Chapter 27

The 2D Equator

Light does not by itself govern the universe's shape, but it follows it, and the radius of the space-bubble of our observable universe is a measure of the maximum distance that light has been able to travel through the universe since the beginning of time, which is stretched by the physical expansion of space.

Any concept we might have of the universe's shape is set by the four dimensions of space-time which act in concert – or to use Einstein's word – as a continuum. However, what we see and measure (gravity waves aside) is *entirely* the product of light as it follows the 3D surface of this 4D shape. Explaining the complications of cosmic distance, Dave Rothstein of the popular Cornell website *Ask an Astronomer* informs us,

> *'...the light that travels from a faraway galaxy to us is our* ***only*** *source of information about that galaxy,..'* [Emphasis his] [a]

So, whilst gravitation and dark energy *may* govern the universe, it's the path and properties of light that determine how we see it[b].

Summarising our progress so far:

- Several chapters ago we derived the dimensional relationship of the universe proper to the observable universe as that of a hypersphere to one of its 3D spherical cross-sections, dispensing with infinity.
- In the last chapter, using the analogy of a globe, we considered the path of relic radiation from origin to observer across (through) the northern and southern 'hemispheres' of a hyperspherical universe, as viewed by an observer from within a 3D spherical cross-section (the observable universe[c]), and found it to be generally consistent with observations of the CMB.
- Now let us consider, *'What shape does light actually render the observable universe as it follows this path through the northern and southern hemispheres?'*

To answer this question we must consider what goes on at the observable perimeter because, clearly, if that is the farthest that light has been able to travel into *my* bubble, in theory there should be other bubbles joined on to this one *in such a way* that original light from the same source has been able to set out in the opposite direction to my light, arriving at another 'observer' (let's call him Λllen the alien) who resides at the centre of his own observable universe with the CMB arriving at him from his perimeter. Science writer Marcus Chown explains to us that this is the natural consequence of the theory of Cosmic Inflation,

> *'So our observable universe is akin to a bubble and beyond it lies an infinite number of other bubbles that have a similarly restricted view.'* [d]

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[a] http://curious.astro.cornell.edu/the-universe/cosmology-and-the-big-bang/104-the-universe/cosmology-and-the-big-bang/expansion-of-the-universe/619-how-do-we-define-distance-in-an-expanding-universe-intermediate - Accessed 11th Aug 2015

[b] Acting, as I argue, in accordance with *Flatland* dimensional principles.

[c] It is essential to remember that the 3D spherical cross-section comprising the observable universe incorporates both hemispheres of the hypersphere.

[d] New Scientist/The Collection, Vol 1 Issue 1, 2014, Marcus Chown, *Is there more than one of me?*, P29

Λllen's bit of universe is filled with different starfield permutations and matter, but is otherwise – in terms of the physics – identical to mine. His bubble could overlap with mine or it could be far away, however, for his CMB and mine to have travelled the same distance from our perimeters, the two perimeters must 'touch'.

