Space, Time, Universes

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Abstract

The first part of the article looks at the concepts of 'space' and 'time' in general, suggesting workable definitions. The second develops diagrammatic representations for 1-, 2- and 3-d static and expanding universes. It ends with a discussion of the related topics of gravity and time travel.

CONTENTS

INTRODUCTION

"*I do not define time, space and motion, as being well known to all.*"
(Isaac Newton[1])

"*We entirely shun the vague word 'space', of which – we must honestly acknowledge – we cannot form the slightest conception.*" (Albert Einstein[2])

The two most famous scientists of all time having resoundingly declined to define 'space' and time'[a], to attempt to do so may seem presumptuous. On the hallowed principle that "fools wander where angels fear to tread", however, we will nevertheless proceed.

[a] Sir Isaac's thesis in particular is a massive conceptual copout, if ever there was one!

SPACE, TIME

1-d[a] universe, static

Consider the *static 1-d universe* of Fig. 0-1a comprising a *closed ring* of zero X-section.

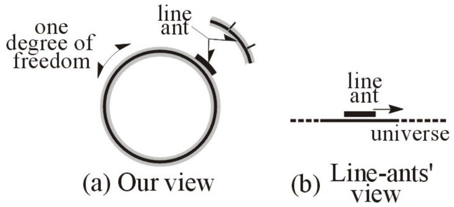

Fig. 0-1. 1-d universe, static (1).

Let it be populated with *1-d line-ants*, sections of the ring whose only characteristic is length. Although shown for clarity 'on' the ring, the ants are part of it. In the same way that we 3-d beings are part of our 3-d universe.

The line-ants have *one degree of freedom*: moving forewards or backwards around the ring. For this to be possible, we need to allow 1-d objects to pass through each other.

We superior 3-d beings, looking on from the outside, can see that the 1-d ring universe is "really"[b] curved and closed in 2-d space. And we see everything happening on it at any instant of our time.

For the 1-d ants, however, with no experience of, and hence no ability to visualize, a second spatial dimension, the idea of 2-d curvature is senseless. They experience their universe as *straight*, Fig. 0-1b. And also as *boundless*, with no limits however far one goes. Even though we superior 3-d beings can see that their universe is "really" finite, being bounded in 2-d space.

Distance

Consider two point objects[c] A and B on the ring, with no other physical objects inbetween, Fig. 0-2. There is however still said to *be a distance* between them. Distance is not, therefore, itself a physical object[d]. An observer counts, either actually physically or in his imagination, the number of times a *measuring rod*, for instance a metre rule[e], would fit between the objects, calling the result the "distance *d*".

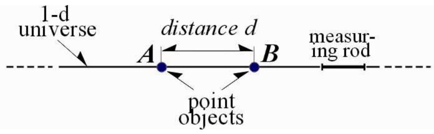

Fig. 0-2. Distance.

The two point objects and the measuring rod are physical. But the distance *d* between them is a *mathematical abstraction*, a number in an observer's mind:

distance: a mathematical abstraction

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[a] 1-dimensional.
[b] In our own 3-d reality.
[c] Infinitesimally small sections of the 1-d ring universe.
[d] Defined for present purposes as something that can be *physically experienced*: seen, heard, touched, smelt and/or tasted, either directly with the senses or indirectly with instrumentation.
[e] A rod one metre long with subdivisions.

For a distance *d* to be meaningful, i.e. to have a specific value, a *length standard* is necessary. With a metre rule as the standard, the distance been two objects would be one thing[a]. With a foot rule[b] it would be another. And so on.

Rules don't therefore *measure* distance – one cannot measure physically something that doesn't exist physically. They *define it*:

rules don't measure distance; they define it

Another approach. One can say "There is a distance of *d* metres" between the two objects. But one can also simply say "There are *d* metres"[c]. The words "a distance of" add nothing to the rational meaning, and are therefore rationally meaningless.

"Distance" is a *verbal convenience*, a *manner of speaking*. The best we can do towards defining it being:

distance = something there is said to be between objects, and that rules are said to measure, but apart from that we can't say what it is

We will call such things *said-to-bes*:

said-to-be = something there is said to be, but apart from that we can't really say what it is

Position, 1-d

Still with respect to the 1-d ring universe[d], define arbitrarily a fixed point object as the *space origin*, Fig. 0-3a,b. Then define the *spatial positions x* of other objects as their distances from it[e]:

spatial position x = distance from the space origin

A *positive sense* is needed, for instance 'clockwise around the ring'.

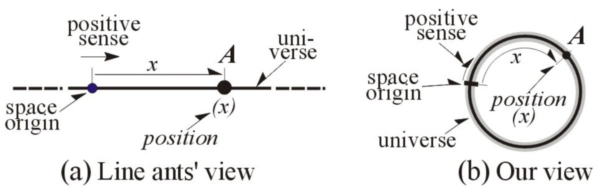

Fig. 0-3. Position.

A 1-d position in a line-ants' view is shown in Fig. 0-3a. And as seen from the outside by we superior 3-d beings in Fig. 0-3b. A position *x* being a distance[f], it is likewise a mathematical abstraction, a number in someone's mind.

Space

Now consider *space*. In a 1-d universe this is equivalent to distance. One can say that there is a "distance" between two objects; or alternatively a "space" between them.

'Space' is likewise a manner of speaking. We can Say that objects "have positions in space". But we can also simply say that they "have positions". A position is inherently 'in space'.

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[a] Would have one value.
[b] Feet and inches.
[c] *d* metre-rule lengths.
[d] Fig. 0-1a.
[e] In whatever units one cares to choose
[f] From an origin or reference point.

Or again: we can say that we "look out into space". But we can also simply say that we "look out". To look out is inherently 'into space'. The word "space" adds nothing to the rational meaning, and is rationally meaningless.

'Space' is another said-to-be, a verbal convenience. The best we can do towards defining it is similarly:

space = something objects are said to have positions in, and that we look out into, but apart from that we can't really say what it is

As is testified by the interminable discussions on the subject.

Time

Still in terms of the 1-d ring universe, imagine a *time marker*, a point object moving forewards around the ring at some steady speed, emitting audible "ticks" as it goes, Fig. 0-4a.

