Space, Time, the Universe

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Abstract

The article is in two parts. The first looks at the concepts of space and time in general, in terms of 1-, 2-, and 3-dimensional universes. The second applies them to our expanding 3-d universe, ending with a discussion of time-travel. The treatment is 100% non-mathematical.

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 the concepts 'space' and time', to even attempt to do so may seem presumptous. On the hallowed principle that 'fools wander where angels fear to tread', we will nevertheless proceed.

SPACE, TIME

1-d[a] universe, static

Consider the *static 1-d universe*:ss of Fig. 0-1a, comprising closed ring of zero X-section. 'At-rest' is here "stationary on the ring"[b]3

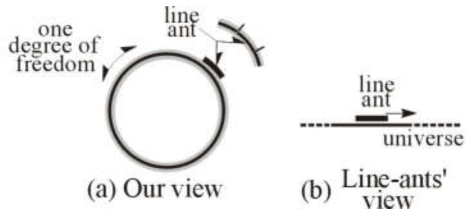

Fig. 0-1. 1-d universe, static (1).

Let the universe 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. 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 move through each other.

We superior 3-d beings, , looking on from the outside, see that the 1-d ring universe is "really"[c] curved and closed in 2-d space. We see everything that is happening in it at any instant of our time. But for the 1-d ants, with no experience of, and hence no ability to visualize a second 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 see that the 1-d universe is in fact *finite*, bounded in 2-d space.

Distance

Consider two point objects[d] A and B in the 1-d universe, with no other objects inbetween, Fig. 0-2. There is however still said to *be a distance* between them. Distance itself is not, therefore, a physical object – something that can be seen, heard, smelt, touched and/or tasted[e]. An observer counts – either actually physically or in his imagination – the number of times a *length standard* – for instance a metre rule[f] – would fit in between the two objects, calling the result the "distance *d*".

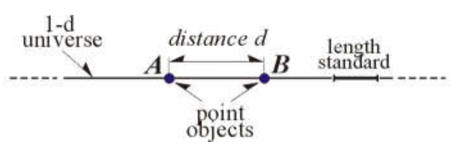

Fig. 0-2. Distance.

A length standard is a physical object. But a distance *d* is a *mathematical abstraction*, a number in someone's mind:

distance: a mathematical abstraction

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[a] 1-dimensional.
[b] This refers to a companion article on Einsteinian Relativity.
[c] In our reality.
[d] Infinitesimally small sections of the 1-d ring universe.
[e] Our definition of a 'physical object'.
[f] 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 always required. With a metre rule as the standard, the distance been two given objects would be one thing, i.e. have one value. With a foot rule[a] it would be another; and so on. Rules don't therefore *measure* distance – one cannot measure physically a mental abstraction. They *define it*:

rules don't measure distance; they define it

Another approach: one can say that "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 in general *said-to-bes*:

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

Position, 1-d

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

spatial position x = distance from the space origin

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

A 1-d position in a line-ants' view is shown in Fig. 0-3a, and as seen from the outside by us 3-d beings in Fig. 0-3b[d]. Being essentially a distance, a spatial position is likewise a mathematical abstraction, a number in an observer's mind.

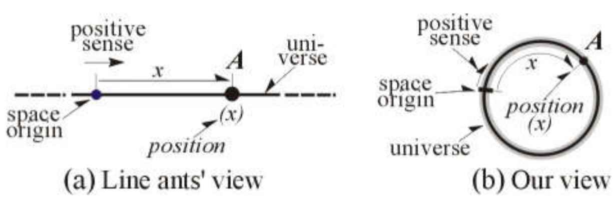

Fig. 0-3. Position.

Space

Turning to *space*, an object's spatial position can alternatively be called its "position in space". But to go on and conceive 'space' as something physical, that can have physical properties such as being 'straight' or 'curved', is senseless. A position is a mathematical abstraction, a number in someone's mind. And a mathematical abstraction cannot meaningfully be said to "be in" anything physical.

Another approach: we can say that an object "has a position in space". But we can also simply say that it "has a position" A position is by nature a position in space. The words "in space" add nothing to the rational meaning and are rationally meaningless.

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[a] Feet and inches.
[b] *d* metre-rule lengths.
[c] An infinitesimally small section of the ring.
[d] Cf Fig. 0-1.

Or again, we can say that we "look out into space". But we can also simply say that we "look out". 'Looking out' is always "into space". The words "into space" add nothing to the rational meaning.

Space is a another said-to-be, a verbal convenience, something we say things have positions in, and that we look out into, but apart from that cannot say what it is:

space = something physical objects are said to have positions in, but apart from that we cannot say what it is

As is testified by the interminable discussions on the subject.

