Chapter 30

The Half-Circumference of Light

So we see that by combining...

- observation of the CMB radiation, with
- the *Flatland*-derived *'Edge-On' Principle*[a], and
- the north/south topology of a hypersphere,

it has been possible to work out the shape of the universe[b]. And all this was derived from a single starting premise – that the dimensional principles of *Flatland* hold good throughout creation – from which we were able to infer the 3D/4D relationship between the observable universe and the universe proper.

In the Introduction I quoted Richard Feynman who said that,

> *"In the case of the chess game, the rules become more complicated as you go along, but in the physics, when you discover new things it looks more simple."* [c]

As an *a priori* model described originally in part[d] by Albert Einstein, I believe that the twin demisphere model demonstrates this simplifying effect of an underlying paradigm. Now let's look closer at the implications…

Death of the Multiverse

Professor of Theoretical Physics at Berkeley, Raphael Bousso tells us that physicists are working hard right now to eliminate the problem of infinities. He describes how his own research was initially inspired by the idea that,

> *'…we shouldn't think of the universe as existing on this global scale that no one observer can actually see …it's actually important to think about what can happen in the causally connected region to one observer.'* [e]

The twin demisphere model not only dispenses with infinity's cosmic horizon but, as we are about to see in more consistent detail, thrusts the observer to centre stage in an observer-based universe that is one single, finite, causally connected region.

As we gaze out into space in any direction we view the relic light of the CMB. The light which arrives at us has travelled a straight path through space-time from its origin and we are viewing it as it was when it left that origin[f]. Having traversed the northern demisphere and crossed the 2D equator, it has travelled through the southern demisphere to arrive at the observer (*Centre B*). Of course everything

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[a] *The 'Edge-On' Principle:* Each dimension is viewed from within itself one dimension lower.

[b] I.e. the 3-Dimensional shape of the observable universe, experienced by the observer as a single spherical cross-section of the 4-Dimensional hypersphere which comprises the block universe.

[c] http://www.dailymotion.com/video/x24gwgc_richard-feynman-the-pleasure-of-finding-things-out_news - Accessed 26th June 2016

[d] Einstein gave a mathematical description of the 'twin demispheres' in Section 31 of *Relativity* in 1916, but did not propose the location of the origin and the observer.

[e] Raphael Bousso, *Thinking About the Universe on the Larger Scales*, from *The Universe*, Edited by John Brockman, Harper Perennial 2014, P301

[f] Barring accidents! Such as gravitational lensing and the Shapiro delay effect. Also the Earth's frame of reference is in fact moving relative to the CMB. This (in the grand scheme of things) very slight effect has built up over 13.8 billion years and is the result of the fact that the CMB is not *Centre A* as such. Astronomers tell us that correcting for this would place the observer in the nearest thing possible to a 'stationary' frame of reference due to the fact that the CMB is the largest cosmic object in the universe.

appears perfectly normal to us because, in light-travel distance, the 2D equator may be some 7 BLY away. But amazingly, beyond this in every direction we look, *we can actually see right inside our opposite demisphere*.

The centre of the 'northern' demisphere (*Centre A*) is the point-event source of all light or events that can ever possibly reach the observer from or since our Big Bang origin. As such, it represents the maximum distance that anything in the universe may be from me; which is the same as to say that, at any given moment, it is ***the maximum possible distance between two points.*** This is an astounding conclusion. It carries the inference that *the universe is a compact system in 3D* – a closed universe that each and every observer, no matter where in the universe proper they may be located, can look out and view in its entirety!

No more snooker balls. No more multiverse. No more infinity.

This is true because light from the Big Bang cannot have 'headed off in the opposite direction' to reach Λllen (whose location we pictured as lying outside our observable perimeter, beyond our observable horizon) because, on reaching the 2D equator at what I in my dimensionally stunted way might think of as its farthest away point, it *enters my demisphere* at that point, radiating in toward me from behind. (We will trace light's path through the universe in more detail in the next chapter.)

This is similar to the old Atari computer game of *Asteroids* (ah, the joys of simplicity) where a small irregular shape would disappear off the top and appear again menacingly from the bottom in what the *Wikipedia* article describes as *'a two-dimensional view that wraps around in both screen axes'*[a]. Shifting this up by a dimension, light is on a round trip across the surface of the hypersphere, and, just as an airliner flying from London to Los Angeles will follow a straight line along the Earth's 2D surface which curves in the 3rd Dimension, light sets off through the 3D universe in a *straight line* which curves back on itself in the 4th Dimension.