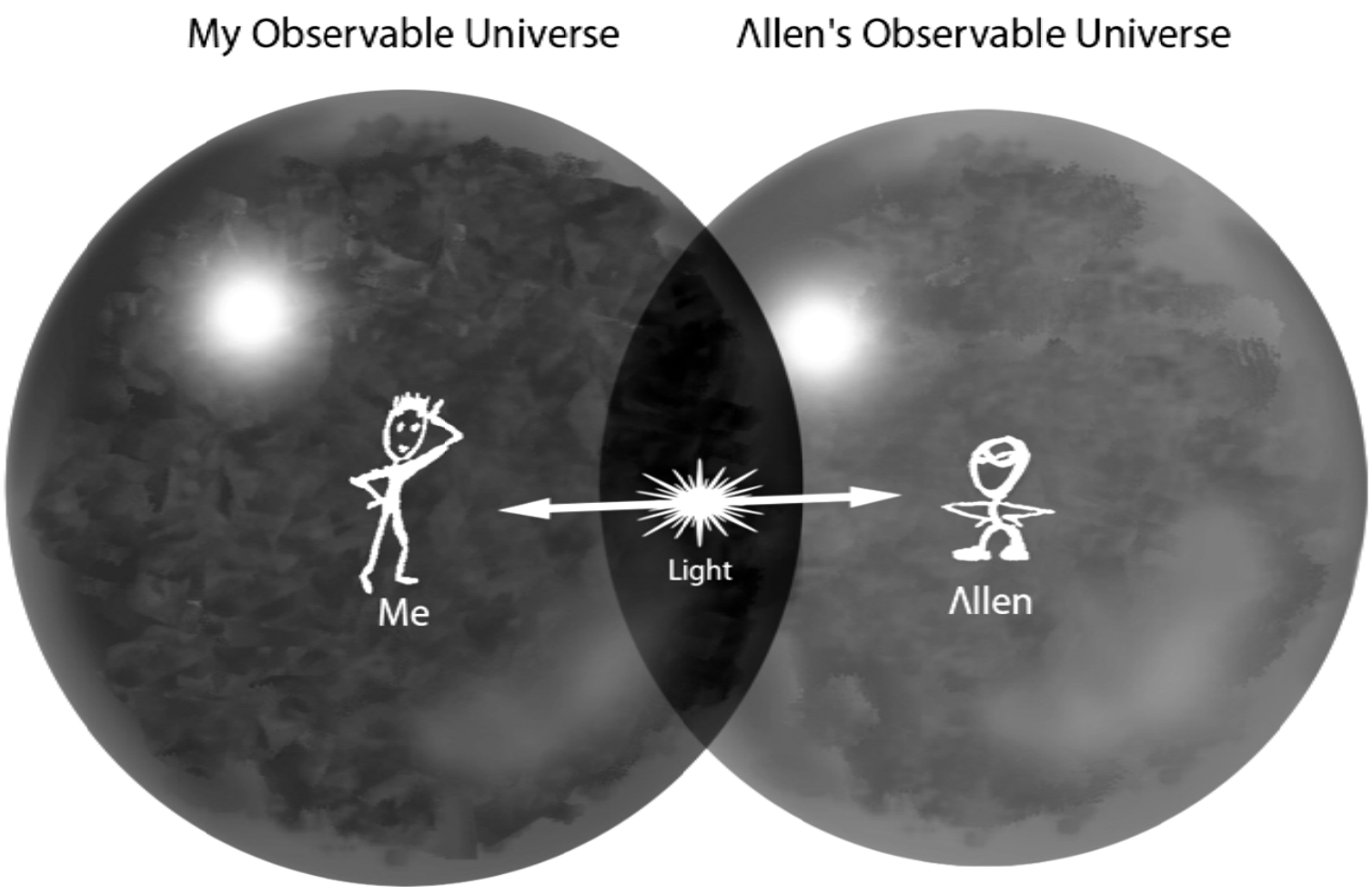
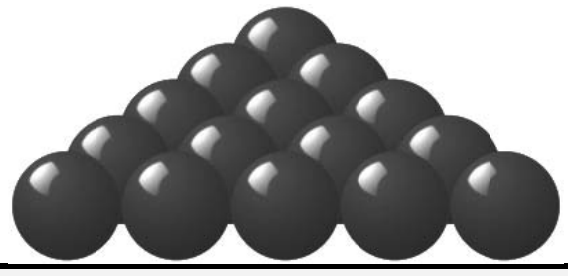


Fig.1 **The 'snooker ball' universe**. In this scenario Λllen resides as far away from me as it is physically possible to be whilst still viewing the same light, because he is twice the radius of the observable bubble away and (in theory at least) the light comes at us both looking like it started out midway between us.

But what happens away at the *other* side of my bubble – or worse, on the other side of *Λllen's* bubble? More bubbles? Infinite observable universes set up neatly like mysterious dark snooker balls stretching off into infinity?

That is exactly how our 3D-based minds will try to frame it, but remember, (to continue the dubious snooker puns) the 3rd Dimension is always trying to screw us over! This 'snooker ball universe' looks suspiciously like the 'chocolate button universe' from Chapter 25, in which spherical cross-sections are permitted to behave in ways that conflict with the dimensional principles of *Flatland* – stacking up without fusing together in accordance with the *Principle of Character*. What has happened to us? We have fallen into the trap of forming a 3D picture of a 4D entity. [a]



Reflection… Remember the *Golden Rule of Dimensionality*: Never try to *visualise* the 4th Dimension. You will force your mind to play tricks on you. Instead, get a feel for it by contemplating how the principles and analogies might apply.[b]

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[a] *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.

[b] Or, some might add, use mathematics. This is the ideal. However, since the application of mathematics has permitted the possibility of buttons and snooker balls it is my contention (as proposed in the Introduction) that we need analogy and our *Flatland*-based principles to maintain a sense of what is real and what is 'just maths'.

