Chapter 25

Two Different Ball Games

Physicist Marcelo Gleiser writes, *'If the Universe were shaped like a sphere, as Einstein wanted...'*[a] The reasoning, as Einstein explained in 1916 (*Relativity*[b] *Section 31*), is that a spherical surface is mathematically preferred *'since all points on it are equivalent.'*

EA Abbott's *Flatland* pre-dates General Relativity (GR) by three decades, therefore the Dutch mathematician Dionys Burger kindly updated its geometry[c] to reflect this with his 1965 book *Sphereland*[d] wherein he has *Sphere* inform *A Square* and his new friend, *Mr Puncto*, *"You are not living on an infinitely large, flat plane but on a spherical surface."*

In other words, if reality comprises a *Flatland*-style nested hierarchy (rather than being grounded in any other particular shape such as cubic) it will be grounded in sphericality, which would not offend Einstein! If you recall, we arrived at this same conclusion in Chapter 9 by applying extrapolation in keeping with the *Principle of Relationship*[e] to the Flatlander's 1D (circular) perception[f] of his world. As a result we are now in a position to describe the ascending dimensional structure and its accompanying *Flatland* analogies in geometrically spherical terms.

In the last chapter I sketched out an overview of our contemporary scientific understanding of the universe – the Standard Model – but now let's take a look at what a dimensional paradigm might have to say. Strangely enough, a simple *Flatland*-based geometrical progression generates many interesting cosmological implications – including the exciting new phenomenon of '2D equatorial lensing'. But please don't be tempted to skip forward because we are following a logical progression in which each new insight derives largely from the one before.

Over the next few chapters we will be looking at:

- The relationship of the observable universe to the universe proper
- The path of relic radiation (the CMB)
- The shape of the observable universe
- The role of the observer
- The lightspeed/gravity relationship
- Recent acceleration/dark energy, and
- The relationship of the temporal dimension to the Big Bang

Physicist Raphael Bousso of UC Berkeley tells us,

"I don't think anyone likes infinity. It's not the outcome of any experiment."[g]

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[a] Marcelo Gleiser, *The Island of Knowledge*, Basic Books 2015, P97

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

[c] Had neither *Sphereland* nor General Relativity ever existed, we should still have been able to deduce that Flatland exists as the surface of a Sphere by the process of reasoning in Chapter 9.

[d] Dionys Burger, *Sphereland*, Harper & Row 1983, P157

[e] *The Principle of Relationship:* Whatever is true of the relationship between two adjacent dimensions is true of the relationship between *any* two adjacent dimensions.

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

[g] New Scientist, *The Infinity Illusion*, Amanda Gefter, 17th Aug 2013

It should therefore come as good news to everyone that infinity is the first thing a *Flatland*-based dimensional structure dispenses with.

From Here to Infinity

Just as space-time geometry may be accessed by extending Pythagoras' Theorem[a] from two dimensions into four, the principles involved in the idea of 3-Dimensionality slicing through a 4D hypersphere generate straightforward explanations for many mysteries of the universe. At their root is the fundamental difference between the observable universe and the universe itself. Unfortunately, separating the two is not as straightforward as it might appear, because…

Reading the literature, one could be forgiven for thinking that this difference is merely a question of scale. The observable bubble is considered part of a greater 3-Dimensional whole which has no edges. It does this by being either infinite (flat or negatively curved in 4D) or finite (spherical in 4D). Take for example a recent paper submitted to *Arxiv* in which UK scientists Mihran Vardanyan, Roberto Trotta and Joseph Silk present a mathematical version of Occam's Razor called *Bayesian Model Averaging*. Casey Kazan of the website *DailyGalaxy.com* reports that,

> *'The Vardanyan model says that… the most likely model is that the Universe is flat. A flat Universe would also be infinite and their calculations are consistent with this too. These show that the Universe is at least 250 times bigger than the Hubble volume. (The Hubble volume is similar to the size of the observable universe.)'* [b]

'Probably-infinite-but-at-least-250-times-bigger' is about as definite an estimate of what's out there I've come across. Most of the scientific community tend to be more guarded, reason being that since the universe's shape is not known, it's impossible to say. Leading cosmologist Max Tegmark of MIT, whose extensive and painstaking work on CMB data has proved invaluable, simply states that,

> *'…we have no reason to doubt that such galaxies [outwith the observable universe] exist,'* [c]