Time

Imagine a *time marker*, a point object moving continuously forewards along the 1-d ring emitting audible 'ticks' as it goes, Fig. 0-4a. Define arbitrarily a *time origin*. Call the number of ticks the marker emits since leaving the origin the *time t*, representing it symbolically on a *clock*.

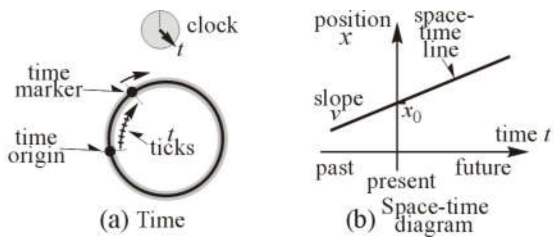

Fig. 0-4.Time.

A time *t* on this approach 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 mathematical abstractions, numbers in someone's mind.

A time-marker strictly does not need not move. It simply has to emit ticks. Conceiving a moving time-marker is however convenient. Firstly because it enables one to estimate the timing of events occurring between clock ticks. It also emphasizes the analogy between spatial and temporal distances.

As for 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". The words "a time of" add nothing to the rational meaning and are rationally meaningless.

Or we can say that events "occur in time". But we can also simply say that they "occur". To 'occur' is always to "occur in time".

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

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

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

For a time *t* to be meaningful, i.e. to have a specific value, a time standard is always required. With one clock as the standard, the time *t* between two given events would be one thing. With another clock as the standard it would be another; and so on. Clocks don't *measure* time. They define it:

clocks don't measure time; they define it

A time-marker must evidently move *continuously*, because otherwise two non-simultaneous events could have the same timing. Seen from the outside, however, the movement/ticks need not be regular.

Imagine that the Creator of our universe, bored with the general 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 on our clocks. We wouldn't even notice any difference.

We thus agree with the 18thC German philosopher Gottfried Leibnitz[a] when he said:

> "Space and time don't exist, but are mere superstitions."[4]

Space-time

Space-time has been defined as:

> "Any mathematical model that combines space and time into a single inter-woven continuum."[5]

In terms of the 1-d ring universe, the relation between a line-ant's spatial position *x* and its temporal position[b] *t* can be represented on a *space-time diagram*. That of Fig. 0-3b, for instance, represents a line-ant moving clockwise at a steady speed *v*[c].

We can further combine an ant's spatial position *x* and its temporal position *t* into a single mathematical variable (*x,t*), calling it the ant's *space-time position*.

But as for space, to go on to call this a "position in space-time". And then conceive 'spacetime' as something physical that can have physical characteristics, such as being 'straight' or 'curved', is nonsensical. A space-time position *(x,t)* is a mathematical abstraction, a set of numbers in someone's mind. There is nothing physical that a mathematical abstraction can meaningfully be said to "be in".

2-d universe, static

Consider a *static 2-d universe*, for instance the spherical surface of Fig. 0-5b. Noting that the 'universe' is here the *2-d sphere surface*, and not the 3-d sphere. Imagine the universe populated with *2-d flat-ants*, animated areas of its surface with length and width but no height.

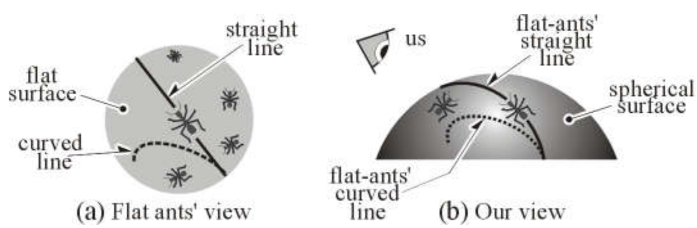

Fig. 0-5. 2-d universe (2).

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

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[a] Gottfiried Leibnitz (1646-1716), the epitome of a genius. Among many other things, he invented binary arithmetic, differential calculus and a machine for measuring good and evil.

[b] Time.

[c] With respect to the time-defining clock ticks.

[d] In our reality.

The 2-d flat-ants, however, with no experience of and hence no ability to visualize a 3rd dimension, cannot conceive their universe in this way. For them it is flat, Fig. 0-5a.

In the line-ants view their 2- universe[a] 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 in our external view it is *finite*, being bounded in 3-d space. .

Position, 2-d

To define a 2-d spatial position, we need firstly a *space origin*. And secondly two *orthogonal axes*, Fig. 0-6a. The origin and the direction of one axis can be chosen arbitrarily. The orthogonality of the axes requires that an object's position on one be able to vary independently of is position on the other – effectively that the two axes must be *perpendicular*.