If the universe proper has a 4-Dimensional shape we are *going* to find it impossible to picture as a complete entity, and this may not simply apply to our concept of its boundaries. We can expect it to be counter-intuitive, and it will have no need of metaphysics to be so – only physics. Yes, the physical universe is *actually weird*. How else could it be finite yet edgeless? And within the bounds of geometry and reasoned analogy we must allow it to be so.

One of the keys to all this is to pin down the 2D equator. Since – by extrapolation of the globe analogy – it is reasonable to posit that relic radiation has travelled an observer-based path from its origin, crossed an equator which is up by one dimension from Earth's linear equator, then converged on the observer from all directions, we must ask, *'Is it possible for us to recreate a 3-Dimensional model of the* ***observable*** *universe in which all of these conditions are satisfied?'*

After all, we are not talking about something that is actually *happening* in 4D. Light is travelling across the surface of the hypersphere – an event which goes on in 3D – and crossing an equator which isn't even 3D, but is in some sense *flat!* There may be *something* counter-intuitive about it, but it should in principle be possible to create a model.

Roll the Balls

To answer this, please try (or imagine) this rather fun experiment:

> Get a ball and think of it as the globe of the Earth, then get another ball exactly the same size which is 'printed' as a mirror image of the first, with all the countries in reverse. Now imagine that they each touch at a certain mirrored geographical location, say Miami. Line up the eastern seaboard of the United States and roll them around slowly and carefully against each other. Notice how they will always make contact at the same places, Rio to Rio, Cape Town to Cape Town, Beijing to Beijing, Hawaii to Hawaii… and no matter how much you roll them you can always return to the twin Miamis?