As has Tegmark, topologists such as Janna Levin have scoured the sky for signs of repeating patterns which would indicate that light has done a round tour, but found none. On this basis sphericality has been largely ruled out[d]. Flat and infinite seems increasingly to be gaining favour as the cautious misgivings of a previous generation over the 'i' word are boldly discarded, although this is by no means unanimous. Levin herself, whilst deeply appreciative of the infinite in the mathematics of Cantor, would be '*pretty shaken*'[e] to find it in nature. She declares,

> *'Still, I don't believe in the physically infinite.'* [f]

And although Tegmark is the architect of the 'levels 1-4' multiverse classification[g], in a short essay he expresses his own heartfelt doubt,

> *'Not only do we lack evidence for the infinite but we don't need the infinite to do physics… So if we can do without infinity to figure out what happens next, surely nature can, too – in a*

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[a] The one from school about the square on the hypotenuse, $c^2 = a^2 + b^2$

[b] http://www.dailygalaxy.com/my_weblog/2011/02/epic-discovery-our-collosal-universe-250-times-bigger-than-what-we-see.html - Accessed 27th July 2015

[c] Max Tegmark, *Our Mathematical Universe*, Penguin 2015, P47

[d] However, a phenomenon which I refer to as the 'half-circumference', described in Chapter 30, explains why it is not possible for light to circumnavigate a closed universe.

[e] Janna Levin, *How the Universe Got Its Spots*, Phoenix 2003, P15

[f] Ibid., P14

[g] The direct implication of Inflationary theory.

way that's more deep and elegant than the hacks we use for our computer simulations. Our challenge as physicists is to discover this elegant way and the infinity-free equations describing it – the true laws of physics. To start this search in earnest, we need to question infinity. I'm betting that we also need to let go of it.' [a]

Infinite or not, the one thing everyone seems to be agreed on is that, even if it's the shape of a donut, the universe stretches off beyond the observable radius into regions beyond the cosmological horizon, way beyond the bit that the speed of light will allow us to observe.

However…

Buttons

Our conventional picture of the universe may simply be rooted in the limitations of the 3-Dimensional mind and for that reason fatally flawed. The observable universe is thought of like a chocolate button, and the universe is the bag; the bag is filled with chocolate buttons – at least 250 (or maybe infinity) of them – and all we are trying to do is figure out the shape of the bag. However, if we are to grant the observable universe due respect as a 3D spherical *cross-section* through a greater 4D whole – and our earlier *Flatland* extrapolations suggest that this is reasonable – then we must understand that a dimensional cross-section is not a chocolate button. Mathematically it does not behave like one, and neither does the bag.

Let's remind ourselves of one of our most basic *Flatland* principles,

The Principle of Stacking:

Each dimension is composed of an indefinitely high number of cross-sections (slices) of the dimension below, stacked together and fused into a single entity.

All the principles point to the idea that a higher dimension is far more than just a rag-tag collection of lower ones. EA Abbott showed in 1884 that, as the nested hierarchy builds, each new dimension graduates into an entity that is greater than the sum of its parts[b]. To confuse the two universes (observable and global[c]) leads straight into the jaws of a fatal dimensional error – one based on an incorrect application of the stacking and cross-sectional behaviour of the 3rd Dimension (which we see) in relation to the 4th (which we don't). ***It is essential to the whole enquiry that we permit the way that one dimension is viewed from another to set the relationship between the universe as observed and the universe as is.***

Our viewpoint demands it[d]. The key is to remember that we are dealing with two very different entities which we must hold in tension at all times:

- The *spherical* 3D observable universe, and
- The *hyperspherical* 4D block universe

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[a] Max Tegmark, *Infinity*, from *This Idea Must Die*, Edited by John Brockman, Harper Perennial 2015, P51

[b] *The Principle of Character:* Once the stacking of a dimension is complete it assumes a whole new character. Its individual cross-sections fuse together and their discrete nature becomes indiscernible.

[c] The universe itself is called the global universe, not because it is presumed spherical, but because it is everywhere that is.

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

The words of Rudy Rucker *'…a hypersphere is a four-dimensional stack of spheres'*[a], quoted earlier, remind us that it is very difficult to get one's head around all this. No doubt it would be better stated purely in maths, but, to be fair, even Stephen Hawking prefers to work in pictures[b]. Considered dimensionally, the universe proper is not simply an infinitely extending compendium of observable universes, but a 4-Dimensional stack of 3D light spheres. There is a crucial difference which will become clear as we go, because it is here that we may apply the principles of *Flatland*.