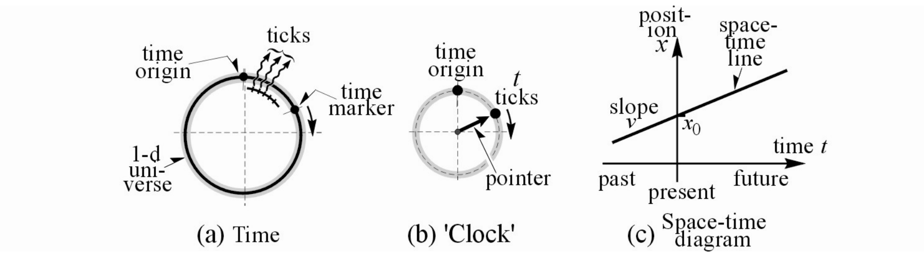

Fig. 0-4.Time.

Defining arbitrarily a point object as the *time origin*, call the number of ticks the time marker emits since leaving it the *time t*, representing it symbolically on a *clock*, Fig. 0-4b.

A time *t* is a *temporal position*. An object's spatial position *x* is its spatial distance from the space origin measured in rule lengths. An event's temporal position *t* is the time-marker's temporal distance from the time origin measured in clock-ticks. Both are abstractions, numbers in someone's mind.

Time-markers strictly don't need to move. They simply have to emit ticks. Conceiving them as steadily moving is however convenient. Firstly because it enables the times of events occurring between clock ticks to be estimated. And secondly, it emphasizes the analogy between spatial and temporal distances.

As for spatial distance, one can say that "There was a time of *t* clock-ticks" between two events. But one can also simply say "There were *t* clock-ticks". And one can say that events "occur in time". But can also simply say that they "occur". Ocurrences inherently at occur at some point in time.

'Time' is another said-to-be, a verbal convenience, a manner of speaking. The best we can do towards defining it being:

time = something there is said to be between events, that clock ticks are said to measure, but apart from that we can't really say what it is

As is evidenced by the even more interminable discussions on the subject.

Time is *event space*. Material objects can be said to "exist in space"; or simply to "exist". Events can be said to "occur in time"; or simply to "occur".

time = event space

For a time *t* to be meaningful, i.e. to have a specific value, a *time standard* is required. With one particular clock as the standard, the time *t* between two events would be one thing. With another clock it would be another; and so on. Clocks don't therefore *measure* time – one cannot measure physically something that doesn't exist physically. They define it:

clocks don't measure time; they define it

Time-markers evidently need to move/tick *continuously*, because otherwise separate events could have the same time. Seen from the outside, however, the movement, or rate of ticking, need not be regular.

Imagine that the Creator of our universe, bored with the slowness of things in it, decides to jazz them up so that what used to take a thousand ages on His extra-universal clock now only takes one second. Down here on Planet Earth, however, our clocks speed up correspondingly. What used to take one minute on our clocks still takes one minute on our clocks. We wouldn't even notice any difference.

We thus agree with Antiphon[a] when he wrote:

> "Time is a thought, not a substance".[3]

And with Tina Turner[b] when she said:

> "What is time, but a second hand in motion?"[4]

Also with Gottfried Leibniz[c]:

> "Space and time don't exist, but are mere superstitions."[5]

Some peoples[d6] don't even have a concept 'time'. They conceive of events occurring in sequence, but have no concept of 'time' as something passing independently of those events. Neither do they have words for periods of time such as 'month' or 'year'.

If they can live quite happily without a concept of time passing, so in principle could we.

Spacetime

Spacetime is defined as:

> "Any mathematical model that combines space and time into a single interwoven continuum."[7]

In a 1-d universe, the relation between a line-ant's spatial position x and its temporal position t can be represented on a *space-time diagram*, as that of Fig. 0-4c above. We can further combine an ant's spatial and temporal positions into a single mathematical variable (x,t), calling it the ant's *space-time position*.

But to call this a "position in spacetime". And then to go on and conceive 'spacetime' as something physical, with physical characteristics such as being 'straight' or 'curved', is evidently nonsensical[e]. A space-time position is a *mathematical abstraction*. There is nothing physical a mathematical abstraction can meaningfully be said to "be in". We continue this discussion elsewhere[f8].

2-d universe, static

Now consider a *static 2-d universe*, for instance the spherical surface of Fig. 0-5b. Noting that the 'universe' is the *2-d surface*, and not the 3-d sphere itself. Imagine the

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[a] Antiphon (end 5th C b.c.), Athenian sophist philosopher.
[b] Tina Turner (1939–), American pop singer and actress.
[c] Gottfiried Leibniz (1646-1716), German philosopher.
[d] The Amazonian Amondawa, for instance.
[e] Cf p.3.
[f] Relativity article.

surface universe populated with *2-d flat-ants*, animated areas with length and width but no height.

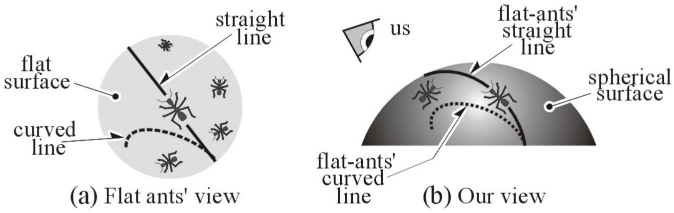

Fig. 0-5. 2-d universe (1)[a].

We superior 3-d beings, looking on from the outside, can see that the 2-d universe is "really"[b] curved and closed in 3-d space. And that what for the 2-d ants is a straight line[c] is "really" curved[d]. We also see everything happening on the surface universe at any instant of our time.

The 2-d flat-ants, however, with no experience of and hence no ability to visualize a 3rd spatial dimension, cannot conceive their universe in this way. They experience it as flat[e].

For its 2-d inhabitants, the surface universe obeys the *cosmological principle*, being:

– 1) *isotropic*: looking the same in all directions
– 2) *homogeneous*: having the same composition everywhere
– 3) *limitless*: with no boundaries, no matter how far one goes

Even though we superior 3-d beings can see that their universe is "really" finite, bounded in 3-d space. We can note that the previous 1-d ring universe[f] also obeys the cosmological principle.

Position, 2-d

To quantify[g] a 2-d spatial position, for instance that of the point X in Fig. 0-6a, we need firstly a *reference frame*; and secondly a *coordinate system*.

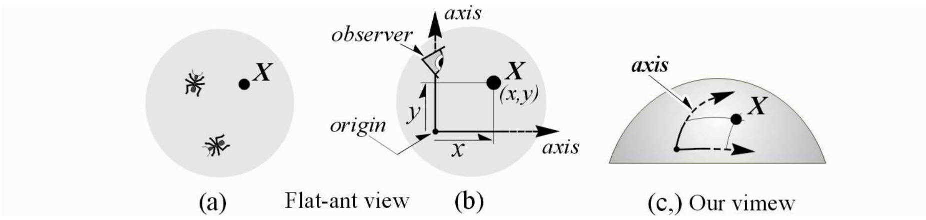

Fig. 0-6. Position, 2-d.