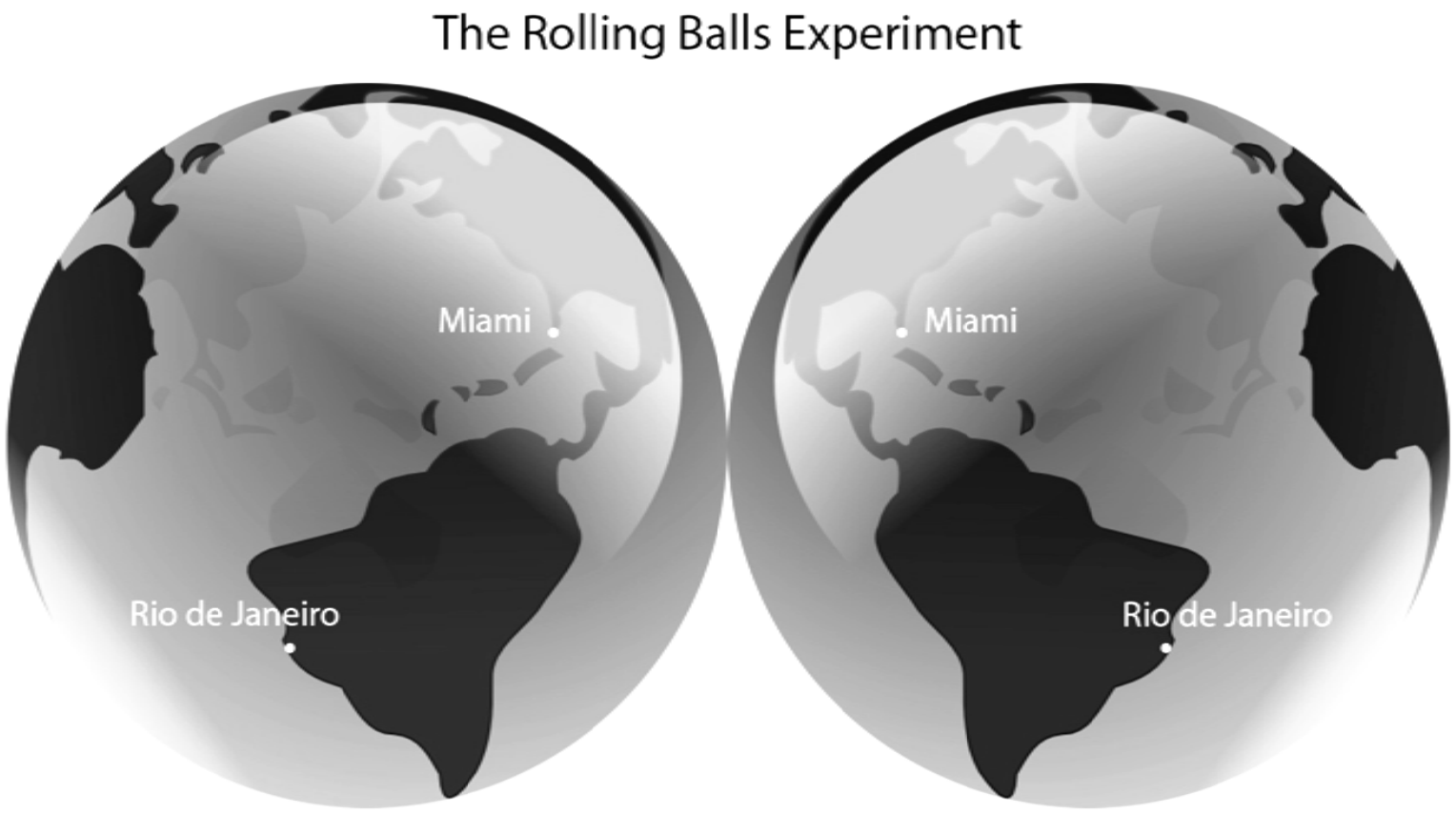


Fig.3 **The 'rolling balls'**. This is a beautiful symmetry which shows that it is possible for bubbles to exist *with their surfaces touching at every same point*. This is possible because Miami is Miami and Rio is Rio; in other words, equivalent locations on the two surfaces are, at the moment they touch, *the same location*.

But (and this is the counter-intuitive bit) what if the surface of this second sphere were somehow able to touch *at every same point simultaneously?*

A way to picture this is to imagine that the second ball is somehow cut open and turned inside out over the surface of the first ball, pasted down like reversed spherical wallpaper so that we end up with a double layer of 'print' on the globe. However, not so fast, because we must allow them to retain the property that *each globe still exists intact on each side of the surface!*

This would mean that – as with the rolling balls – a straight line can always be traced *in any radial direction* from the centre of globe *A* to the centre of globe *B*, or vice versa. To view this line in action we must roll the globes, however, *in the 4th Dimension the globe surfaces are able to touch simultaneously at every same point.*

No rolling required.

Now... imagine you are inside one of the balls, at its centre. ***Any direction you look you will view a straight line that leads to the centre of the other ball***. The second ball appears distorted… so you set off to walk toward it… suddenly as you cross the join you enter the second ball which materialises intact before you, and you carry on to its centre. Looking back, you see that it is your starting point that is all around you, distorted.

Walking from one into the other would be analogous to walking up then down a seesaw: your objective at *Centre B* looks like it is 'up in the air' (actually, distorted) until you cross the mid-point where it tips so that you are now walking 'down' a mirror image path, with your starting point *Centre B* 'in the air' (distorted) behind you.