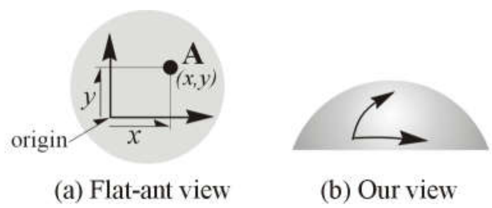

Fig. 0-6. Position, 2-d.

The origin and the axes both being imaginary, "exising"[b] only in an observer's mind, they are not themselves physical objects. In the 2-d flat-ants' view the axes are straight and extend infinitely in their respective directions. Even though we 3-d beings see that they are "really" curved in 3-d space, and would eventually close back on themselves, Fig. 0-6b.

As in a 1-d universe, a *2-d* object's spatial position (*x,y*) and temporal position *t* can be combined into a single mathematical variable (*x,y,t*), calling it the ant's *space-time position*. But to go on and call this a "position in space-time". And then conceive 'space-time' as something physical that can have with physical properties, such as being 'straight' or curved", is again senseless.

3-d universe, static

We 3-d beings likewise experience a universe obeying the cosmological principle, being isotropic, homogeneous and unbounded. We can further *conceive* of superior 4-d beings looking in from the outside and seeing it as "really" curved and finite in their 4-d space. And as seeing 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 question:

> "Can we visualize a 3-d universe that is finite yet unbounded?"[6]

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

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

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[a] As does also the 1-d static universe.
[b] In quotes, 'existence' here always being *physical* existence (p.2).

Orthogonal spatial axes in a 3-d universe are shown in Fig. 0-7. For us the universe's inhabitants they are straight and extend infinitely in their respective directions. Even though hypothetical 4-d beings could well see them as curved and bounded in 4-d space.

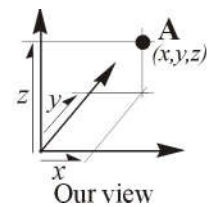

Fig. 0-7. Position, 3-d.

We can again combine a 3-d object's spatial positions (*x,y,z*) and its temporal position *t* into single mathematical variable (*x,y,z,t*), calling it the object's *space-time position*. But as before, to then call this a "position in space-time", conceiving 'space-time' as something physical that can have physical properties such as being 'straight' or 'curved', is nonsensical.

Higher dimensions

Define an *independent characteristic* of an object as one that can vary independently of its other characteristics:

independent characteristic = one that can vary independently of other characteristics

In the 2-d universe of Fig. 0-6, for instance, an object's *x*-axis position and *y*-axis position can vary independently of each other and are independent characteristics.

Define further a *dimension* as something an independent characteristic can be ordered along':

dimension = something an independent characteristic is ordered along

In the 2-d universe of Fig. 0-6a, the *x*- and *y*-axes are simultaneously dimensions.

Extending the idea: dogs for instance have the independent characteristics of size, colour, friendliness and smelliness. For a specific dog, we could assess each of these on a 1..5 point scale. A '(3,4,2,5)' dog would for example be of average size, lightish colour, less than average friendliness and extremely smelly. We could then imagine the values ordered in "4-d dog space".

The values of up to three such characteristics are representable diagramatically. An object's three spatial positions (*x,y,z*), for instance, are shown in Fig. 0-7. For more characteristics than this, however, cannot be done. Our spatial visualization limit is three dimensions[a]. Higher dimensional spaces are therefore *purely mathematical*, sets of numbers with no visual representation.

So when string physicists tell us that "reality is 11-dimensional", this means that the values of eleven independent characteristics are required to define it. But when they go on to say that "the fourth and higher spatial dimensions are curled up so small that we don't notice them", this makes little sense". Spatial dimensions are all essentially equivalent, and infinite in extension[b]. Imagine trying to convince a 2-d flat-ant that it is really a 3-d being inhabiting a 3-d universe, but that its height dimension is so curled up that it doesn't notice it.

[a] p.6.
[b] Cf Fig. 0-6.

Dimensions don't exist physically. They are *imaginary*: we create them in our minds[a]. And how can something imaginary have the physical property of being 'curled'?

EXPANDING UNIVERSES

Big Bang

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. 0-8a. And has been expanding ever since.

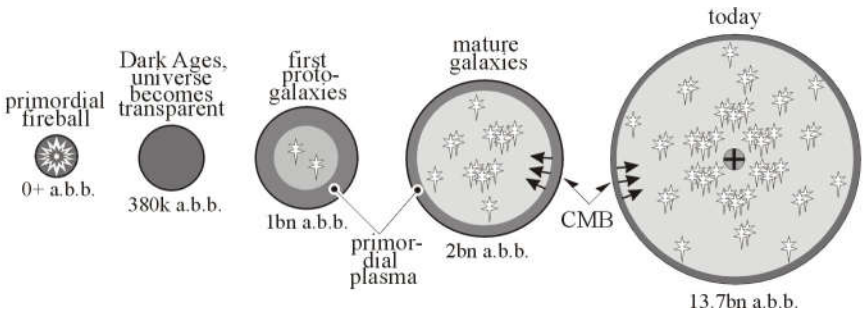

Fig. 0-8. Big Bang.