A *reference frame* is for practical purposes *an observer's world*, what he experiences from his point of view:

reference frame = observer's world

[a] Although shown as bounded (Fig. 0-5a), for the flat-ants their universe extends infinitely in all directions, and in principle closes in on itself.
[b] p.2, note.
[c] Fig. 0-5a.
[d] Fig. 0-5b.
[e] Fig. 0-5a.
[f] Fig. 0-1.
[g] Attribute a specific value to.

A 2-d *Cartesian*[a] coordinate system comprises a *space origin* and two *orthogonal axes*. It is shown in a flat-ant's view in Fig. 0-6b, and in our 3-d view in Fig. 0-6c. Fig. 0-7 shows corresponding *polar coordinates (r,θ)*.

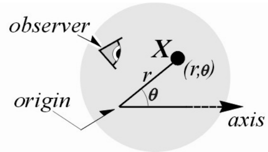

Fig. 0-7. Polar coordinates.

For Cartesian coordinates, the origin and the direction of one axis can be chosen arbitrarily. The orthogonality condition however requires that the axes be *independent*: that an object's position on one axis can vary independently of its position on the other. This in practice means that the two axes must be *perpendicular*.

The origin and the axes and again imaginary, "existing"[b] only in an observer's mind. Reference frames and coordinate systems are likewise *abstractions*, and not themselves physical objects.

The 2-d flat-ant inhabitants conceive their axes as *straight* and *extending infinitely* in their respective directions. Even though we superior 3-d beings can see that they are "really" curved in 3-d space, and would eventually close back on themselves[c].

3-d universe, static

We 3-d beings likewise experience a universe obeying the cosmological principle[d], being isotropic, homogeneous and unbounded. We can *conceive* of superior 4-d beings looking in from the outside and seeing it as "really" curved and bounded in their 4-d space. And seeing everything that is happening in it at any instant of their time.

We inferior 3-d beings, however, with no experience of, and hence no ability to visualize, a 4th spatial dimension, cannot conceive our universe in this way. So in answer to Einstein's[e] question:

"Can we visualize a 3-d universe that is finite yet unbounded? "[9]

the answer is "No". The best we can do is to *presume* that our actual 3-d universe is *like* a closed 2-d surface universe, but in three dimensions rather than two:

we presume our 3-d universe to be like a closed 2-d surface universe,
but in three dimensions rather than two

A 3-d Cartesian coordinate system is shown in Fig. 0-8. We the universe's inhabitants conceive the axes as being straight and extending infinitely in their respective directions. Even though we can imagine hypothetical superior 4-d beings perceiving them as curved and closing back on themselves in their 4-d space.

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[a] Named after the French philosopher René Descartes (1596-1650).
[b] In quotes, 'existence' here being always *physical* existence (p.2, note).
[c] Fig. 0-6c.
[d] p.6.
[e] Einstein, Albert (1879-1955), German theoretical physicist.

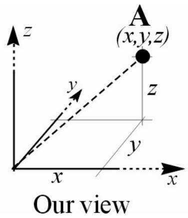

Fig. 0-8. Position, 3-d.

EXPANDING UNIVERSES

Big Bang[a]

On the currently orthodox *Big Bang model*, the universe originated 13.7 b.y.a[b] as an incredibly small (believe it if you can), incredibly dense, incredibly high-temperature pinpoint-sized ball of pure energy, the so-called *primordial fireball*, Fig. 0-9a, and has been expanding ever since.

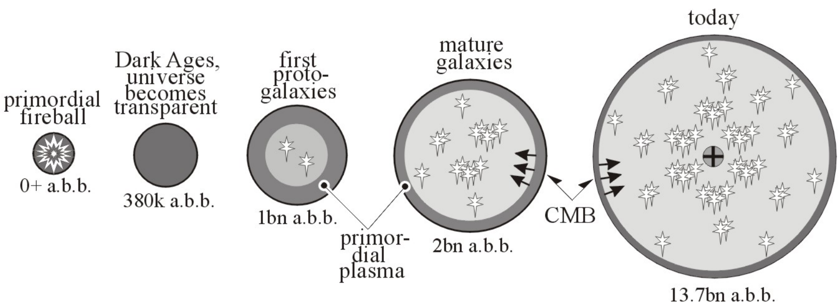

Fig. 0-9. Big Bang.

According to the[c][10] $E=mc^2$ equation, energy and matter are different forms of the same thing, like steam and water. Energy is vaporised matter. Matter is condensed energy. The primordial fireball was however so concentrated that no matter as such could yet exist. Everything was pure energy.

As the fireball expanded, its temperature fell rapidly. At 1 sec. a.b.b.[d] *protons*[e] and *neutrons* were forming. And after three minutes the first *complex nuclei*, mainly helium. Due to the very high temperatures there were however no atoms as such[f]. Any electron that did attach itself to a nucleus would immediately get knocked off again. What existed at that point was a *plasma* of stripped hydrogen and helium nuclei, and free electrons, in a 'sea' of energy photons.

A quarter of an hour later the temperature had fallen to the point where no further nuclear reactions could take place, and the primary conversion of energy into matter was over. Some 10^{80}[g] *elementary particles* – protons, neutrons and electrons[h] – had been formed. The proportion of the original energy that condensed into matter was however

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[a] Those familiar with the Big Bang model can skip this sub-section.
[b] Billion years ago. Figures in general are estimates and/or rounded off.
[c] We won't say "Einstein's" because it wasn't his.
[d] "After Big Bang".
[e] Hydrogen nuclei.
[f] Nuclei with orbiting electrons
[g] A '1' followed by eighty zeros.
[h] For present purposes these are what we will mean by "fundamental particle".

very small. For every particle of matter created, there remained a billion photons of uncondensed radiation energy.

As the universe expanded further its temperature continued to fall. By 380k[a] a.b.b. it was low enough for electrons to remain permanently attached to nuclei, forming *atoms* of hydrogen and helium gas. At this point the universe ceased to be incandescent and became *dark*. And also *transparent to photons*, which could now travel freely though space. The photons from this point that are now reaching us comprise the *cosmic microwave background* ('CMB'), which we discuss later. The *Dark Ages* had begun.