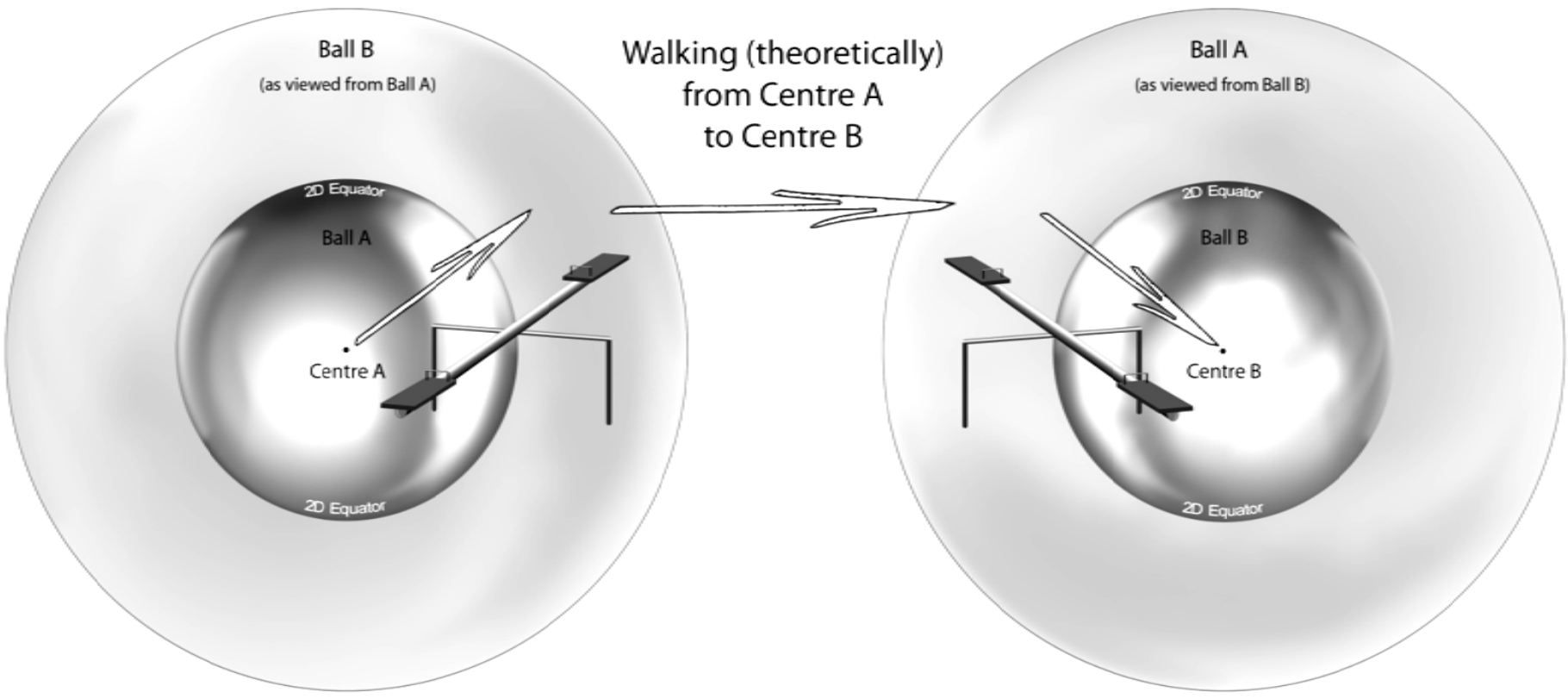


Fig.4 **The seesaw analogy**. Passing from one ball into the other, you would only see the sphere you were in *as a sphere* – the other would appear distorted as though it were an outer shell, with its centre projected spherically across the whole sky. This is because both 3D spheres share the same surface which acts as their 2D equator.

In summary:

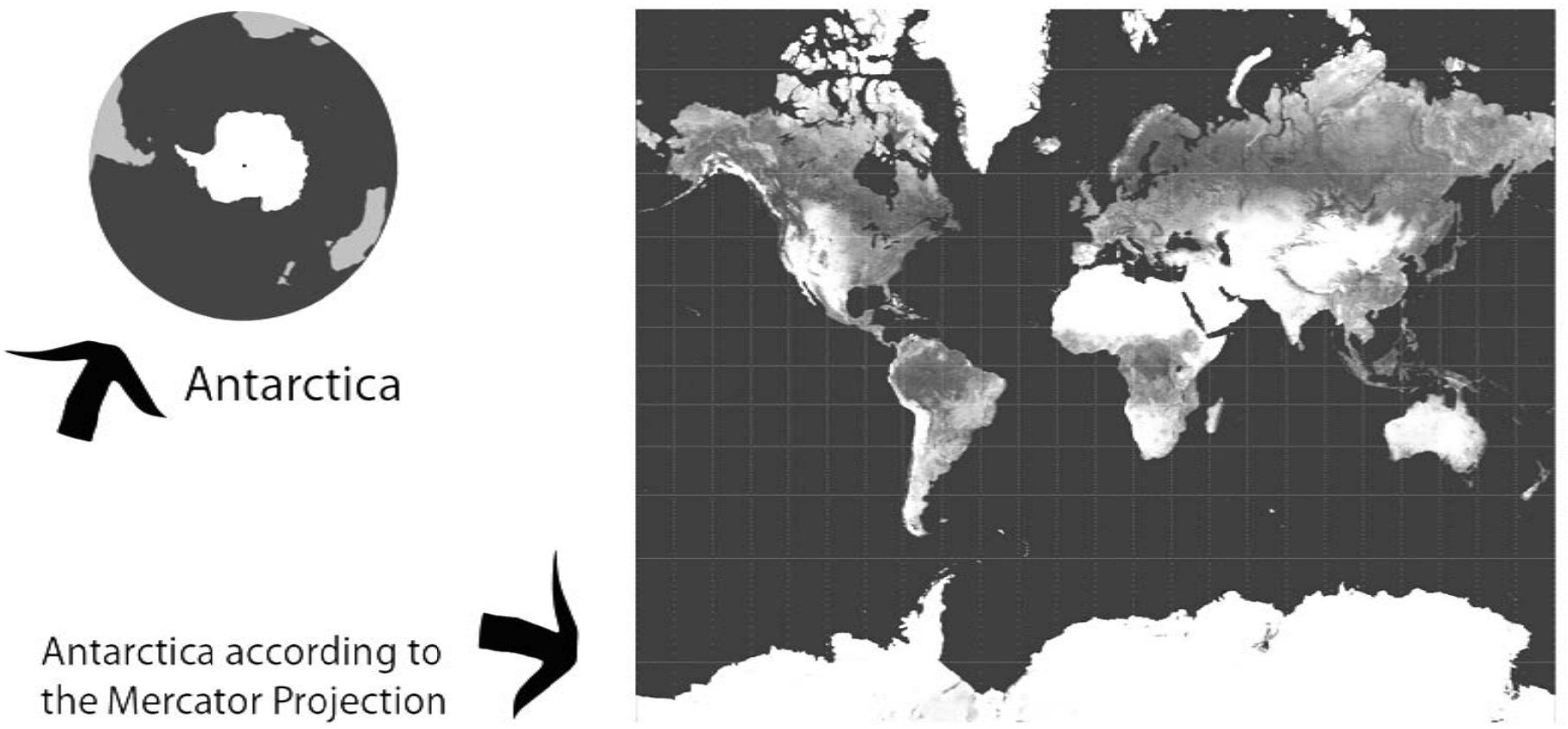
- A second bubble exists on the other side of *any point* at which we leave our own bubble.
- The two bubble-centres, *Centre A* and *Centre B*, are joined by a straight line which runs through every 'same point' (Miami etc) on the perimeter.

