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 part develops diagrammatic representations for 1-, 2- and 3-d static and expanding universes. It ends with discussions of gravity and time travel.

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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", we will nevertheless proceed.

[a] Sir Isaac's 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.

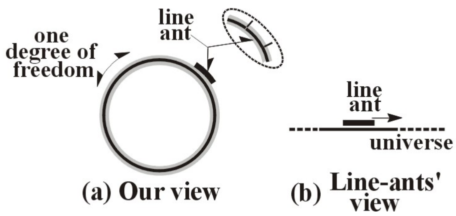

Fig. 0-1. 1-d universe, static (1).

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 in fact part of it. As 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"[c] finite, bounded in 2-d space.

Distance

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

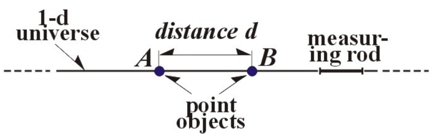

Fig. 0-2. Distance.

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

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

distance: a mathematical abstraction

For a distance *d* to be meaningful, i.e. to have a specific value, a *length standard* is required. With a metre rule as the standard, the distance been two objects would be one thing[a]. With a foot rule 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 two objects. But one can also simply say "There are *d* metres"[b]. The words "a distance of" add nothing to the rational meaning, and are rationally meaningless.

"Distance" is effectively 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[c], 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[d]:

spatial position x = distance from the space origin

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

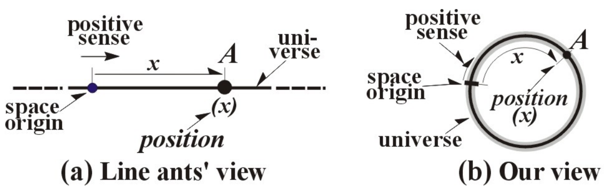

Fig. 0-3. Position.

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

Space

Space in a 1-d universe is equivalent to distance. One can say that there is a certain "distance" between two objects. Or alternatively that there is that "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 by nature a position in space.

---

[a] A specific number in someone's mind.
[b] *d* metre-rule lengths.
[c] Fig. 0-1a.
[d] In whatever units one cares to choose
[e] From an origin or reference point.

And we can say that things "exist in space". Or simply that they "exist". To 'exist' is inherently to exist in 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 being:

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

As testified by the interminable discussions on the subject. And Isaac and Albert's refusal to define it[a].

Time

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

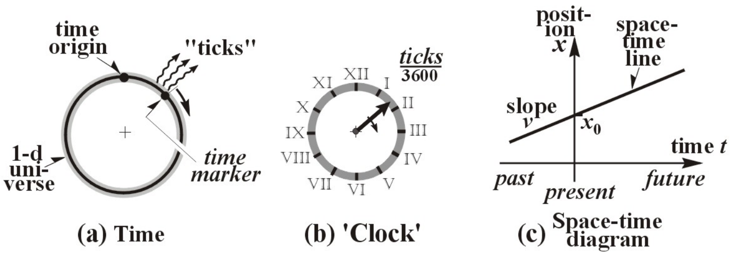

Fig. 0-4.Time.

Define arbitrarily a point object as the *time origin*. Call the number of ticks the time marker has emitted since leaving it the *time t*, representing it symbolically on a *clock*, Fig. 0-4b[b] .

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

Time-markers don't in fact 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 time-marker 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 where one can say that events "occur in time", one can also simply say that they "occur". Events inherently occur at points in time.

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

time **=** *something there is said to be between events, and that clocks 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 effectively *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

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[a] p.1.

[b] Drawn for 1-second 'ticks'.

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 and/or ticks 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 would speed up correspondingly. What used to take one minute on our clocks, would still take one minute. We wouldn't even notice any difference.

We therefore agree with Antiphon[a] who wrote:

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

Also with Tina Turner's[b]:

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

And with Gottfried Leibniz'[c]:

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

Some peoples[d][6] don't even have a concept 'time'. They think of events occurring in sequence, but have no concept of 'time' as something that passes independently of those events. Nor do they have words for periods of time such as 'month' or 'year'.

And if they can live quite happily without 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] (italics ours)

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*, such as that of Fig. 0-4c. 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 to conceive 'spacetime' as *something physical*, that can have physical characteristics such as being 'straight' or 'curved', is evidently senseless[e].