But although dark, the universe in this phase was not inactive. Under the action of gravity the hydrogen and helium gases were slowly concentrating into vast *clouds*, with increasingly dense *clumps* at their centres, Fig. 0-10a,b.

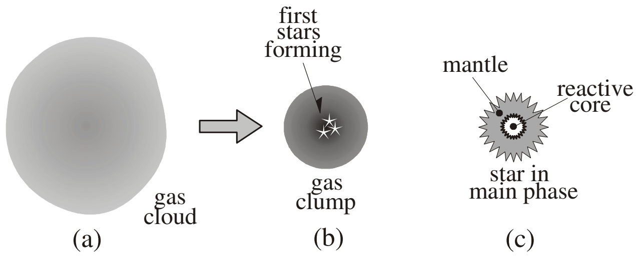


Fig. 0-10. Birth of a star.

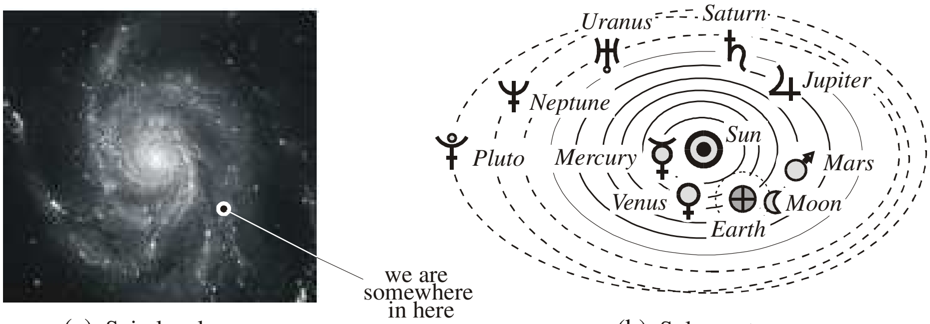
The more gas a clump attracted, the bigger it grew. And the bigger it grew, the stronger its gravity became, and the more gas was drawn into it. The kinetic energy of the arriving gas molecules caused the temperatures of the clumps to rise. By 1bn a.b.b. those at the centres of the largest clumps had reached 10mn ^{O}C, the point at which the *nuclear fusion* reaction begins, where two hydrogen atoms combine to form one of helium with the release of a large amount of energy – the principle of the hydrogen bomb. The first *visible stars* were born.

A star in its 'main phase' comprises a reactive core surrounded by an incandescent mantle, Fig. 0-10c. Agglomerations of stars deriving from a single gas clump formed *proto-galaxies*. Over the next 12bn years these grew in size and number to give *mature galaxies*, which again due to gravity became grouped into *clusters*.

The result is what we see in the night sky today. Our present visible universe contains 160bn galaxies, each with an average of 100bn stars. The total number of stars in the universe is thus enormous. And that is only the *visible universe*, the part we can see from planet Earth. What might lie beyond it we inherently cannot know.

Our own *Milky Way galaxy*, Fig. 0-11a, is a large spiral type with 200bn stars, a diameter of 100k light-years[b], and a mass of a trillion suns. The *solar system* is situated out on one of its arms, Fig. 0-11b[c].

[a] 'k' = thousand; 'mn' = million; 'bn' = billion.
[b] Light takes 100k years to cross it.
[c] The three exterior planets: Uranus, Neptune and Pluto, are invisible to the naked eye.



(a) Spiral galaxy (b) Solar system

Fig. 0-11. Solar system.

In spite of its 10^{80} elementary particles, however, the universe as a whole is a *virtual vacuum*, with an average density of one hydrogen atom for every four cubic metres of space. By earthly standards it is enormous. Light travelling at 300'000 km/s takes 1.3 s to reach us from the Moon; 8 min 20 s from the Sun; 5.5 hrs from the furthest planet, Pluto; 4 years from the nearest star, Alfa Centauri; 800 years from the Pole-star; 30 thousand years from the centre of the Milky Way galaxy; 2 million years from the nearest neighbouring galaxy, Andromeda; and 12 billion years from the earliest visible proto-galaxies.

If the solar system were the size of a football pitch, the Sun would be a miniature light bulb at its centre; the Earth would be 1 m away from it; Pluto 40 m; Sirius 300 km; and the Milky Way would have a diameter of 3 million km. If the Milky Way itself were the size of a football pitch, the solar system would be a particle of dust.

At the microscopic end, if an orange were blown up to the size of the Earth, its atoms would be as cherries. If one of these was expanded to fill the dome of St Peter's, its nucleus would be a grain of salt and its electrons specks of dust[11]. If all empty space were eliminated, the whole of humanity could fit into a sugar cube.

The range of densities is likewise enormous. That at the centre of neutron stars, the most compact objects known, is 7×10^{17} kg/m^3. A pinhead of the material would weigh a hundred thousand tons. Whereas the average density of the universe[a] is 10^{-45} times less than this. All in all, things are pretty spaced out in space!

With regard to the Big Bang itself, we are accustomed to think of it as something that occurred in the past, and our present universe as the result of it. In fact there is no dividing line. From the word "Go" (don't ask *Whose* word!) all there has ever been is an expanding configuration of energy/matter. Evidently with varying *characteristics*, but essentially one thing.

The Big Bang is still going on, and we are part of it. The photons from the primordial plasma are pretty much cooled down by now. But they are still around in the form of the microwave background. When the signal to one's TV fails, the "scribbles" that appear on its screen are in part due to it.

Not only is the Big Bang still going on. But like just about everything else in the modern world:

you can see it on the telly!

1-d universe, expanding

Consider an *expanding 1-d universe*. Its state at successive instants is represented on a space-time diagram by *concentric circles*, Fig. 0-12a[b]. Due to the expansion, the dis-

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[a] One hydrogen atom for every four cubic metres of space.
[b] Cf Fig. 0-1a.

tance between 'stationary'[a] objects here increases continually. Meaning that steadily moving line-ants will take longer to reach their destinations – if they get there at all.

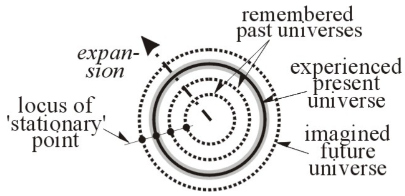

Fig. 0-12. 1-d universe, expanding (1).

In the previous static 1-d universe[b], if a light photon[c] travelled long enough in any one direction it would eventually end up back where it started. But were the universe expanding sufficiently fast, and were the speed of light around it limited, this would not necessarily be the case.