If you could look through a telescope and see all along its path, away in the distance you might (in theory) see the back of your head. But we must remember that, so far as the light is concerned, it continues to follow a straight path.

Reflection… The path that light travels from origin to observer is the straightest path through space-time – not necessarily through space – which takes it through all the distortions of *local* gravity. This is similar to the orbit of the moon which, although curved to us, is straight to it, because it is the shortest path through the curvature of space-time that results from the mass of the Earth.

This is not nearly so weird as it sounds, and is already a scenario which cosmologists have for a long time recognised as a potential solution. Here it is described by Werner Heisenberg in 1958,

> *'It may be that the space filled by the universe is finite. This would not mean that there is an end of the universe at some place. It would only mean that by proceeding farther and farther in one direction in the universe one would finally come back to the point from which one had started. The situation would be similar as in the two-dimensional geometry on the surface of the earth where we, when starting from a point in an eastward direction, finally come back to this point from the west.'* [b]

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[a] https://en.wikipedia.org/wiki/Asteroids_(video_game) - Accessed 22nd Mar 2017

[b] Werner Heisenberg, *Physics and Philosophy*, Penguin Classics 2000, (original copyright 1958), P79

Now known to theoretical physicists as the Pac-Man universe, the twin demispheres describe a practical 3D mechanism for this phenomenon.

The idea that light may have circumnavigated the universe (several times) has been extensively researched by topologists and cosmologists both mathematically and observationally. The distance photons would be able to cover – and therefore the number of times they would be able to go round a 'hall of mirrors' universe – is thought only to be limited by the size of that universe. Neil Cornish, an astrophysicist at Montana State University, puts it thus,

> *"If the universe was finite, and had a size of about 4 billion to 5 billion light-years, then light would be able to wrap around the universe, and with a big enough telescope we could view the Earth just after it solidified..."* [a]

This is based on the conventional view that the universe out there exists in an objective physical form which light is free to explore at warp speed like the *Starship Enterprise*. However, in the dimensional paradigm light forms part of the structure of the universe, is utterly subject to it, and conscripted to express it by the laws enshrined within Relativity. Understood dimensionally, light as the speed limit of the universe has less to do with light itself as a 'free-roving entity' and more to do with Einstein's description of the universe as a *'four dimensional continuum'*. This has serious implications which we are about to examine.

The Point of No Return

English mathematician Sir Roger Penrose observed that,

> *'It is a striking fact that **all** the established departures from the Newtonian picture have been, in some fundamental way, associated with the behaviour of **light.**'* [b] [Emphasis his]

This model must necessarily do the same.

Einstein changed the world by imagining that he was able ride with the photon… in the same spirit let us now visualise the little photon of light's post-Big Bang journey through the twin demisphere model:

> The primeval photon sets off from its point of origin near *Centre A*, travels in a straight line along the shortest path available to it around and between all the local lumps and bumps of space-time through the northern demisphere, crosses the spherical equator (Einstein's 'world-radius', where the twin spheres touch at all 'same' points) and continues in a straight line into the southern demisphere, straight through the observer's location at *Centre B* – i.e. the origin's antipode – after which, theoretically, it should re-cross the 2D equator, returning into the northern demisphere at its opposite side to pass straight through its point of origin at *Centre A*. It then sets off again…

But what *actually* happens to the light as it passes me as observer – does it really set forth on the long journey back? Or will it simply be lost in the void – stretched by expansion, cooled by time, sniped by particle collisions, vandalised by ionisation and deflected by gravitational lensing – on its quest to re-cross the equator? One thing is for certain.

It will ***never*** be able to reach its original point of origin because…

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[a] http://edition.cnn.com/2004/TECH/space/05/24/universe.wide - Accessed 17th Nov 2015

[b] Roger Penrose, *The Emperor's New Mind*, Oxford 1989 (Revised 2016), P285

Oh dear, I died.

And, as I have been stressing all along, the whole path is observer-dependent. *For the photon* there is no 'path', no 'equator', and no 'return to the origin'. All that photons are actually doing is being *observed* whilst *existing* on the frontier of expansion at the speed of light[a]. It is central to the model that, whilst the demispheres accurately describe the path that relic light has taken, ***that path may only be described retrospectively by the observer***.