According to the $E=mc^2$ 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 exist. Everything was pure energy.

As the fireball expanded its temperature fell rapidly. At 1 sec. a.b.b.[c] *protons*[d] and *neutrons* were forming. And after three minutes the first complex nuclei, mainly helium. Due to the very high temperatures, there were still no atoms as such[e]. 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. The primary conversion of energy into matter was over. Some 10^{80}[f] *elementary particles* – protons, neutrons and electrons – 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[g] a.b.b. it was low enough for electrons to remain permanently attached to atomic 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

[a] Cf Fig. 0-7.
[b] Billion years ago. All figures are estimates and/or rounded off.
[c] "After Big Bang".
[d] Hydrogen nuclei.
[e] Nuclei with orbiting electrons
[f] A '1' followed by eighty zeros.
[g] 'k' = thousand; 'mn' = million; 'bn' = billion.

space. The photons from this point in time 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 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. 0-9a,b.

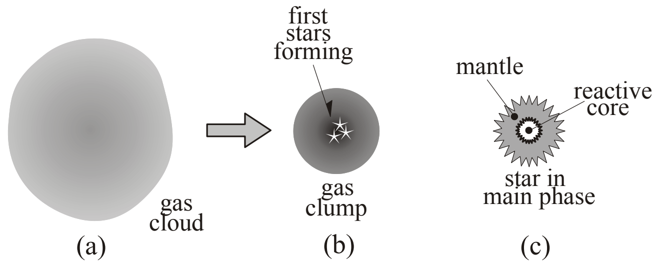

Fig. 0-9. Birth of a star.

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 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 fusio*n 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 star*s were born.

A star in its "main phase" comprises a *reactive core* surrounded by an *incandescent mantle*, Fig. 0-9c. 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 part of the universe we can see from planet Earth. What might lie beyond it we inherently cannot know.

Our own Milky Way galaxy, Fig. 0-10a, 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. 0-10b. The three exterior planets – Uranus, Neptune and Pluto – are invisible to the naked eye.

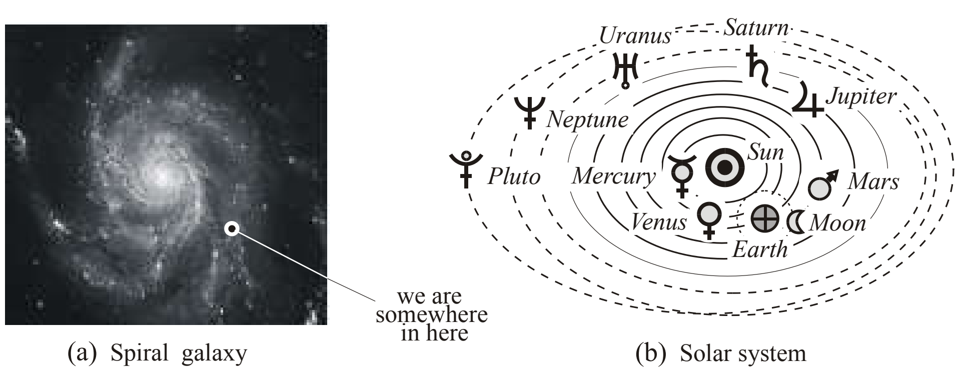

Fig. 0-10. Solar system{.

In spite of its 10^{80} elementary particles, the universe as a whole is a virtual vacuum. Its average density is one hydrogen atom for every four cubic metres of space. By earthly

[a] Light takes 100k years to cross it.

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[7]. If all empty space were eliminated, the whole of humanity would fit into a sugar cube.

The range of densities is likewise enormous. The density at the centre of neutron stars, the most compact objects known, is 7×10^{17} kg/m^3. A pinhead of this 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. And when the signal to one's TV fails, the "scribbles" that appear on the screen are in part due to it. Not only is the Big Bang still going on. But like just about everything in this modern world:

you can see it on the telly!

1-d universe, expanding

Consider an *expanding 1-d universe*, whose state at successive instants is represented by concentric circles on a space-time diagram, Fig. 0-11a[b]. The distance between "stationary" objects[c] here increases continually, and a steadily moving line-ant's space-time line would be correspondingly curved, Fig. 0-11b[d].