My Space

By the 'observable universe' astronomers mean the bit we can see or theoretically detect, in the sense that, because of the speed of light, it is the only bit it is *possible* for us to see. However…

They tend to use this term as though we on Earth all see the same thing. Because space is so vast the observable universe is described, in *Wikipedia* for example, as *'centered on Earth'*[c], but this may be one generalisation too far. I believe that it is fundamental to our enquiry to grasp that *your* observable universe and *my* observable universe are not the same. Four people standing loosely in a line, viewing the night sky, *do not see the same thing*, because each of their light sphere centres will be a few metres apart. The observable universe is not centred on the Earth, but <u>the observer</u>, because ***each and every location in the whole of 4D space-time is located at its own light sphere centre.***

This may sound like splitting hairs, but if an observer was viewing from within the Andromeda galaxy the sky would be filled with a whole new set of stars! And things really start to hot up for an observer located billions of light years away, who would see virtually a whole different universe from us.

Homogenous and isotropic no doubt, but different.

Of course astronomers know all this, but the universe is a mighty big place, and because the observable universe is *virtually* identical for any observer located in the vicinity of our Solar System, it suffices as a working approximation in the same sense that Newton's equations of gravity may suffice for NASA to send stuff into space. However, by taking this observational nuance for granted we may be missing something of great dimensional import, because it could hold the power to unlock several enduring mysteries of our cosmos.

How?

Because each light sphere is a unique 3-Dimensional cross-section through the whole of time, and the hyperspherical universe possesses as many cross-sectional centres (i.e. observer locations) as there are space-time events within it, each with its own distinctively unique view of the cosmos. As unique observers

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[a] Rudy Rucker, *The Fourth Dimension*, Houghton Mifflin Company 1884, P19
[b] Stephen Hawking, *Black Holes and Baby Universes, and other essays*, Bantam Books 1994
[c] https://en.wikipedia.org/wiki/Observable_universe - Accessed 2nd Aug 2015

we each have our own, stretching off into history until it hits the Big Bang on its perimeter, and each of us moves around within our own 'observable universe experience', always located at a centre in space and time.

In that sense our moment-by-moment light sphere experience is similar to the 'physical moment now' identified earlier, because both represent 3D cross-sections through the 4th Dimension, resulting in the view around us from the instant we are in: the present. In terms of what physicists call 'light cones' which show the observer's position in relation to the arrival and departure of light, each light sphere centre corresponds to the point at which the cones intersect the plane they call the *hypersurface of the present*.

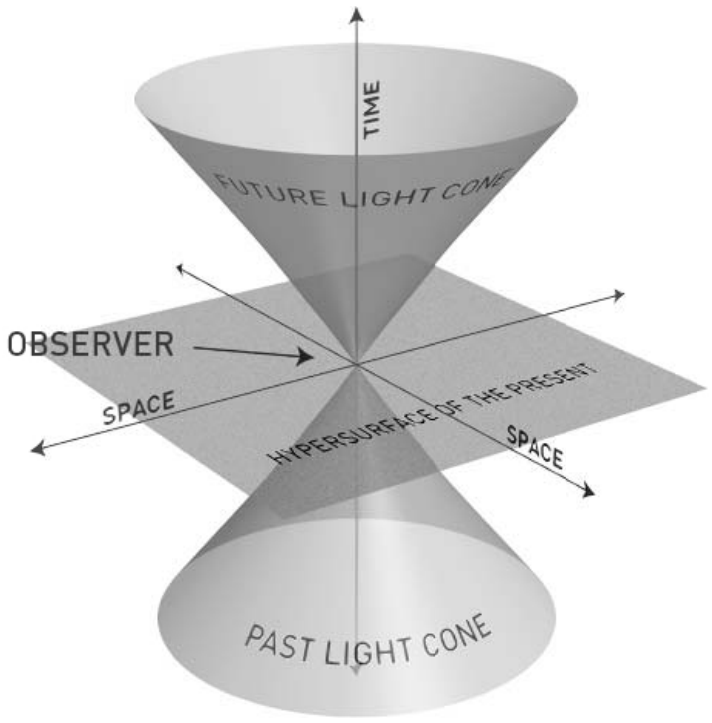

Fig.1 The Light Cone. Light arrives at the observer as she moves from past to future, therefore the cones represent all light that could possibly arrive at or leave the observer's location. Anything outside the cones is causally unrelated to the observer.

In the light cone physicists represent the world as 2D, removing the dimension of 'height', otherwise we would be unable to visualise the time dimension or plot it (vertically) on a graph. However, shifted up to the real world, the 2D plane becomes 3D space and the whole illustration goes spherical, because the *hypersurface of the present* represents our 3-Dimensional world – the 3D surface of the hypersphere – with the time axis *t* pointing in a 4th, invisible, direction which we cannot visualise spatially.