So when Einsteinian Relativists tell us that:

> "The Moon appears to curve as it orbits the Earth. But in reality it follows a straight line in curved spacetime."[8].

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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.

this is nonsensical. Spacetime is a *mathematical model*, a *string of symbols* set out on a piece of paper. And the Moon can hardly be said to follow a straight line in a curved string of symbols[a][9].

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

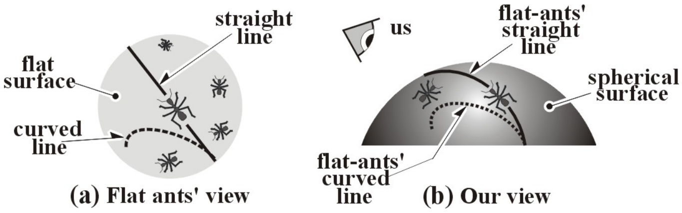

Fig. 0-5. 2-d universe (1)[b].

We superior 3-d beings looking on from the outside can see that the 2-d universe is "really"[c] curved and closed in 3-d space. And that what for the 2-d ants is a straight line, Fig. 0-5a, is "really" curved, Fig. 0-5b. 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[d].

For its 2-d inhabitants, the 2-d 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 it is "really" finite, bounded in 3-d space.

We can note that the previous 1-d ring universe[e] likewise obeys the cosmological principle of being isotropic, homogenous and limitless.

Position, 2-d

To quantify[f] 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*.

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[a] Discussed further in the Relativity article.
[b] Although shown as bounded (Fig. 0-5a), the flat-ants experience their universe as extending infinitely in all directions.
[c] p.2, note.
[d] Fig. 0-5a.
[e] Fig. 0-1.
[f] Attribute a specific value to.

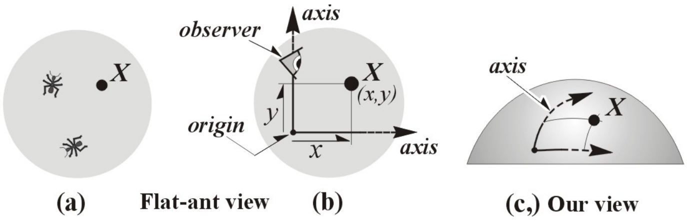

Fig. 0-6. Position, 2-d.

A reference frame is essentially an *observer's world*, what he sees from his own viewpoint:

reference frame = an observer's viewpoint

Coordinate systems can be *Cartesian*[a] or *polar*. A 2-d Cartesian system comprises a *space origin* and *two orthogonal axes*. It shown in a flat-ant's view in Fig. 0-6b and in our 3-d view in Fig. 0-6c. Corresponding polar. coordinates *(r,θ)* are shown in Fig. 0-7.

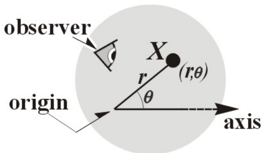

Fig. 0-7. Polar coordinates.

In a Cartesian system, the origin and the direction of one axis can be chosen arbitrarily. The orthogonality condition[b] then requires that the second spatial axis be perpendicular to the first.

The reference frame – in the Cartesian case, the origin and the axes – are not therefore physical objects themselves. They are *abstractions* only "existing"[c] in a someone's mind.

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[d].

3-d universe, static

We 3-d beings likewise experience a universe obeying the cosmological principle[e], 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 being aware of everything 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[f] question:

"Can we visualize a 3-d universe that is finite yet unbounded? "[10]

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

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[a] Named after the French philosopher René Descartes (1596-1650).
[b] An object's position on one axis must be independent of that on the other.
[c] In quotes, since 'existence' is here always *physical existence* (p.2**,** note).
[d] Fig. 0-6c.
[e] p.6.
[f] Einstein, Albert (1879-1955), German theoretical physicist.

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 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.

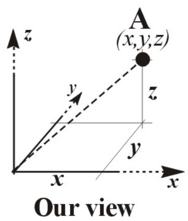

Fig. 0-8. Position, 3-d.

EXPANDING UNIVERSES

Big Bang[a]

On the currently orthodox *Big Bang model*, the universe originated[b] 13.7 b.y.a[c] 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*, and has been expanding ever since. It is shown in 2-d terms in Fig. 0-9[d] .

