineteenth Century had little thought of such a solution and continued to wind itself into a scientific fury over the existence or non-existence of the Ether.

(It's off our subject but I just *have* to put this bit in, here. The idea of the 'Ether' is now dismissed as a Victorian fancy: too daft for words. Here in the advanced Twenty-First Century we only have clever *new* ideas. Take the idea of 'dark matter' for instance: an all-pervading, universal substance spread throughout Space that – sounds sort of familiar, somehow. Where *have* we heard that one before?)

Six - The 1880s bombshell: the Michelson-Morley experiment

In the early 1880s, two scientists, Albert Michelson and Edward Morley (one American, one British), designed a series of experiments aimed at settling at least part of this debate. They believed that their experiment would either demonstrate that the Ether really did exist – or prove it didn't. They chose to base their experiment on observing the Ether's effect on Light.

Clever idea: possibly a very bad one, as well. As we'll see.

They reasoned that if the Ether was present throughout Space then Earth must move *through* it in its orbit and that motion must create a wind-like effect (the 'Ether Wind'). If it existed, this 'Ether Wind' should be detectable with suitable equipment. Their experiment essentially consisted of splitting a beam of light in half and sending one half off at right-angles to its 'brother'. After bouncing these half-beams around for a while by means of a series of adjustable mirrors the experimenters recombined them to examine the resulting interference pattern.

If that concept of 'Light Interference' is new to you, imagine you are playing a film on your TV. You allow your DVD player (or whatever) to run normally but in addition to its normal output you copy its signal via another set of connections before returning it to your screen. The detour would cause a delay in transmission so that you would now have *two* signals arriving on your screen – and they would be out of sync, yes? (Yes, Science Nerds, I *know* that's not a brilliant example of Interference but it's the best I can come up with without needing another 10 pages.)

Now then: in accordance with 'classical', Newtonian principles for the summation of velocities Michelson and Morley expected to see that the pattern so obtained varied depending on the path taken by the diverted half-beam. That is, the diverted half should have been *slowed* by the detour; the amount of the delay depending on the direction taken. Aimed in *one* direction the speed of the diverted half-beam should be affected only by Earth's own motion through Space (which could readily be calculated); aimed in another, there should be the additional effect caused by the 'drag' of the Ether Wind. If it existed.

If the idea of 'summation' bothers you, try this (it's an example Einstein used – as did many others – to explain the Michelson-Morley conundrum): imagine you are travelling on a train that is moving along at 70 mph. If you *just* stand there *you* are being carried along at 70mph, yes? Fine. But if you walk about a bit on that train then your *actual* progress is no longer 70mph but '70 *plus* your walking pace' if you move in the same direction as the train is moving and '70 *minus* your pace' if you walk the other way. Someone watching you from the trackside would notice the difference even if you didn't. That's 'summation of velocities': one of Newton's Bright Ideas (and he had *lots*). OK? Good. And if there's a wind blowing in through a window that may *also* affect your progress depending on whether it's pushing you forward or back.

(There's more about the basics of Newton's Physics further on and in Appendix 2. You needn't bother if you don't want to.)

Now let's suppose you are carrying a torch and wave it all around you. You would expect the same principle to operate, wouldn't you? Light shone in the direction as the train's movement would gain a little speed and Light shone in the opposite direction would lose a little, yes? That was indeed what they expected would happen. It didn't.

It – just – *didn't* vary. At all. All they got, each time was a result that showed Light moving at its normal speed: 300,000 kilometres per second or 186,000 miles per second (usually we just write 'C' to represent that: when you see 'C' just think 'oh, yes, standard speed of Light', OK?).

I'll say that again – because this *really* matters. Without it, there probably wouldn't have been any 'Einstein' (not in the sense of 'most famous scientist ever' sort of a way) and we'd all be quite happy with the notion of moving faster than Lightspeed (that's 'faster than 'C'', remember?). In the Michelson-Morley experiment, they knew the speeds of the 'train' (the Earth itself) and the 'man' moving in different directions on that train (the split beams of Light): they expected to prove (and measure) the speed of the wind (the Ether: if any).