Reflection… Your expanding light sphere and the universe itself are two different things: the first is a 3-Dimensional (spherical) cross-section of the second, a 4-Dimensional hypersphere. The first 'passes through' the second along the time axis.

As a result, astronomers and cosmologists are not actually able to observe the universe *per se*, but extremely near-neighbouring and therefore virtually identical spheres, each of which is a single, ever-expanding cross-section[a] of the hypersphere, centred on the observer, with all sharing the same origin on their extreme surface.

I, Observer

The origin remains fixed for everyone at the maximum observable distance, and due to the speed of light everyone sees the immediate aftermath of creation happening on that surface. We may imagine that the universe stretches off beyond our light-perimeter, but that ‘stretching off’ is not a 3-Dimensional, but a 4-Dimensional phenomenon.

The shape or form of the wider universe beyond our light sphere is 4D, but light can never allow us to see it, at least in that direction[b]. Shortly after the Big Bang, the CMB flashed into being *at every point-event* which means we are all ‘viewing’ it 14 billion years later, and to someone located far away in the

[a] These vary in space due to the location of a discrete light sphere centre at every point, but they also vary in time. For instance, two observers standing side by side – space – or the same observer 10 minutes apart – time.

[b] Dimensionally, the reason for this is not that the 3D physical universe stretches beyond this cosmic horizon whilst lightspeed prevents our seeing it, but that each observer has a 3D ‘one observer’ view in accordance with the dimensional principles of *Flatland*.

universe the light from the CMB that originated near us would still be arriving, streaming in from their spherical perimeter. In this way light permeates the universe, and since – with the single exception of gravity – our entire experience of the universe is a light experience, we are completely at its mercy.

However, and this is where it starts to get 4D weird, *the origin viewed on the edge of every light sphere is the same*. Counter-intuitively, because there was only one origin event, the observable universe possesses *one single perimeter at the extreme spherical surface of the observable distance with multiple centres in the 4D space-time continuum*, each of which is the centre of one individual 3D spherical cross-section of the hypersphere in one observer's present. Light conspires with space and time in such a way that all we can do is switch centres, swapping one spherical 3D light experience – with the same boundary – for another.

Reflection… It is important to note that, although there exist a virtually (but not quite) infinite number of centres, the extreme perimeter of each 3D light sphere is identical. As we switch centres we simply view the same perimeter from a different perspective. We will examine this apparent paradox as we go because it is a 4-Dimensional phenomenon, a result of *Flatland*- rather than chocolate button-style stacking.

Although each sphere is centred on a different space-time event which may be located anywhere in the universe proper, *each light sphere radiates inwards from the uniformly spread-out origin on its spherical edge*, converging on a moment now. The perimeter is the beginning; it is the origin of first light, and you can't go beyond that, therefore each light sphere shares a view of the same event. This indicates that, as the years go by, the light sphere is expanding like a balloon being pumped up from the centre (the location of the observer) by the passage of time.

Notice particularly that, in this model, the universe proper as it extends away in a 4th direction in accordance with the bubbling forth of the 'magic treadmill' (like spherical rippling onion skins; see Chapter 11) is in principle identical to the universe as it extends away in 3D through space, because *what we are viewing is a cross-section* – an 'ice core' of the block universe. This is consonant with our earlier *Flatland*-derived *Magic Treadmill Principle*[a] and the stacking[bc] of 'physical moment nows' into the block universe.

In this way we begin to see that the 4D hyperspherical universe may not simply be thought of as extending spatially beyond the cosmic horizon at the boundary of our observable universe, as it is currently – it is overly simplistic and dimensionally inconsistent to think of it in this way – but is instead ***synonymous with the block universe*** as it exists and extends through all of space *and* all of time. The universe proper is a vaster-than-vast, unimaginably-shaped thing in the 4th Dimension comprising all observer points, whilst the bit I see in the present is just one single, spherically observer-centric, 3-Dimensional cross-section through both space and time. The past as I, observer, have experienced it exists out there in space and time, whilst the future does not. It hasn't yet 'bubbled up' to become an observable sphere. But it will.

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[a] *The Magic Treadmill Principle:* Time, as the *n*th Dimension in an *n*Dimensional space-time, issues forth perpendicularly and radially from within the frame of reference of each space-time event. To the observer this *n*th Dimension appears 0-Dimensional (is viewed 'point-on') and is therefore invisible, but results in (*n*-1)Dimensional change, and stacking of the (*n*-1)D surface into the *n*th Dimension, taking the form of the past. (See Chapter 11)

[b] *The Principle of Stacking:* Each dimension is composed of an indefinitely high number of cross-sections (slices) of the dimension below, stacked together and fused into a single entity.