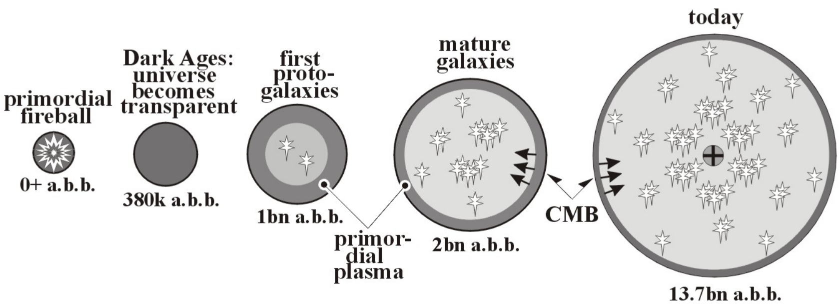

Fig. 0-9. Big Bang (1).

According to the[e][11] $E=mc^2$ 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 so concentrated, however, 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.[f] *protons*[g] and *neutrons* were forming. And three minutes later the first *complex nuclei*, mainly helium.

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[a] Those familiar with the Big Bang model can skip this sub-section.
[b] Is conceived to have originated.
[c] Billion years ago. Figures in general are estimates and/or rounded off.
[d] A 'present surface' (Fig. 0-19 below).
[e] We won't say "Einstein's", because it wasn't his.
[f] After Big Bang.
[g] Hydrogen nuclei.

Due to the very high temperatures, there were as yet no atoms as such[a]. Any electron that attached 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}[b] *elementary particles* – protons, neutrons and electrons[c] – had been formed.

The proportion of the original energy that condensed into matter was however 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[d] 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 now reaching us comprise the *cosmic microwave background* ('CMB'), which we discuss later. The so-called *Dark Ages* had begun.

But although dark, the universe 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.

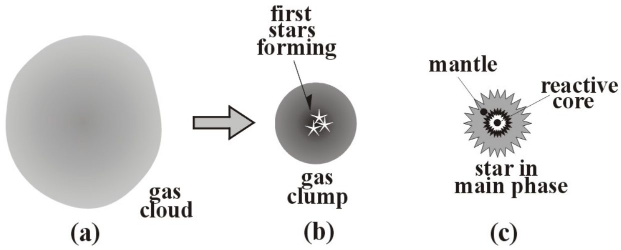

Fig. 0-10. Birth of a star.

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. the temperatures 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*. Again due to gravity, these 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 *our visible universe*, what we see from planet Earth. What might lie beyond it we inherently cannot know.

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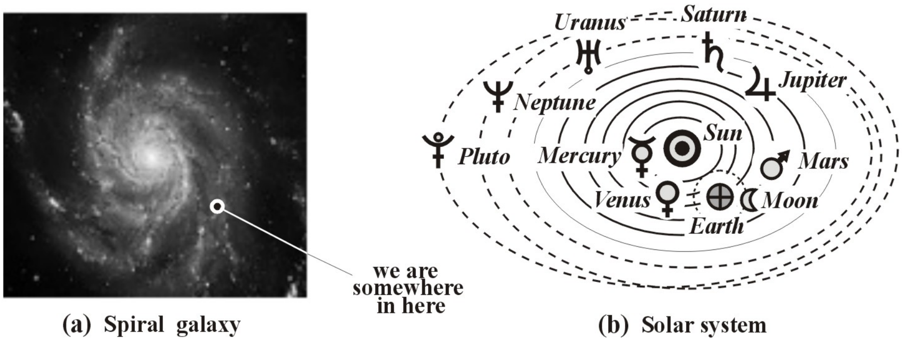
[a] Nuclei with orbiting electrons
[b] A '1' followed by eighty zeros.
[c] Our "fundamental particles" for present purposes.
[d] 'k' = thousand; 'mn' = million; 'bn' = billion.

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



(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 300k 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 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[12]. If all empty space were eliminated, the whole of humanity could fit into a sugar cube.

The range of densities is likewise enormous. The density at the centre of a neutron star, the most compact object 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[c] 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. 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 in the modern world:

you can see it on the telly!

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[a] Light takes 100k years to cross it.
[b] The three exterior planets: Uranus, Neptune and Pluto, are invisible to the naked eye.
[c] One hydrogen atom for every four cubic metres of space.