This situation is analogous to the events which accompany an airliner as it crosses the equator on Earth: basically, *nothing happens*. Unless the pilot spots it on his instruments then announces it from the cockpit as a big deal, we have no way of knowing the equator has been crossed. In a similar way – from the photon's perspective – there is nothing special or unique about its trans-equatorial adventure which it retains and is somehow able to impart to us, because the whole trip is only a description of the light's journey *from the observer's perspective*. The light itself did not cross any actual, fixed backdrop-style 'equator' any more than it is crossing an equator now. It may only be *viewed* as having taken *that* path by *that* observer. And that retrospectively viewed path will continue to expand from moment to moment as the distance between the observer and the origin increases over time.

Summing up, the path of light through the universe may only be described in terms of what goes on between *origin* (at *Centre A*) and *observer* (at *Centre B*). Every point on its journey, past or future, might equally be considered a *Centre B* by any observer located there. Therefore, ***the path of light as viewed by any observer at any location comprises only the first half of the hypersphere's polar circumference***.

In summary:

1) The light from the CMB is *always* travelling away from *Centre A*.
2) The light has *always* completed a half-circumference with respect to an observer at *Centre B.*
3) The observer views light's path along the half-circumference as a straight line.
4) An expanding 2D equatorial surface linking the two demispheres is *always* located at the retrospective mid-point of the light's journey's (i.e. Einstein's "world-radius").

It's worth noticing that, since this mathematical relationship does not change over time, the universe has held this shape ever since it began to emerge from the Big Bang singularity. A direct link therefore exists between the *Centre A/B* half-circumference and the phenomenon of the universe's expansion, which we will investigate shortly.

So What Does Someone Else See?

From the viewpoint of another observer, light's path through space and time will be different and unique to them, although all the same geometrical features will be present. Comparing another observer's experience to mine, anyone located at another point in space-time would see one of three things:

[a] Relativity tells us that from the photon's viewpoint as a massless particle travelling at the speed of light, the universe is completely length contracted, therefore its origin and its destination are the same. The photon's path – and therefore the universe as we view it – is not objective, but wholly observer-dependent.

- An observer at a ***different location in space*** at the same time would have the same experience from a different viewpoint (with an alternative constellation view).
- An observer at a ***different time*** at the same location in space would see a smaller or larger observable universe corresponding to the same universe at an earlier or later stage.
- An observer located at a ***different location in space*** at a ***different time*** would experience both of the above.

One might ask, *'If the origin is everywhere, wouldn't CMB radiation that left from a point nearer me have reached me then passed me by?'* The answer is yes, nearer light did reach you and pass you by, but you were not born for most of it! Although your current location in space may have existed with light passing it by for nearly 14BY, your current location in space *and time* did not yet exist.

'*And what happens to the light after it passes me, will it be viewed again?'* Having passed me, the same light will continue to be viewed on its journey by other theoretical observers at other *Centre B*'s which are (to me) currently future, at which the CMB will converge radially with other light beams arriving at them from their *Centre A* experience, all having covered an equal distance (half-circumference) through a more expanded universe. Of these, only light beams which are in line with my location (having passed through it) will have been observed by me. The rest will never be visible to me because I am not, nor (due to lightspeed) could ever be on their path.

