The Universe as a Multi-Dimensional Fractal

Recurring patterns through dimensional zooming

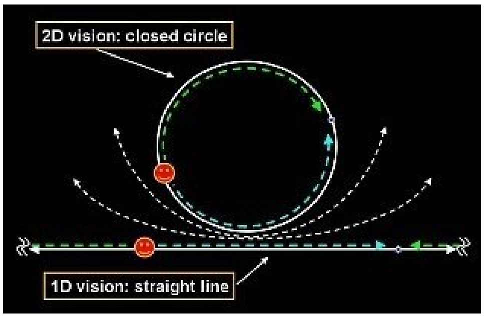
By R.F.J. van Linden

From various points of view a fractal-like universe is described. Unlike in usual fractals, recurring patterns correlate with the number of dimensions in the observation, i.e., zooming out and in occurs by adding or removing dimensions rather than changing scale. In this way, the forces of Nature together with their fermions and bosons are ordered hierarchically through their number of dimensions. The first sections shows some examples of physical phenomena that re-appear in spaces with one dimension less or more. The sections describe 1, 2, 3 or 4 dimensional worlds that are closed in the next higher dimension. In section 5, this will be put in a broader context, covering all of Nature's forces and particles.
The model builds on the Euclidean interpretation of relativity that can be found on www.euclideanrelativity.com.

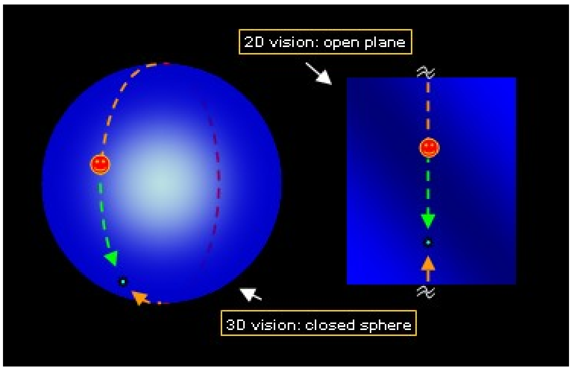
1. Closed universes in n dimensions

The descriptions that follow all take a closed universe as a starting point, i.e., if you would travel long enough in one direction, you would eventually return to the point where your journey started. That concept will be explained beginning with a simple 1D world.

Imagine some point-shaped being living on a circle. His limited 1D vision makes the circle appear to him as a straight line because to actually see the curvature of the circle he would need to have 2D vision.
He is looking at a point in the distance in his Lineland. Now he turns around and looks in the opposite direction. He sees "another" point but this is actually the same point again, looked at from the "backside".
This basic principle remains the same in a 2D world, where a Flatlander will also see two projections of each point or line in his Flatland.



World perception of a point-shaped being in Lineland



World perception of a flatlander

Also for our own 3D world, closed in the 4th dimension, this means that there should be "linked", points, lines or surfaces. A potential example regarding linked surfaces in particular will be given later in this text.

The list will continue since each *n*-dimensional world implies the existence of yet another higher dimension in which it is closed. So there will be a 4D world closed in the 5th dimension, a 5D world closed in the 6th and so on.

2. Closed 4D worlds: Black holes and gravity

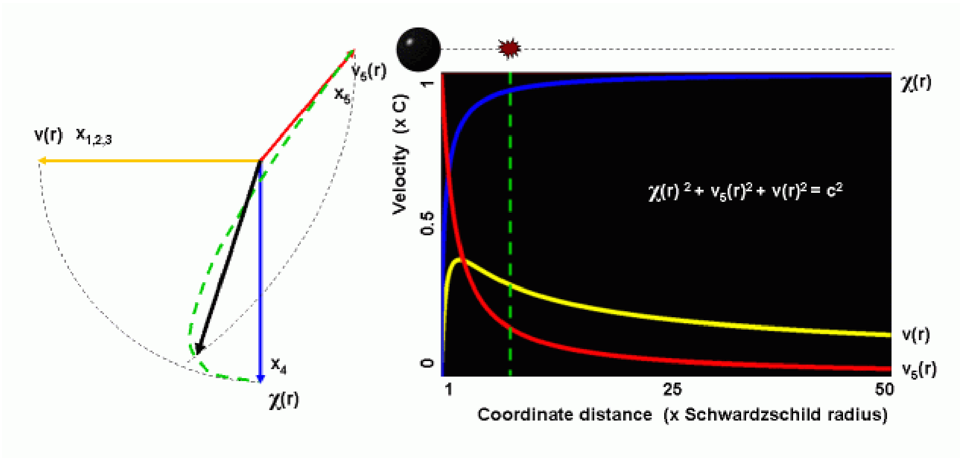
It is here assumed that massive objects, specifically black holes, and their gravity field represent the 4D world. The fourth dimension is proper time τ (following Euclidean relativity concepts [1]) while it is closed in a 5th dimension.