1-d universe, expanding

Consider an *expanding 1-d universe*. On a space-time diagram its state at successive instants is represented by *concentric circles*, Fig. 0-12a[a]. Due to the expansion, the distance between "stationary"[b] objects now increases continually, meaning that a steadily moving line-ant will take longer to reach its destination – if it gets there at all.

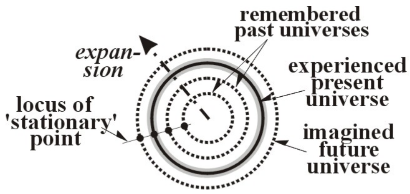

Fig. 0-12. 1-d universe, expanding (1).

In the previous static 1-d universe[c], if a light photon[d] travelled for 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[e] is then a series of circles centred on the Big Bang, Fig. 0-13.

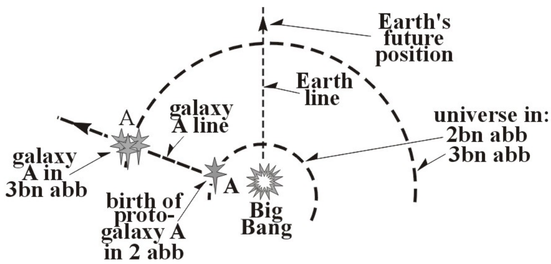

Fig. 0-13. 1-d universe, expanding (2).

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

Imagine a '*pgA*[g] *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[h], Fig. 0-14a.

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[a] Cf Fig. 0-1a.
[b] With respect to the ring,.
[c] Fig. 0-3 .
[d] Here conceived as a miniscule section of the ring travelling around it at a characteristic speed.
[e] With only one spatial dimension, as a 1-d ring universe (Fig. 0-1).
[f] On the 1-d ring universe.
[g] 'Proto-galaxy A'.
[h] The point on the 1-d ring universe where the Earth will appear in 9.1bn a.b.b. (the Earth's age being 4.6bn years).

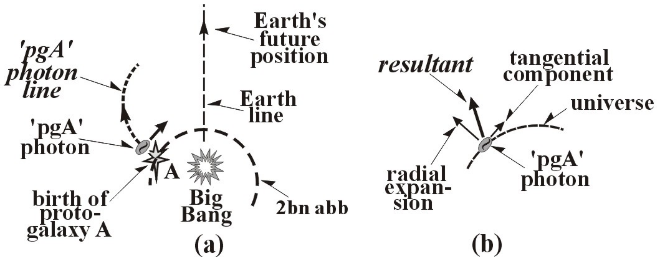

Fig. 0-14. 'pgA' photon.

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

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

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

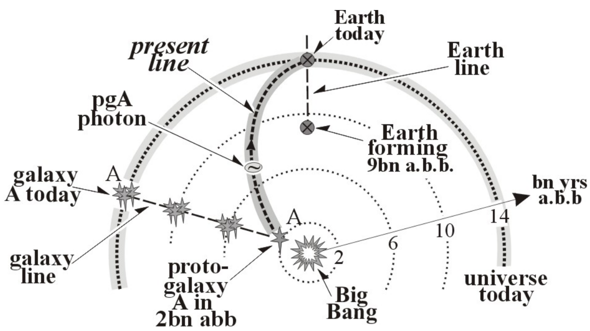

Fig. 0-15. 1-d universe, expanding (3).

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

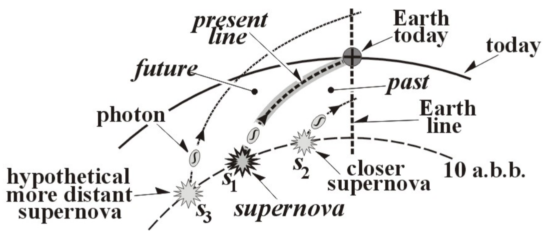

Fig. 0-16. Supernovas.

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 thus simultaneously our *present line*, containing all the 1-d events that we are now observing , those whose photons are reaching planet Earth right now:

[a] Their speed relative 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* 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 occurring in 10bn a.b.b, but this time 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[a] is the 'expanding balloon-surface model' of Fig. 0-17[13]. Noting again[b] that the 'universe' is the 2-d *balloon surface*, and not the 3-d balloon. 'Stationary' in this case is 'on the balloon surface'.