- What we have is *two 3D spheres with the same 2D surface* (a surface which Einstein referred to as the *'world-radius'*, but we'll come to that).
- This shared spherical surface acts as a flat *2-Dimensional equator* between the spheres, joining them in precisely the same way that the Earth's *1-Dimensional equator* acts as a 'join' for the northern and southern hemispheres.
- The twin spheres are 3-Dimensional 'hemispheres'[a] which divide the surface of the 4D hypersphere in half. To distinguish them from our accustomed Earth-style hemispheres I will press-gang into service the historically redundant term, 'demispheres'[b].

The CMB Projection

I mentioned above that looking into your neighbouring demisphere it will appear 'distorted'. This is a very rough description. In actual fact, everything beyond the 2D equator will appear *lensed*. ***The effect of this lensing will be to magnify everything in proportion to distance, until the centre of the northern demisphere (Centre A) fills our vision***.

Viewed from *Centre B*, *Centre A* will appear *as though it were projected across the entire sky* by precisely the same principle that renders Antarctica by far the widest landmass on Earth (which it is not) on a map projection of the Earth's surface onto a flat page.



The 'Antarctica effect'. In order (very successfully as it turned out) to facilitate exploration, Gerardus Mercator in 1569 rendered the spherical surface of the Earth on a flat sheet of paper, representing sailing courses of constant bearing as straight lines. His lines of longitude no longer converge at the poles but instead run parallel down the map, causing the northern and southern extremities to appear increasingly wider than they are. The 'dot' at the pole (to left) fills the whole width of the map (to right). Note that South America and Australia remain roughly the same size.

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[a] Northern and southern '3-hemispheres'.

[b] The mathematically correct term is 'hemi-ball', but I will reserve 'demisphere' for its specific application here to the universe.

Centre A looks from *Centre B*[a] to be coated evenly over what appears to be the inner surface of a sphere, at a distance equal to the combined radii of the two demispheres (see *Fig.4*). This map projection effect – shifted up by a dimension – is what gives us as observers the impression that the CMB is coming at us from every direction in space. If we think of the origin of the light as *Centre A* and the observer as located at *Centre B* (as per the globe analogy of last chapter) relic radiation crosses the 2D equator at virtually every point (because it was emitted from virtually every point on the 'surface of last scattering') and converges on the observer from every direction, radially in 3D.

This is in keeping with observation of the CMB, which comes at us spherically in 3D from opposite sides of the sky – from *every* direction. However, it does not require the 'arbitrary fix' of Inflation to explain its uniformity as it is all the same light, released at the same time from the same source. In a sense this 2D equatorial lensing effect is an observer-centric 'optical illusion'.

However, as we shall see, this is a *dimensional* effect resulting from the universe's shape and is not merely 'visual'. As such it may instead represent something entirely new and counter-intuitive:

Dimensional lensing.

[a] And vice versa, as the phenomenon is observer-dependent.