[c] *The Principle of Character:* Once the stacking of a dimension is complete it assumes a whole new character. Its individual cross-sections fuse together and their discrete nature becomes indiscernible.

Just one thing… if all this seems a bit like an octopus in a string bag, please stick with it as it will click into place as we go.

Dome Sweet Dome

How can we imagine all this? The truth is we can't, fully, but what we must not do is think of the universe *itself* 3-Dimensionally. To do so is to fall into exactly the same trap that our forebears did[a] – except, up by one dimension! Let me explain…

The ancients viewed the sky as a solid gigantic dome. They were living inside an Earth-sized planetarium comprising the flat inner surface of a 3-Dimensional (hemi)sphere, on which were painted all the mystifying lights. Even the sphericality of the Earth (if such were recognised) wasn't a problem as it was obviously at the centre. Nowadays, with all the benefits of modernity, we know that the lights hang within a 3-Dimensional space – however, *this is up by just one dimension from the flatness of the ancients' dome*. They saw 2D which formed the surface of 3-Dimensional space; we see 3D which forms the surface of 4-Dimensional hyperspace.

Dome of the Basilica di San Lorenzo, Florence
Giuliano d'Arrigho (il Pesello), c1367-1446

Edwin Hubble's Newfound Bubble

We dwell within a 4D continuum. As a result, as viewed by you, the physical shape of the 4D universe is not just a spherical 3D cross-section of space but of the whole of time, with the beginning of time on the visual perimeter and the latest point (now) at the centre where you are. The Book of Genesis might just as well have read, *"On the perimeter, God created the heavens and the Earth,"* because the origin was *always* on the perimeter – even as it emerged from the singularity! (We will examine this further dimensional paradox in due course.)

Reflection… Keep in mind that the perimeter of the 3D (observable) universe and the perimeter of the 4D (global) universe are two separate entities:

- Just beyond the CMB, the beginning of the universe forms the boundary or surface of the 3D observable universe, and may theoretically be *observed* 2-Dimensionally, however it is...
- All of the 3-Dimensionality around us (the table, the chairs, the trees, the Sun, the Moon, the people...) that acts as the boundary or surface of the 4D universe.

To recap...

[a] I'm not referring to their astrology – science is in no danger of that.

- As observer, we each occupy the centre of an observable universe, or ‘light sphere’.
- There are as many observer locations as there are point-events (space-time events).
- We are each viewing the 4D universe in spherical cross-section, in keeping with the *Flatland*-derived *'Edge-On' Principle*[a] identified earlier, resulting in the perception by all our senses of a physically 3D universe.
- The origin is observable on everyone’s perimeter and, due to the speed of light, each observer views the entire history of the universe from the edge to the centre in all stages of development.
- Although constellations seen will vary – because we are each, as observer, viewing the cosmos from a different 3D perspective within its 4D shape – each light sphere is similar in character, which is in agreement with the Cosmological Principle.
- The observer at the centre of each point-event views the same origin on the perimeter, and although each 3D bubble has its own unique starfield view, it is not the perimeter that changes, but the centre. This is counter-intuitive, but because the origin is set, *the observer at the centre recedes from the perimeter*.

It seems clear we must not think of the universe *itself* as having a physical shape, although it should possess the spherical geometry of a hypersphere. Being 4D, it is ‘space-*and*-time-shaped’, which is why when we gaze out into it we see not merely distance, but history. As *Flatland* demonstrates: a cross-section of a sphere is a disk, therefore a cross-section of a hypersphere is a sphere, with *the observable universe as a 3D spherical cross-section of the 4D hyperspherical universe*, placing the observer at not only spatial, but temporal ‘distance’ from the origin. Astronomers call this measure of cosmic distance ‘look-back’ distance, or ‘look-back’ time, because they are both the same thing, and, measured in light-years, these may never exceed the age of the universe.

Although time is an aspect of the universe's shape, like HG Wells' *'instantaneous cube'* it is not a physical thing that may somehow be contained within a single snapshot of the present. The 4D hypersphere may only be fully expressed by the smooth combination of every snapshot from every location in space through the whole of time, past, present and future. In accordance with the *Principle of Character*[b], 3D slices meld together to form the 4D character of the block universe.

From all this I would suggest that the universe as understood by contemporary cosmology lends itself extremely well to an inductive dimensional interpretation. So far, the dimensional structure holds good. But there’s more…

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

[b] *The Principle of Character:* Once the stacking of a dimension is complete it assumes a whole new character. Its individual cross-sections fuse together and their discrete nature becomes indiscernible.