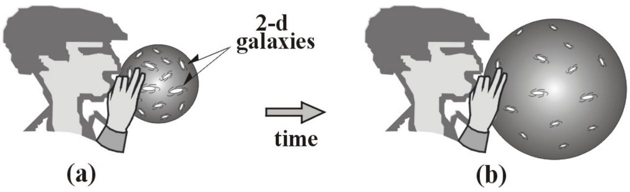

Fig. 0-17. 2-d universe (2).

The previous 1-d present line[c] is here the *2-d present surface* of Fig. 0-18a. Noting that it is not a 'universe'; but rather a *hypothetical surface* containing all the 2-d events, occurring at varying times in the past, that we are experiencing on Planet Earth 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 present line of Fig. 0-18b[d].

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[a] Arthur Eddington (1882–1944), English astronomer.
[b] p.6.
[c] Fig. 0-15.
[d] Cf Fig. 0-15.

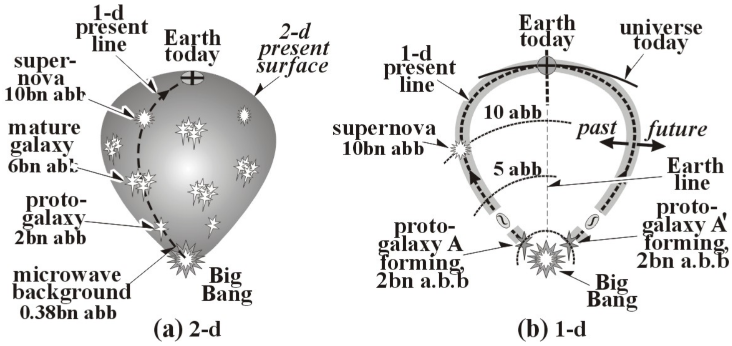

Fig. 0-18. Present surface.

We see from Fig. 0-18b that in 1-d terms 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 1-d 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*, 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].

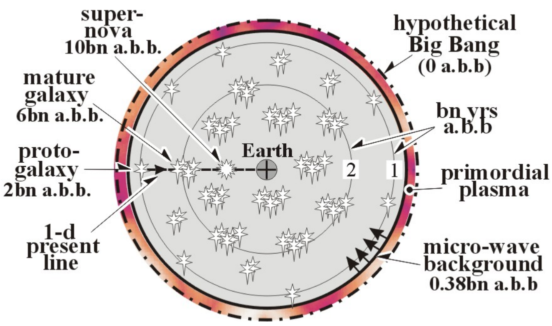

Fig. 0-19. 2-d universe (3).

Due to the primordial plasma, however, photons from the Big Bang itself cannot reach us directly. The practical limit to 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 reach us travelling freely through space[e].

CMB

When the cosmic microwave background was discovered in 1965, it was quickly realized that it could provide an absolute reference[f] for speeds[g][14]. The 'universe' for us is the Big Bang and its sequel. The CMB being our earliest view of the Big Bang, it is our most 'absolute' universe reference.

---

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

Consider a spaceship out in deep space, shown in 2-d terms in Fig. 20. When moving relative to the CMB, the pilot experiences a higher frequency in front of him and a lower frequency behind – the *Doppler effect*[a][15]. When he sees the same frequency all around him, he knows that he is at rest with respect to the CMB, effectively 'stationary on the balloon-surface'[b].

Fig. 20. Microwave background (2).

On this basis, the absolute velocity of the solar system through space[c] 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].

On the expanding-balloon model there is thus an 'absolute'[d] reference for *speeds*, namely 'stationary on its surface'. But because every individual experiences himself at the centre of the (strictly "his") universe[e], there is no corresponding spatial reference, no 'absolute space'[f]. A spatial position is always with respect to an arbitrarily chosen origin[g].

Redshift

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

We can visualize the red-shift as being due to the universe's expansion "stretching" the aether, increasing the wavelength of the light and lowering its frequency, Fig. 0-21[h].

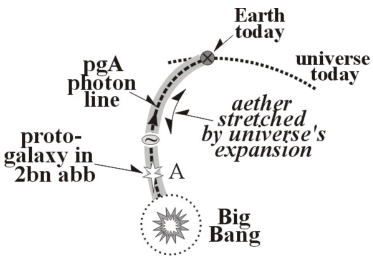

Fig. 0-21. Redshift.