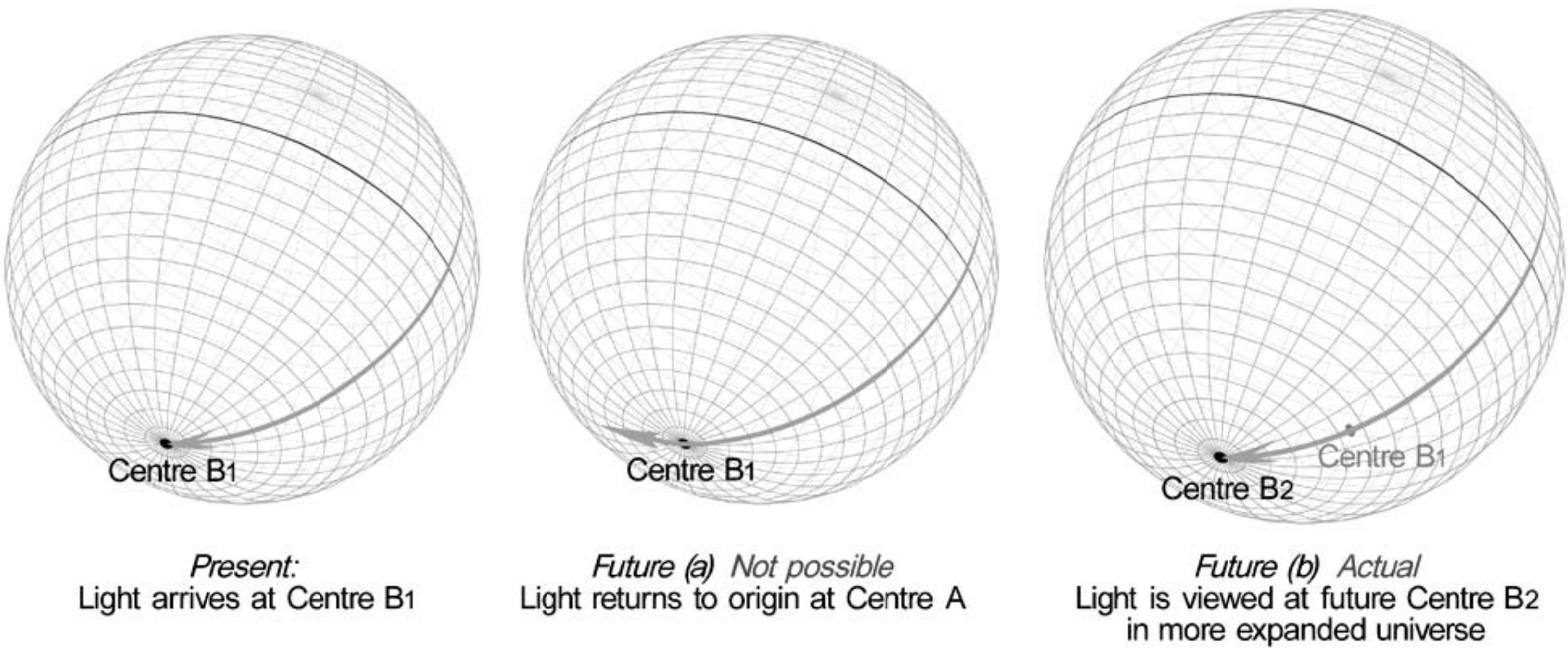

Fig.2 Taking the analogue down by one dimension, these three spheres demonstrate why it is not possible for relic radiation to circumnavigate the universe. The photon always exists at an observer location, a *Centre B*, which corresponds to an antipode of *Centre A*. In this way, all observers at *Centre B* view the photon's history as having covered a half-circumference of the observable universe.

I mentioned in Chapter 26 that light from the CMB 'criss-crosses' at the observer at *Centre B*. Although it is true that light converges on the observer from all directions and continues on its way, it cannot in fact 'head back' toward the origin. Every point on the light's journey is an observer-point at *Centre B*, therefore future radiation from the CMB must also converge on future *Centre B's*.

Although light is following the geodesic across (or as we experience it, through) the 3D surface of the hypersphere, it can never actually complete a round trip because, no matter where in the universe the

light starts off, the *definition* of its path ends at the observer at *Centre B* in the moment now. Yes, of course the light continues on past him – into the future at the speed of light – but it has no more 'universe-defining' relevance to his experience. When the same light is viewed by another observer at *Centre B2*, she will experience it within her own *Centre B* experience in her moment now in the same way as the first observer: coming at her in a straight line from her past – a direction that is *always* in 'line of sight' to the origin at *Centre A*, and *always* bisected by her experience of the 2D equator[a].

Strong Complementarity

Clearly, a dimensional understanding of the universe's physical shape places the observer firmly in the driving seat. To think of the observable universe as 'centred on the Earth' is far too woolly an approximation for a phenomenon which is subject to all the 'frame of reference' constraints of Relativity. Science writer Amanda Gefter encapsulates this in her short essay[b] in the 2015 anthology by John Brockman, *This Idea Must Die*, where she describes the experience of each observer as having his or her 'own universe'. Discussing recently uncovered problems associated with black holes she writes,

> *'Physicists are beginning to think that the best solution to the firewall paradox may be to adopt "strong complementarity" – that is, to restrict our descriptions not merely to spacetime regions separated by horizons but to the reference frames of individual observers, wherever they are.'*

Discussing the problem of infinity in relation to cosmic horizons she continues,

> *'Now strong complementarity is undermining the possibility of a single, shared universe. On a glance, you'd think it would create its own kind of multiverse, but it doesn't. Yes, there are multiple observers, and yes, any observer's universe is as good as any other's. But if you want to stay on the right side of the laws of physics, you can talk only about one at a time.'*

She goes on to describe how this approach may have wider implications not only for cosmology, but for Quantum theory and the ongoing program in physics of Quantum Gravity. The role of the observer's viewpoint would appear to be growing in significance in the world of physics.