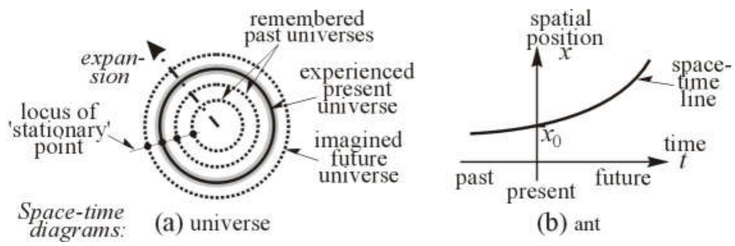

Fig. 0-11. 1-d universe, expanding (1).

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[a] One hydrogen atom for every four cubic metres of space.

[b] Cf Fig. 0-1a.

[c] Here again: "stationary on the ring" (Cf p.2),.

[d] Cf Fig. 0-4b (assuming a constant length metre rule).

In the previous static 1-d universe[a], if a light photon[b] travelled for long enough in any Fig. 0-12 one direction it would eventually end up back where it started. But were the universe expanding sufficiently rapidly, and were the speed of light around it limited, this may not be the case. We discuss it further below.

Our own expanding 3-d universe in 1-d terms is a series of circles centred on the Big Bang. Consider a specific event, for instance a proto-galaxy A forming in the year 2bn a.b.b.

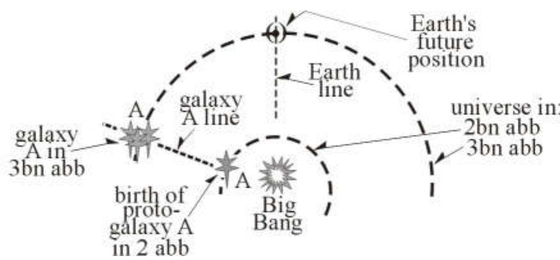

Fig. 0-13. 1-d universe, expanding (3).

The galaxy being stationary in space[c], 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 photon in 2 a.b.b. setting out from the nascent proto-galaxy A in the direction of the Earth's future position[d], Fig. 0-14a. Call it a "*pgA*[e] *photon*".

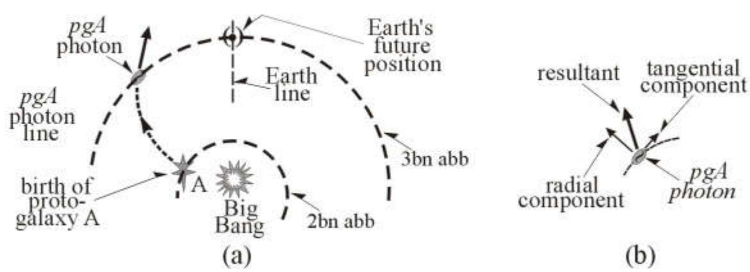

Fig. 0-14. 1-d universe, expanding (2).

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

– 1) a *tangential component* along the 1-d universe
– 2) an outward *radial component* due to its expansion

Due to their tangential component of velocity, photons travelling at the speed of light around the universe thus have *curved loci*. Whereas objects such as planets, stars and galaxies that are essentially stationary in space[f] have radial loci.

Fig. 0-15 shows the overall space-time diagram from 2bn a.b.b. up till today. We discuss the "present line" in a moment.

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a Fig. 0-3 .
b Here a miniscule section of the ring travelling around it at a characteristic speed *c*.
c On the ring universe.
d 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).
e "Proto-galaxy A".
f On the expanding balloon surface.

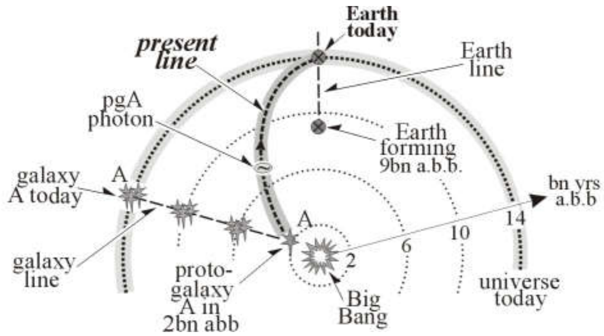

Fig. 0-15. 1-d universe, expanding (4).

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'.

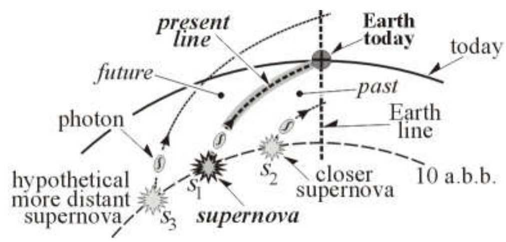

Fig. 0-16. Supernovas .

The photons from the supernova reach the Earth together with those from the birth of proto-galaxy A[a]. Should some earthly astronomer look into his telescope right now, he will see both events. The pgA photon line is thus simultaneously our *present line*:, containing all the events that we are experiencing right now, those whose photons are reaching planet Earth at this instant.