Our own expanding 3-d universe in 1-d terms[d] is represented by a series of circles centred on the Big Bang, Fig. 0-13.

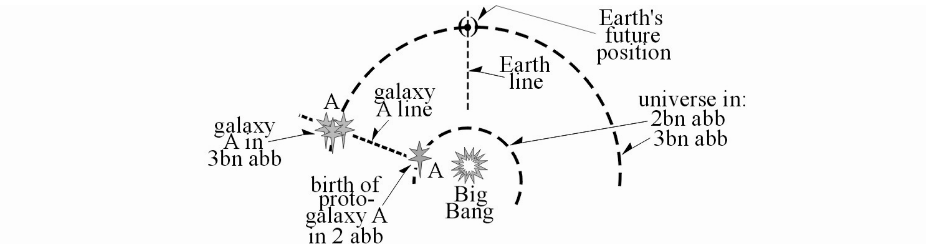

Fig. 0-13. 1-d universe, expanding (2).

Consider a specific event, for instance the birth of a proto-galaxy A in the year 2bn a.b.b. A galaxy being for practical purposes stationary in space[e], its locus on the space-time diagram is a *radial line* originating in the Big Bang. We will call it the "galaxy A line". The same applies to the 'Earth line', the locus of the Earth's future position.

Now imagine a '*pgA*[f] *photon*' setting out from the nascent proto-galaxy A in 2bn a.b.b, and travelling clockwise around the 1-d universe at the speed of light *c* in the direction of the Earth's future position[g], Fig. 0-14a.

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[a] With respect to the ring,.

[b] Fig. 0-3 .

[c] Here conceived as a miniscule section of the ring travelling around it at a characteristic speed.

[d] With only one spatial dimension, as a 1-d ring universe (Fig. 0-1).

[e] On the 1-d ring universe.

[f] "Proto-galaxy A".

[g] The point on the 1-d ring universe where the Earth will appear in 9.1bn a.b.b. (the Earth's age is 4.6bn years).

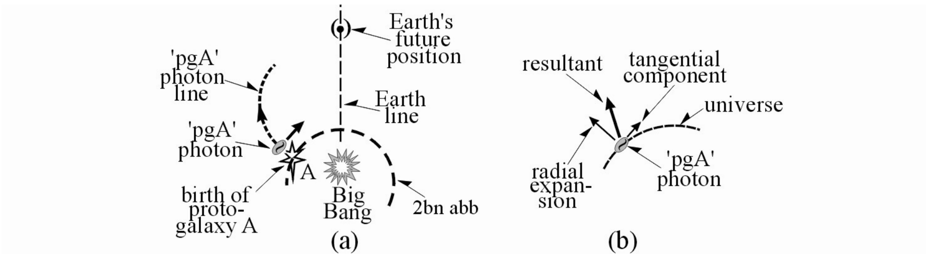

Fig. 0-14. 'pgA' photon.

The photon has two components of velocity, Fig. 0-14b:

– 1) a *tangential component* due to its speed around the 1-d ring universe
– 2) an outward *radial component* due to the universe's expansion

Photons thus have *curved loci*, as opposed to the radial loci of objects essentially stationary[a] in space[b] such as planets, stars and galaxies.

Fig. 0-15 shows the overall 1-d space-time diagram for our universe from the Big Bang up till today. We discuss the 'present line' in a moment.

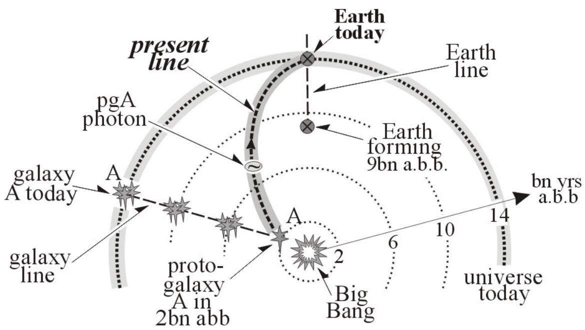

Fig. 0-15. 1-d universe, expanding (3).

Consider a *supernova* S_1 occurring in the year 10bn a.b.b, lying on the pgA photon line, Fig. 0-16. A supernova being in astronomical terms an instantaneous event, it is represented by a point on the space-time diagram. There is no corresponding 'line'.

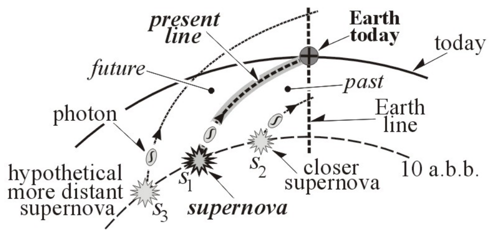

Fig. 0-16. Supernovas.

The photons from the supernova reach the Earth together with those from the birth of proto-galaxy A in 2bn a.b.b. Both lie on the pgA photon line. Should an earthly astronomer look into his telescope right now, he will observe both events.

The pgA photon line is simultaneously our *present line*, containing all the 1-d events that we are presently seeing, those whose photons are reaching planet Earth right now:

[a] Their speed with respect to the ring being negligible compared to that of light.
[b] On the 1-d expanding ring universe.

present line: contains all the 1-d events we are seeing right now

Due to the finite speed of light, when we look out into *space*[a] we *look back in time*. We see simultaneously the birth of the proto-galaxy A in 2bn a.b.b; the supernova in 10bn a.b.b; and the cup of coffee on our table in 13.7 a.b.b. We don't even see the Moon as it is right now, but only as it was 1.3 seconds ago when the photons now reaching us left it. Objectively speaking, everything external we see is strictly 'past'.

Returning to Fig. 0-16, consider another supernova S_2 also occurring in 10bn a.b.b, but this time closer to us. Its photons already arrived at planet Earth and we missed it.

Now imagine a hypothetical supernova S_3, likewise in 10bn a.b.b, but now further from us. Should there have been such an event, its photons will reach Earth at some point in the future. Right now we cannot know whether it occurred.

The region to the *right* of our present line thus represents our *past*, events we could have observed but no longer can. The region to its *left* represents our *future*, hypothetical events that we might see one day, but at present cannot know about.

2-d universe*,* expanding

Now consider an *expanding 2-d universe*. An analogy first used by Arthur Eddington[b] is the *expanding balloon-surface model* of Fig. 0-17[12]. Noting again[c] that the 'universe' is the *2*-d *balloon surface*, and not the 3-d balloon. 'Stationary'[d][13] in this case is "on the balloon surface".