In the dimensional model, it is everything.

Reflection…. Combining the twin demisphere model of the universe with the strong complementarity approach of physics provides the basis of a framework by which to extend the centrality of individual experience right down through the 4-Dimensions of the physical world. A *Flatland*-based dimensional approach to the structure of the universe places the observer at the centre, not merely of the universe, but of the whole of reality including the mystery of life itself, because I (as I understand the term) am at the centre of my own conscious experience. This will prove significant as we go on to examine the possibility of a 5th Dimension because it suggests the existence of an observer-defined 'dimensional axis'.

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[a] Remember that the 2D equator does not actually exist *in this form*. The CMB is an observer-based phenomenon, the product of extreme 2D equatorial lensing, although as a dimensional effect our observation of it renders it real. To find the true value of all its various attributes, theoretical physicists may have to re-make the northern demisphere into the sphere that it is by, in a sense, turning the outer ring inside out.

[b] Amanda Gefter, *The* Universe, from *This Idea Must Die*, Edited by John Brockman, Harper Perennial 2015, P113

Finity

Of course there is nothing special or unique about *my* observer-dependent southern/northern twin demisphere experience. Insofar as each space-time event possesses equal significance, all observer locations are equivalent. And there are an equal number of *Centre B's* to *Centre A's* because each pair comprises a single entity – one 'universe-experience' or cross-section of the hypersphere – with the number of demispheres only limited by the proximity of their centres to one another (*A* to *A*, *B* to *B*) which may or may not be Planck lengths/times apart. The whole universe is jam-packed full of these overlapping demispherical bubbles, centred on every (*x*,*y*,*z*,*t*) co-ordinate location in the whole of space through all of time.

Going back to the globe analogy, any pair of diametrically opposite points on a sphere are antipodes. Shifting this up to 4D, light within the universe is converging at every moment in time on every individual antipode to its 'everywhere-point of origin' at the Big Bang event. This zoning in and converging from every direction takes place at every location in space through all of time, so that ***each and every observer always stands at a unique viewpoint which is a 3-Dimensionally radial antipode of an origin of the Big Bang***.

Reflection…. An interesting question arises: *Does the total number of Centre A/B systems increase over time?* If the Planck quantities remain constant as space expands, then, by analogy, disks (2D slices completing a 3D sphere) should theoretically increase in number over time, with each centre retaining the same 'relationship of proximity' to those around. This presents us with the possibility of the following scenario: ***At Inception*** the universe would have begun with one single *Centre A/B* pair (cross-section) and ***at Completion*** the universe would end with the 'full number' of *Centre A/B* pairs (cross-sections).

Although the global universe has a 4-Dimensional 'shape', it is not something we need twist our minds into knots trying to imagine because, as a compact system, *the hypersphere comprises the sum total of all viewpoints, through all time*. Try imagining that from one viewpoint! This is a far cry from my single viewpoint – my unique observable universe bubble which is *just one cross-section*. We are 3-Dimensional creatures, simple 3D cross-section dwellers, and must be thankful that we may view it through the eyes of geometry.

However, interestingly, the hypersphere is not *physically* bigger than the cross-section I inhabit, because 3D space forms its surface, enclosing it in the same way that the Earth's 2D surface encloses its 3D volume. And, filling the surface of the hypersphere, the volume all viewpoints occupy may be considered 3-Dimensionally unbounded in the same sense as the 2D surface of a globe. This 3D surface is however finite, though not in terms of physical shape as per the surface of a sphere; instead, ***the finiteness of the universe is defined by the way in which light is unable to escape the system.***

Far From Sufficient?

So why did Einstein not declare this to be the shape of the universe? We must remember that he was writing in 1916 when our galaxy was the known universe, and he died 9 years before the discovery of the CMB. Although he fancied it, described it mathematically, and ventured it as highly likely, he drew back with the phrase,

'Our experience is far from being sufficient for us to answer this question'[a].

It is my contention that this limitation no longer applies.

[a] Albert Einstein, *Relativity, Section 31*, Routledge 2001