But it didn't work like that. Instead of the expected result, Michelson and Morley found that the speed of the beams of light in their experiments *didn't* change (apart from some tiny variations: no experiment is perfect!) Neither the effect of the Ether nor the motion of the Earth itself seemed to register. It was as if the 'train' wasn't moving at all: Light's progress remained the same. Coo!

And that was truly shocking. That the Ether might have no effect on Light's speed would have been quite acceptable: it would simply add strength to the argument that the Ether didn't exist. That the *Earth's* motion couldn't affect Light's speed was surely *impossible.*

That *couldn't* be right, could it? There must be something wrong with the experiment. So they tried again. And again. And *again.* They tried putting the experiment in the cellar, in an attic, at sea level, at mountain-height. They tried varying the air pressure, checked the weather – everything they could think of, over and over. And over and over they got the same appalling result.

Up until that experiment no-one had ever suggested that light would not conform to Newtonian principles. If *it* could ignore Newton's rules then maybe other 'stuff' could as well. And that would mean that anything that depending on Newton's ideas could be wrong – which was pretty much *all* of Physics.

The Michelson-Morley experiment caused a convulsion in the world of Physics, not just in that decade but for the rest of the century. That Light *might* breach Newton's laws was so terrible an idea that a number of alternative explanations were put forward. For example, it was proposed:-

- that a mistake had been made – but repetitions of the experiment didn't make the problem go away

- that the Earth somehow dragged the Ether along with it as a consequence of its orbit

- that Copernicus had been wrong: the Earth really *was* the fixed centre of the Universe (you have *got* to be kidding, right?)

- that some *other* phenomenon was occurring, causing the experiment to deliver false results

- but if none of *that* answered the problem then maybe

- Light really *was* an exception to Newtonian Laws. HELP!

The idea that the Earth might be dragging the Ether along with it received initial support but it was a mess of an idea and felt it. If Ether is universal and all pervading, Earth cannot possibly drag *all of it* along. There would still to be *some* part of the Ether unaffected and where it was, Light's speed should be affected. Even were this somehow *not* so, the Earth's own motion should have *some* effect.

There continued to be debate over the experiment itself: *had* it been properly designed? Was there something the experimenters had overlooked? *Were* there mistakes in their work? No-one could see any at the time (but have a look at appendix 1 for more on this: the experiment may indeed have been badly designed. It is now highly likely that the Michelson-Morley result was simply wrong.) If it *was* correct, what then? *Did* the laws of Physics need rewriting?

Some scientists still believed in the existence of the Ether **and** that Newton was unchallengeable. The most notable for our story was Hendrick Antoon Lorentz ('H A Lorentz'), a Dutch physicist and mathematician born in the 1850s. He felt that something *else* must be affecting the experiment and preventing it from showing 'proper' results.

Lorentz offered the idea that the Earth's motion through the Ether might somehow shorten or crush the experiment's equipment, in much the same way that motion through air or water can cause compression in the moving object. What air- or water-resistance could do, Ether-resistance might also do. He reasoned that it could be this 'shortening' that caused the odd results in the Michelson-Morley experiments.

This theory became known as the 'Lorentz-Fitzgerald contraction' (because an Irishman had the same idea at the same time) and for a time was quite popular. Lorentz developed a set of formulae to demonstrate the effect and these, 'the Lorentz Transformations', did indeed match the Michelson-Morley result. (More on these later on.)

But it still wasn't entirely convincing. It could only be the answer if the Ether did indeed exist but there was still no *proof* that it did. Meanwhile the thought that Newton was no longer 'Master of Mechanics' was gaining (nervous) support.

Then (roll of drums and fanfare, please!) an unknown clerk working in a Swiss Patent Office had an idea. Enter Albert Einstein and his Really Bright Idea: the New Theory of Relativity!!! The laws of Physics were about to get a makeover.

END OF SAMPLE

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