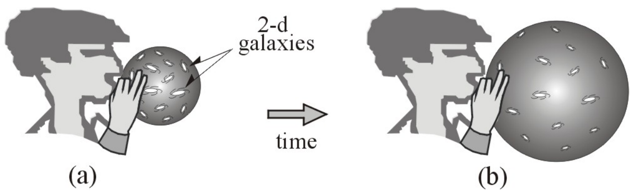

Fig. 0-17. 2-d universe (2).

In 2-d terms, the previous 1-d present line[e] becomes the *present surface* of Fig. 0-18a. Noting that this is not a 'universe', but rather a hypothetical surface containing all the 2-d events, occurring at varying times in the past, that we on Planet Earth are experiencing right now:

present surface: contains all the 2-d events we are observing right now

A section through the 2-d present surface of Fig. 0-18a gives the previous 1-d present line (Fig. 0-18b[f]).

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[a] Alternatively: "look out". 'Space' being a manner of speaking with no physical existence (p.3).
[b] Arthur Eddington (1882–1944), English astronomer.
[c] p.5.
[d] Or 'at-rest'. As in Einstein's first Special Relativity postulate.
[e] Fig. 0-15.
[f] Cf Fig. 0-15.

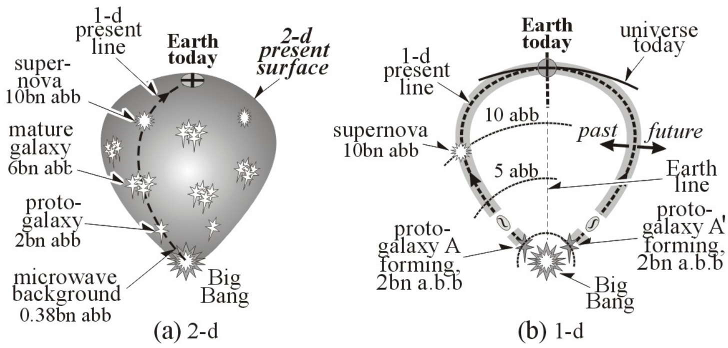

Fig. 0-18. Present surface.

We see further from Fig. 0-18b that in the 1-d case we in fact observe the births of *two proto-galaxies*, A and A', in the year 2bn a.b.b, one on each side of the Earth line. Photons from both events are now reaching us from opposite sides of our horizon.

As the inhabitants of a 2-d balloon-surface universe, however, we don't *experience* our present surface as curved[a], but rather as *flat* as in Fig. 0-19[b]. Its theoretical outer limit – the most distant point in space and time whose photons could theoretically reach us – is the *Big Bang*, represented by the lower apex of the present surface[c] and by the outer rim of the disc[d].

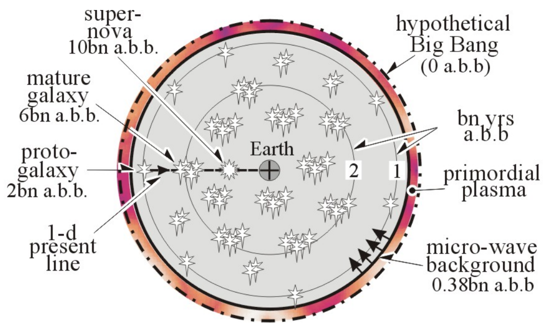

Fig. 0-19. 2-d universe (3).

Due to the primordial plasma, however, photons from the Big Bang itself cannot reach us directly. The practical limit of our visible universe is the *cosmic microwave background* (CMB), the photons from the start of the 'dark ages' in 380k a.b.b, the first to travel freely through space[e].

CMB

When the cosmic microwave background was discovered in 1965, it was quickly realized that it could provide an absolute 'at-rest' reference for speeds[f][14]. Consider a spaceship out in deep space, shown in 2-d terms in Fig. 20. When moving at some speed

[a] As in Fig. 0-18a.
[b] Cf Fig. 0-5.
[c] Fig. 0-18a.
[d] Fig. 0-19.
[e] p.9.
[f] In 2-d terms: stationary on the balloon surface (Fig. 0-17). Contradicting Einstein's first 'relativity' postulate that there is none..

with respect to the CMB, due to the Doeppler effect[a][15], the pilot experiences a higher frequency in front of him and a lower frequency behind. When he sees the same frequency all around him, he then knows he is at rest with respect to the CMB.

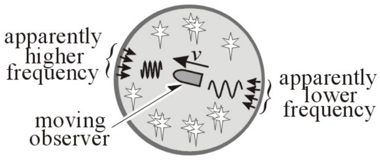

Fig. 20. Microwave background (2).

On this basis, the absolute velocity of the solar system has been calculated to be 370 km/s in an astronomical direction (α =11.2 hrs, δ=–7.2^{o}), towards the constellation Leo[16].

Redshift

The spectral lines of elements in distant galaxies are *red*-shifted, with a lower frequency than those on planet Earth. The greater the distance away, the greater the red-shift. It was this that led astronomers to conclude that the universe is expanding.

The Doeppler effect on Earth depends on the observer's speed relative to the wave medium, for sound the air, and for light the aether[b]. But how to interpret it in terms of light waves originating in a proto-galaxy in the year 2 a.b.b. – and that might not even exist any more – is a good question. Like most such things, it is essentially a matter of definition.

In the present case we can visualize the red-shift as due to the universe's expansion "stretching" the aether, increasing the wavelength of light travelling through it, and lowering its frequency, Fig. 0-21[c].

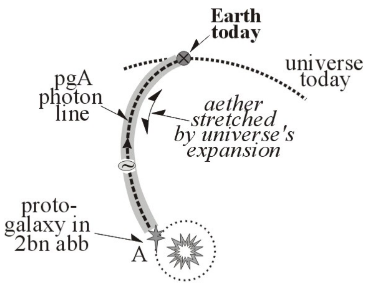

Fig. 0-21. Redshift.

GRAVITY, ETC.

Inertial/gravitational mass

Einstein like many others had the strange idea of separate 'inertial' and 'gravitational' masses. He for instance wrote in his 1916 Relativity paper:

> "The same quality of a body manifests itself, according to circumstances, as ' inertia' or as weight (lit. 'heaviness'). The gravitational mass of a body is equal to its inertial mass." [17]

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[a] Aether article.
[b] Aether article.
[c] Fig. 0-15. Here it is evidently better to think of light as waves rather than particles.

This even became formalized as the "Weak Equivalence Principle".

The distinction makes little sense. Mass is defined in terms of the 1 kg platinum-iridium block kept in Paris[a]. This is not specified as being 1 kg of "inertial mass", nor "gravitational mass", but simply "mass".