Due to the finite speed of light, when we look *out into space*[b] we look *back in time*. We see simultaneously the birth of the proto-galaxy A in 2bn a.b.b. and the supernova in 10bn a.b.b. We don't 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. I don't even see my big toe as it "really" is, but only as it was a fraction of a nanosecond ago. Objectively speaking, everything external we experience 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 further from us. Should there have been such an event, its photons will reach Earth some time 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 the *left* represents our *future*, hypothetical events that we may one day observe, but at present cannot know about.

2-d universe, expanding

Now consider an *expanding 2-d universe*. An analogy, first used by the English astronomer Arthur Eddington (1882–1944), is the *expanding balloon model* of Fig. 0-17[8].

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[a] Both lying on the pgA photon line.
[b] p.4.

Noting again that the 'universe' is here the *2-d balloon surface*, and not the 3-d balloon. 'At-rest' in this case is "stationary on the balloon surface".

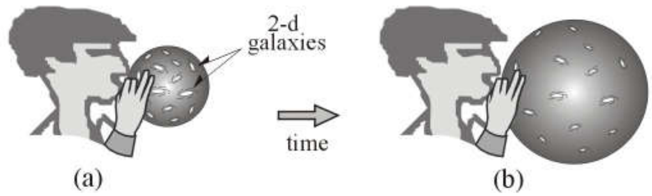

Fig. 0-17. 2-d universe (1).

In 2-d terms, the 1-d present line of Fig. 0-15 becomes the 2-d *present surface* of Fig. 0-18a. Noting that it is not itself a 'universe'. But rather a hypothetical surface containing all the 2-d events, occurring at varying times in the past, that we are experiencing right now.

A section through the surface gives the 1-d present line of Fig. 0-18b. We see that we in fact observe the births of *two* proto-galaxies, A and A', in 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.

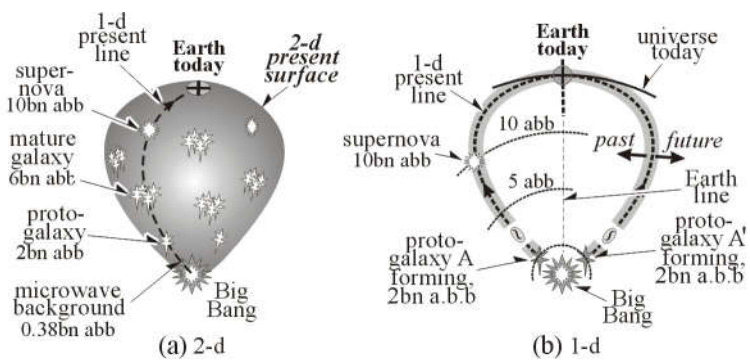

Fig. 0-18. 2-d universe (4).

As the inhabitants of a 2-d balloon-surface universe, we don't however *experience* our present surface as curved, as in Fig. 0-18a, but rather as *flat*, Fig. 0-19[a]. The 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 curved surface of Fig. 0-18a, and by the outer rim of the disc of Fig. 0-19.

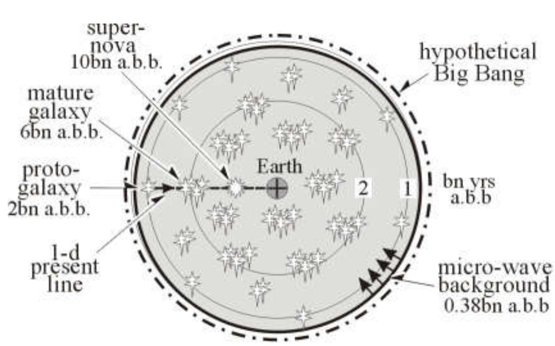

Fig. 0-19. 2-d universe (5).

[a] Cf Fig. 0-5.

Due to the primordial plasma, however, photons from the Big Bang itself cannot reach us directly. The outer limit of our visible universe is in practice the *cosmic microwave background* ('CMB'), the photons originating from the beginning of the Dark Ages in 380k a.b.b.[a] when the universe first became transparent to them, Fig. 0-20.

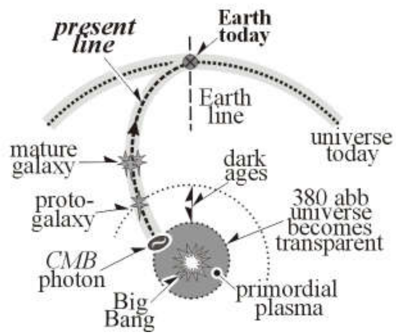

Fig. 0-20. Microwave background (1).