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[a] Aether article.
[b] Fig. 0-17.
[c] With respect to the CMB.
[d] Preferred.
[e] The one he experiences.
[f] Sorry, Sir Isaac!
[g] Cf Fig. 0-6b.
[h] Fig. 0-15.

GENERAL

Newton's Laws

Turning to Newton's *Laws of Motion*, Sir Isaac's original formulation was somewhat long-winded, and also in Latin. They have been summarized[17]:

– 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 however one with no acceleration. Making the first law simply the second in the specific case of zero force, and hence *redundant*.

A force being by definition "that which causes a mass to accelerate"[b], the second law is a *truism*, implicit in the definition of a force.

For the third law, assuming that by "action" Sir Isaac meant "force", this simply 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 bodies. There is no such thing as a "free-floating force". If the Earth exerts a gravitational force on the eminent scientist's apple, the eminent scientist's apple exerts an equal and opposite force on the Earth. The third law is likewise a truism, implicit in the concept of a force.

All three of Sir Isaac's laws are thus either redundant, or truisms that don't say anything meaningful about anything. *But* – and this is a massive 'but' – what Sir Isaac did was to *rectify the concept of a natural state*. Pre-Newtonian mechanics was based on *Aristotle*, who held that the natural state of things is *rest*. They only move so long as some force obliges them to.

Newton said no, the natural state is *inertial motion*. Hence his 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 has never looked back.

Full marks, Sir Isaac! Go to the top of the class.

Fields (1)

Newton like many others had a problem with 'action at a distance'. He wrote:

> "That one body may act upon another at a distance thro' a vacuum, without mutual contact or the mediation of any thing else, is to me so great an absurdity that I believe no thinking man can ever fall into it. Gravity must be caused by an agent acting according to certain laws. But whether this agent be material or immaterial, I have left to the consideration of my readers."[18][c]

As did also Einstein:

> "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[19]. But are constrain-

---

[a] Which can also be zero.
[b] p.18.
[c] Noting again Sir Isaac's tendency to conceptual copout. (Cf p.1).

> ed to imagine that the magnet calls into being a 'magnetic field'. And that this operates on the piece of iron so that it strives to move towards the magnet."[20]

Action at a distance is however an *experimental fact.* And Science's task is to develop theories to give rational coherence to experimental facts – and not dismiss them as "impossible".

Magnets, electric charges and masses all demonstrably exert force at a distance across empty space. And since magnetic attraction was already known in Newton's time, one wonders why he didn't also conceive gravity in these terms.

Far from there being 'no such thing' as force at a distance, there is in fact *nothing but* force at a distance. What we fondly call "solid matter" is in reality *empty space permeated with electrostatic fields*[a][21]. When I hit my head against a jagged concrete beam, what actually happens in physical terms is that the concrete beam's outer electrons repel those of my head. And since there is no such thing as 'direct electron-electron contact'[b], this is action at a distance:

there is nothing but action at a distance

Fields (2)

Returning to gravitational fields, consider two masses M_1 and M_2 in outer space, Fig. 0-22a. M_2 experiences a gravitational force f_g due to M_1, given by Newton's inverse square law.

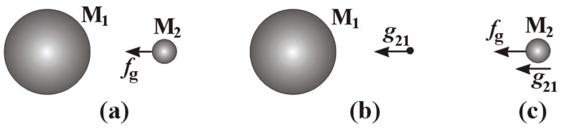

Fig. 0-22. Gravitational field.

According to Einstein, however, M_1 doesn't cause the force on M_2 directly. It sets up a *gravitational field* g_{21}[c], Fig. 0-22b. *This* then acts on M_2 to produce the force f_g, Fig. 0-22c.

But if a mass cannot produce a *force* at a distance, how can it produce a *field* at a distance? All Einstein has done is to replace "force at a distance" with "field at a distance", explaining nothing.

And because the only way to know whether there is a gravitational field[d] at a point is to place a mass there and see whether it experiences a force[e], gravity at the end of the day always boils down to masses exerting forces on other masses across empty space.

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

Fields (3)

The final question on fields is "Do they actually exist. Or are they simply a *mental model*, a way of thinking about things?". As always in such cases, this is essentially a question of *definition*. How are we to define the word "existence"? What *criterion* do we use when deciding whether to say that something "exists"?