The fundamental MKS mechanical units are mass (kg), length (m) and time (s), Force not being one of these, it is defined in terms of them via Newton's second law. If a force applied to the standard 1 kg mass produces an acceleration of 1 m/s^2, then the value of that force is by definition 1 N[b].

This allows the values of other masses to be determined. If a given force applied to the standard 1 kg mass produces an acceleration a_1; and when applied to some other body gives an acceleration a; then the mass of the second body is by definition $M=a/a_1$.

In possession of practical procedures for measuring force and mass, the gravitational force f_g between two bodies a fixed distance apart is found experimentally to be proportional to the product of their masses, giving Newton's famous law.

And that's it. No separate inertial and gravitational masses, simply 'mass'. .

Fields

Again as many others, Einstein had a problem with 'action at a distance'. He for instance wrote:

> "We have come to regard action at a distance as a process impossible without the intervention of some intermediary medium. If a magnet attracts a piece of iron, we cannot be content to regard this as meaning that the magnet acts directly on the iron through the intermediate empty space[c][18]. But are constrained to imagine that the magnet calls into being a 'magnetic field'. And that this field operates on the piece of iron so that it strives to move towards the magnet."[19]

Take the simpler gravitational case of two masses M_1 and M_2 in outer space. Experimentally there is found to exist a gravitational force f_g between them, Fig. 0-22a.

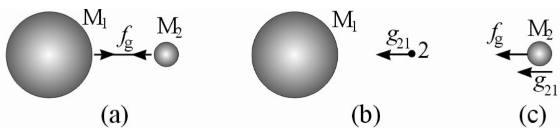

Fig. 0-22. Gravitational field.

On the 'field' approach the mass M_1 sets up a field g_{21}[d] at point 2, Fig. 0-22b. This then acts on mass M_2 to produce the gravitational force f_g, Fig. 0-22c.

All this however effectively does is to replace 'force at a distance' with 'field at a distance', explaining nothing. If Einstein couldn't visualize a mass producing a force at a distance, how could he visualize it producing a field at a distance?

And since the only way to know whether there is a gravitational field at a point is to place a mass there and see if it experiences a force, at the end of the day gravity always boils down to masses exerting forces on other masses across 'empty' space. The same in principle applies to electric and magnetic fields.

The field concept undoubtedly facilitates calculation. But its explanatory power is zero.

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[a] Or its more modern equivalent.

[b] Newton.

[c] Space is of course not empty. It is full of aether. But since it refutes both his Relativities, Einstein was not prepared to admit this.

[d] The gravitational field at point 2 due to mass 1.

We derive our conceptual models from our everyday experience of visible material reality. And so cannot assume that they will necessarily apply to its invisible aspects. This is evidently also the case in quantum physics, which we discuss elsewhere[20].

Apparently mysterious 'action at a distance' is an experimental fact, a property of our universe. The universe's Creator could evidently explain it rationally in his own terms. We as non-Creators cannot.

Newton's Laws

Sir Isaac's original formulation of his three Laws of Motion was somewhat long-winded and in Latin. They have been summarized[21]:

– 1) when not acted on by an external force, a body moves at constant speed[a] in a straight line
– 2) the force on a body is its mass times its acceleration
– 3) for every action there is a reaction

A body moving at constant speed in a straight line is one with no acceleration. The first law is simply the second for the specific case of zero force, and is *redundant*.

As just seen[b], a force of 1 N is by definition that which, when acting on a mass of 1 kg, causes it to accelerate at 1 m/s^2. The second law is then a *truism*, implicit in the definition of 'force' .

Assuming that by "action" Sir Isaac meant "force", the third law says that if one body exerts a force on another, then the second exerts an equal and opposite force on the first.

Forces, however, *inherently* act between two bodies. There are no such things as 'free-floating' forces. If my bum exerts a downward force on the chair, the chair necessarily exerts an equal and opposite upward force on my bum. If the Earth exerts a gravitational force on the eminent scientist's apple, the eminent scientist's apple necessarily exerts an equal and opposite force on the Earth.

The third law is then likewise a *truism*, implicit in the concept of a force.

All three of Sir Isaac's laws are thus either redundant or are truisms, and don't say anything meaningful about anything.

But – and this is a massive 'but' – what Newton essentially did was to *rectify the concept of a natural state*. Pre-Newtonian mechanics was based on *Aristotle*, who held that the natural state for objects is *rest*. And that they therefore only move so long as some force obliges them to.

Newtonian said no, the natural state of objects is *inertial motion* – hence the apparently redundant first law. And his insight that the same force that made the apple fall onto his snoozing head, also holds the planets in orbit, was the starting point for modern cosmology. From which it never looked back.

TIME TRAVEL

Time travel (1)

To finish off, consider *time travel*. Time being a mathematical abstraction, a number in an observer's mind[c], the idea of "travelling" through it – as one travels through the countryside – is evidently senseless.

Our idea of time comprises *past*, *present* and *future*. The past is *memories*, neural traces in our present brains. The future is our *present idea* of how things could come to

---

[a] Which can also be zero.
[b] p.16.
[c] p.4,4.

be, likewise neural traces in our present brains. The only 'reality' we ever actually physically 'travel' in is *present reality*, that physically existing right here right now. Khalil Gibran[a] wrote:

> "Yesterday is today's memory. Tomorrow is today's dream"[22]

Another approach. On the well-known *grandfather paradox*[b][23], if time travel were possible one could return to the past and assassinate one's grandfather before he sired one's father. In which case there would be no 'one' to return to the past to assassinate one's grandfather. Being of the form:

> *"If A were possible, then it would be possible for A not to be possible"*

this is rationally nonsensical. And so therefore on the philosophical *reductio ad absurdum* principle[c][24] is the respective premiss of being able to change the past.

That raw red wound you just saw in my leg, for instance, caused by the dog that bit me yesterday. If time-travel were possible, some benefactor of mankind could have returned to the past and one minute ago killed the dog's grandfather. In which case the wound was never there. Not that it "wouldn't have been" there. Nor that it "is no longer" there. No. Five minutes ago it was there and you saw it. Right now it never was there. (Make sense of *that* if you can!)

A shorter way into this is that if the past can be changed, then what actually happened didn't necessarily happen. This is again senseless.

On the Big Bang model the universe comprises its 10^{80} fundamental particles – protons, neutrons and electrons. A *universe state* is a specific arrangement of these. Yesterday's universe state was yesterday's arrangement of the 10^{80} particles. Today's state is today's arrangement. Tomorrow's state will be tomorrow's arrangement.