In terms of our 3-d universe, we experience it populated with planets, stars and galaxies. The further away they are from us in space, the further back in time we see them. From behind them all the CMB photons arrive from all 3-d directions.

3-d universe, expanding

Returning to the 1-d representation of our 3-d universe[b], and ignoring for simplicity the CMB, photons from the births of two proto-galaxies A and A' in 2bn a.b.b.[c] are arriving at Earth today, Fig. 0-21a. Whose those from the formation of the more distant proto-galaxy B, lying outside our present line, have not yet had time to reach us. Should such an event have occurred, it is still invisible to us. The limit of our *visible universe* is the births of the proto-galaxies A and A'.

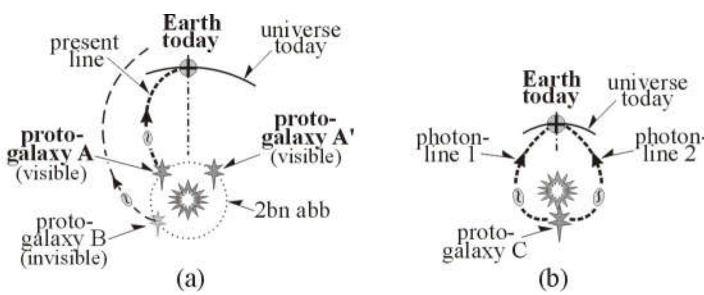

Fig. 0-21. Visible universe.

Now consider the universe of Fig. 0-21b, with a slower expansion rate, and a proto-galaxy C forming on its far side. Two photons from this event would reach us simultaneously, travelling in opposite senses around the universe. We would thus see it twice, once on each side of our horizon. We would also see repeated patterns in the microwave background.

That this in practice apparently does not occur[9], means that the average rate of expansion of the universe up till now must have been *greater* than that of Fig. 0-21b. Had it however been faster than the speed of light, no photons from past events could have

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[a] p.9.
[b] Cf Fig. 0-15.
[c] Fig. 0-18b.

caught up with us, and our night sky would be black. The actual rate of expansion of the universe must thus lie somewhere between these two extremes.

How much of the universe we see today depends on its past rate of expansion. Maybe we only see a small fraction of it, as in Fig. 0-21a. Or maybe we see nearly all of it, approaching the case of Fig. 0-21b. We cannot know. The only information we have is that carried by photons now arriving at planet Earth.

Inflation

A problem with the Big Bang model is that the *energy distribution* of the early universe, as seen in the micro-wave background, appears to have been exceptionally uniform. The question is: how can this be, when even with the slowest possible rate of expansion (that of Fig. 0-21b), in 12bn years photons from the earliest proto-galaxies have only had time to travel half way around the universe?

One theory is that immediately after the Big Bang the universe's rate of expansion was relatively slow. Energy was exchanged throughout it, resulting in a homogeneous distribution. Then at around 10^{-35} s a.b.b. the universe suddenly *inflated* by a factor of 10^{25}, from the size of an atom to that of a cherry stone, while maintaining its initial uniform energy distribution. After which the expansion slowed down again to its present rate[10], Fig. 0-22.

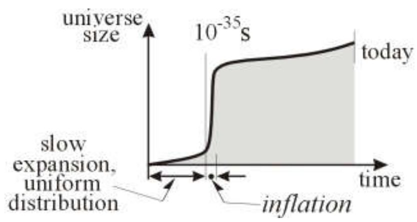

Fig. 0-22. Inflation.

One might have expected that, due to gravity, the universe's overall expansion rate would slow down with time. At present it however appears to be increasing. This is currently attributed to hypothetical "dark energy", which is outside our present scope to discuss.

CMB

When the CMB was discovered in 1965, it was quickly realized that it could provide an absolute 'at-rest' reference. Consider a spaceship out in deep space, Fig. 0-23. When the pilot heads into the 'CMB wind' he experiences a higher CMB frequency. And when flying with it he experiences a lower frequency[a][11]. When he observes the same CMB frequency all around him, he knows he is at rest with respect to it – in 2-d terms: stationary on the balloon surface.

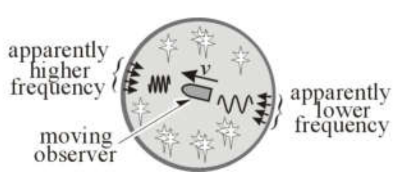

Fig. 0-23. Microwave background (2).

[a] The Doeppler effect.

On this basis the absolute[a] speed of the solar system has been calculated to be ~370 km/s in an astronomical direction (α =11.3 hrs, δ=7.2^{o}N), towards the constellation Leo[12], Fig. 0-24a.