One reasonable definition of 'existence' could be "what is physically experienced, either directly with the senses or indirectly via instrumentation:

---

[a] QM article.

[b] Except possibly in particle accelerators.

[c] Field at point 2 due to M_1.

[d] g_g.

[e] eq.3.

'existence' = what is directly or indirectly experienced

A mass in a gravitational field being subject to a measurable force, this can be considered 'indirect experiencing' of that field[a]. And similarly for a charged body in an electrostatic field. On this definition gravitational and electric fields *would* be said to exist. On some other definitions they might not be.

Inertial/gravitational mass

Like many others, Einstein had the strange idea of separate 'inertial' and 'gravitational' masses, for instance writing 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." [22]

This has even been formalized as the 'Weak Equivalence Principle'.

The distinction however makes little sense. Mass is defined in terms of the standard 1 kg platinum-iridium block kept in Paris[b]. It is not said to be "inertial mass", nor "gravitational mass", but simply "mass".

The fundamental 'MKS' mechanical units of mass (kg), length (m)[c] and time (s)[d] are defined essentially arbitrarily. Force not being one of these, it has to be defined in terms of them – for instance via Newton's second law. If a force applied to the standard 1 kg mass in Paris results in an acceleration of 1 m/s^2, then its value is by definition 1 N[e].

This allows the values of other masses to be determined. If a force applied to some body gives an acceleration a. And the same force applied to the standard 1 kg mass produces an acceleration a_1. Then the mass of that body is by definition $M=a_1/a$.

In possession of operational procedures for measuring mass and force quantitatively, Newton's gravitational "constant" G[f][23] can then be determined experimentally.

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

TIME TRAVEL

Time travel (1)

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

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 conceivably come to be, likewise neural traces in our present brains. The only 'reality' we ever physically experience and can conceivably travel in is *present here-and-now reality*, that existing right here right now. Khalil Gibran[h]:

> "Yesterday is today's memory. Tomorrow is today's dream"[24]

---

[a] 'Indirect', because what is actually physically experienced is the *force*, and not the field as such.
[b] At present. The standard is currently being revised.
[c] Originally a standard metre rod, also kept in Paris. Now the distance light travels in a certain time.
[d] Originally a certain fraction of a solar year, but now defined in terms of the emission frequency of a caesium atom.
[e] Newton.
[f] In practice, not quite as 'constant' as a proper constant should be. Cf the Aether article.
[g] p.4,4.
[h] Khalil Gibran (1883–1931), Lebanese poet and writer who spent much of his life in the USA.

Another approach. On the well-known *grandfather paradox*[a][25], 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, it would be possible for A not to be possible"

this is rationally nonsensical. And so also, on the philosophical *reductio ad absurdum* principle[b][26], is therefore the respective premiss of being able to change the past.

That raw red wound you saw on 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 never was 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, which is again senseless.

On the Big Bang model[c], the universe comprises its 10^{80} fundamental particles – protons, neutrons and electrons. A *universe state* being 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. Whereas 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 can't 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} fundamental particles that once made up past states, and will conceivably one day make up future states, have today all been cannibalised to form today's state.

A further consideration is that back in the Jurassic we ourselves[d] were small nocturnal insectivorous tree-shrews. So had you been fondly imagining that on your forthcoming package tour 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. All of which 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:

> "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."[27]

And:

---

[a] In fact: 'absurdity'.
[b] That premisses leading to a contradictory/absurd conclusion are themselves contradictory/absurd
[c] p.8.
[d] Strictly: our ancestors.
[e] Stephen Hawking (1942–2018), English theoretical physicist, cosmologist and popular author.

> "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."[28]

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* however explain 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 awaiting 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 else 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*, doesn't necessarily make it *physically feasible*. A reasonable solution to Newton's second law of motion has also been found, allowing a body with negative mass to accelerate in the opposite direction to the force applied to it. Although to date 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: well, this *would* seem to require further explanation.

And when he further says that:

> "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"[29]

but without telling us what replicable scientific experimentation his assertion is based on, this too would appear to need justification.

And in this case God's own confirmation. As his omniscient Creator, God obviously knows what Dr Hawking 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. As 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."[30]

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