The essential difference between the Jurassic and today is thus that back in the Jurassic the universe's 10^{80} particles were arranged in the Jurassic way. And today they are arranged in today's way. To travel back to the Jurassic is thus in principle very easy. One simply rearranges the universe's 10^{80} particles back into their Jurassic state.

In practice of course this cannot be done. The Laws of Nature determine that universe states shall occur in the order Triassic→Jurassic→Cretaceous, and not in any other. In a properly ordered universe things occur in their proper order.

In a continuously expanding universe, past states – like Clementine – are 'lost and gone forever', never to return. The basic reason being that the very same 10^{80} particles that once made up past states, and will conceivably one day make up hypothetical future states, have today all been cannibalised to form today's state.

A further consideration is that back in the Jurassic we[d] were small nocturnal insectivorous tree-shrews. Had you been fondly imagining that on your forthcoming package tour back to the Jurassic you would be dining out nightly on barbecued dinosaur steak: well, think again. Your menu will consist solely of creepy-crawlies – variegated insects and their larvae – and no HP sauce to mask the taste. This could well dampen down somewhat the kick of being back in the Jurassic.

Time travel (2)

Given the absurdity of the idea of time travel, it is surprising to find even famous physicists like Stephen Hawking[e] taking it seriously:

---

[a] Khalil Gibran (1883–1931), Lebanese poet and writer who spent much of his life in the USA.
[b] In fact: 'absurdity'.
[c] That premisses leading to a contradictory/absurd conclusion are themselves contradictory/absurd
[d] Strictly: our ancestors.
[e] Stephen Hawking (1942–2018), English theoretical physicist, cosmologist and popular author.

> "It is possible to travel into the future. We don't have the technology to do it today, but it is only a question of engineering. We know it can be done."[25]

And:

> "Reasonable solutions to Einstein's General Relativity equations allowing time travel have now been found. Spacetime could be so deformed that you could set off in a spaceship, travel down a wormhole to the other side of the galaxy, and return before starting your journey, in time for dinner."[26]

Here am I, a privileged member of an advanced civilisation, and one night decide that, rather than of my customary after-dinner stroll I will take a quick wormhole trip to the other side of the galaxy and return before starting my journey, in time for dinner.

What Dr Hawking *doesn't* explain, however, is how my *dinner*, which set off on our worm-hole trip together with me cosily lodged in a mastigated state in my stomach, can be there on my plate waiting for me on my return in all its original pristine glory.

Maybe wormholes are full of fiendish negative-time wormlets, that inverse-excrete my mastigated dinner through their anal orifices, and then zap off down super-high-speed micro-wormholes of their own to inverse-ingest it through their oral orifices back onto my plate before I or anyone can realize what they've been up to. Far more evidently goes on in these wormholes than we the general public are being told about.

Further, just because something is *mathematically possible*, that doesn't necessarily mean it is *physically feasible*. A reasonable solution to Newton's second law of motion has recently been found, showing that bodies with negative mass will accelerate in the opposite direction to the forces applied to them. To date, however, this has never been actually observed.

The ancient Greek philosopher Heraclitus[a] said that one cannot step twice into the same river. Depending on a suitable definition of 'river' – for instance a specific configuration of water molecules, fish, flotsam, etc. – we could agree with him. But when Dr Hawking tells us that one can eat the same dinner twice: this *would* seem to require further explanation. And when he further says:

> "Even God is limited by the uncertainty principle[b], and cannot know both the position and velocity of a particle, but only its wave function"[27]

but without saying what replicable scientific experimentation this is based on, this too would appear to need justification.

And in this case God's own confirmation. As Dr Hawking's omniscient Creator, God obviously knows what he can and cannot do. But has Science made Dr Hawking sufficiently omniscient to know what *God* can and cannot do? *That* is the question.

From another point of view, however, time travel is not only feasible, but we all do it all the time. Ashleigh Brilliant[c] points out:

> "We know how to travel into the future, but not the other way. And only at a speed of sixty minutes per hour."[28]

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[a] Heraclitus of Ephesus (535-475 b.c.), pre-Socratic Greek philosopher.
[b] Of quantum physics.
[c] Ashleigh Brilliant (1933-), English epigramist.

BIBLIOGRAPHY

(cited works only)

Brilliant, A. (1979) *I May not be Perfect, but Parts of Me are Excellent* (Santa Barbara: Woodbridge)
Cahill, R.T (2003) *Quantum Foam and Gravitational Waves* (http://www.mountain man.com.au/process_physics/HPS16.pdf)
Einstein, A. (1916) *Relativity: The Special and General Theory* (London: Methuen) (https://www.marxists.org/reference/archive/einstein/works/ 1910s/relative/ relativity.pdf)
Fiennes, J. (2019a) *The Aether* (www.jeremyfiennes.com)
------ (2019b) *Einstein's Terrible Twins* (www.jeremyfiennes.com)
------ (2019d) *The Copenhagen Trip* (www.jeremyfiennes.com)
Hawking, S. et al (2005) A Briefer History of Time (Rio de Janeiro: Ediouro)
Strathern, P. (2000b) *Leibniz in 90 minutes* (Chicago: Dee)

INDEX

Newtonian action at a distance is only apparent. In truth is conveyed by a medium permeating space.

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[1] plato.stanford 1508.
[2] Einstein 1916.
[3] en.wikipedia 1006.
[4] members.tripod 0501.
[5] Strathern 2000b, p.20.
[6] bbc, telegraph, 1808.
[7] en.wiki 1511.
[8] Fiennes 2019b, p.31.
[9] spaceandmotion 1509.
[10] Fiennes 2019b, p.37.
[11] map.gsfc.nasa 0908; Goldsmith 1981, p.367; Capra 1992, p.75.
[12] corepower 0908
[13] Fiennes 2019b, p6.
[14] Fiennes 2019a, p.6.
[15] Fiennes 2019a, p.5.
[16] Cahill 2003.
[17] Einstein 1916.
[18] Fiennes 2019a.
[19] Einstein 1916, 1920.
[20] Fiennes 2019d.
[21] en.wikipedia 1002.
[22] theinspirationplace 0501
[23] Fiennes 2019b, p.10.
[24] Fiennes 2019b, p.65.
[25] Hawking 2005, p.109.
[26] Hawking 2001, p.135,136.
[27] Hawking 2001, p.107.
[28] Brilliant 1979, p.75.