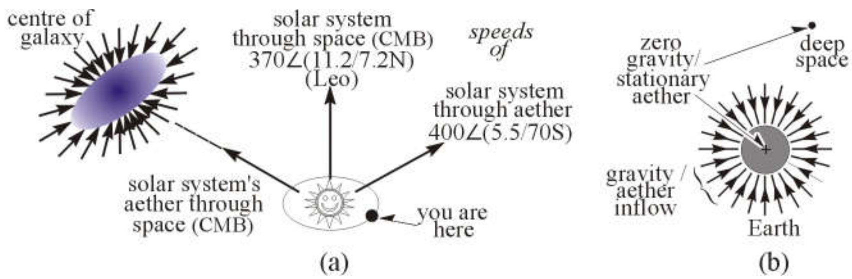

Fig. 0-24. Absolute speed, gravity.

The solar system's velocity through the *aether*, as determined by interferometer experiments, is however ~400 km/s in an approximately southerly direction[b]. The difference is then the absolute speed of the aether with respect to the CMB in the vicinity of the Earth.

Cahill's re-analysis of Dayton Miller's interferometer data[c][13] showed this speed to comprise[14]:

– 1) 30 km/s due to the Earth's orbital rotation around the Sun
– 2) 42 km/s towards the Sun
– 3) 420±30 km/s towards the centre of the galaxy

The last two suggest that *gravity* is associated with an *aether inflow*. Out in deep space where gravity is zero the aether is stationary. But there is also a zero gravity point close to the Earth's centre[d], Fig. 0-24b. Meaning that the aether is stationary there too.

So the solar system travels through the aether at 400 km/s. The Earth orbits the Sun at 30 km/s. And the centre of the Earth is stationary in the aether! This "aether" is evidently a highly complicated "stuff", a far cry from the essentially stationary medium envisaged by Maxwell and Lorentz.

That the nature of the aether should be essentially incomprehensible to us, is however hardly surprising. If everything in the universe, including we ourselves, is made of aether, in trying to understand it, we are a part trying to comprehend the whole of which it is part. This being rationally senseless[e][15], the fundamental nature of the aether could well inherently elude us.

Time travel (1)

Now consider *time travel*. Time on the above approach being a mathematical abstraction, a number in an observer's mind[f], the idea of travelling through it[g] is evidently nonsensical.

On the well-known *grandfather paradox,* if time travel were possible one could return to the past and assassinate one's grandfather. 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 nonsensical. And so also, on the

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[a] With respect to the CMB.
[b] (α =5.5, δ=67^{o}S). See the Relativity article.
[c] Ditto.
[d] Not exactly at the centre, due to the gravitational effects of the Sun and Moon.
[e] The 'self-incomprehension' principle, discussed in the quantum physics article. .
[f] p.4.
[g] As one travels through the countryside.

reductio ad absurdum principle[a][16], is therefore the original premise, the idea of time-travel.

That raw red wound in my leg caused by the dog that bit me yesterday, for instance. If time-travel were possible, some benefactor of mankind could have this instant returned to the past and killed the dog's grandfather. In which case the wound was never there. Not that "it is no longer there". Five minutes ago it was there and you saw it. Right now it was never there. (Make sense of *that* one if you can!)

A shorter way into this is that defining the 'past' as "what happened", if the past could be changed then what happened didn't necessarily happen. This is likewise senseless.

Another approach: on the Big Bang model the universe comprises its 10^{80} fundamental particles: protons, neutrons and electrons. A universe state being a specific arrangement of those. Today's universe state is today's arrangement of the 10^{80} particles. Yesterday's state was yesterday'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 10^{80} particles of the universe 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 sequence Triassic→Jurassic→Cretaceous, and not in any other. In a properly ordered universe things occur in their proper order.

In a continuous universe, past states are like Clementine lost and gone forever, never to return. The basic reason is that the very same 10^{80} particles that once made up past universe-states, and that could 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 ourselves[b] were small nocturnal insectivorous tree-shrews. So had you been fondly imagining that on your forthcoming package tour back to the Jurassic you would be dining out nightly on dinosaur steak, well, think again. The items on your menu will all be creepy-crawlies: insects and their larvae. And with no barbecue 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[c] 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."[17]

And:

> "Reasonable solutions to Einstein's general relativity equations allowing time travel have now been found. Space-time 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."[18]

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

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[a] Relativity article.
[b] Strictly our ancestors.
[c] Stephen Hawking (1942–), English theoretical physicist, cosmologist and popular author.

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 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 anyone can realize what they're up to. Evidently far more goes on in these wormholes than we the general public are being told about.

And just because something is *mathematically possible*, that doesn't necessarily make it *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 force applied to them. To date, however, this has never actually been 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. in a specific location − 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"[19]

but without saying what replicable experimental results this is based on, it too would seem to need further justification. And in this case, God's own confirmation. Because 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."[20]

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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.

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