When nearing a black hole these dimensions will show increasing curvature. An object that falls towards the black hole's Schwarzschild radius follows a geodesic path along these curved dimensions. An observer at infinity, using a flat 5D coordinate system will observe that the velocity vector of the falling object will be subject to a 3-dimensional rotation.
When at first the object is in rest, the velocity vector has magnitude $\boldsymbol{c}$ in the proper time dimension [2]. When falling begins, it initially rotates towards space (hence it's acceleration in space), and finally, with increasing strength of the gravity field, it gains an increasing rotation towards the 5th dimension. Eventually the vector will fully rotate into the axis of the 5th dimension. So we talk here about a 5-dimensional velocity vector rather than a 4-vector as commonly used in relativity. During the whole process its magnitude remains $\boldsymbol{c}$.

An observer, using a flat 3D coordinate system, will observe this as an initial acceleration in space that will eventually decelerate again until the particle fully stops when it reaches the Schwarzschild radius. It finally has zero velocity in both space and (proper) time like predicted in general relativity, and seems to stay forever at the Schwarzschild radius.

The graph below shows the three different speed components of such an object that falls radially to a black hole from infinity with zero starting velocity in space. The speed components are expressed as a function of the radial coordinate distance $\boldsymbol{r}$ in a flat 5D coordinate system as used by an observer at infinity:

- the coordinate speed in 3-dimensional space $\boldsymbol{x_{1,2,3}}$: $v(r) = \left(1 - \frac{2MG}{rc^2}\right)\sqrt{\frac{2MG}{r}}$
- the coordinate speed in the proper time dimension $\boldsymbol{x_4}$: $\chi(r) = c\sqrt{1 - \frac{2MG}{rc^2}}$
- and the coordinate speed in $\boldsymbol{x_5}$: $v_5(r) = \sqrt{c^2 - \chi(r)^2 - v(r)^2}$



5D velocity vector and speed components of an object falling radially towards a black hole

3. Curvature in a closed universe

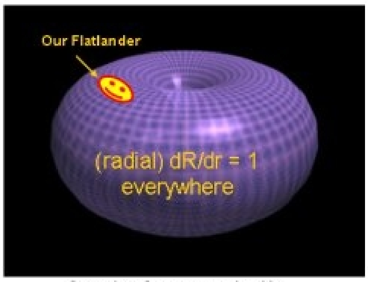
The example above shows that, even in a flat 3D coordinate system, an observer at infinity is still indirectly able to *perceive* the curvature of space-time in the neighborhood of the black hole because he observes the acceleration of the falling object.

That curvature is given in classical general relativity as the ratio between infinitesimal coordinate distance ***dR*** and radial distance ***dr*** :

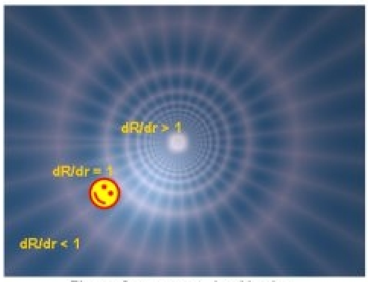
$$\frac{dR}{dr} = \frac{1}{\sqrt{1-\frac{2Gm}{rc^2}}}$$

The ratio becomes ***1*** at infinity, where curvature of space is assumed to be zero as a a result of the absence of mass.

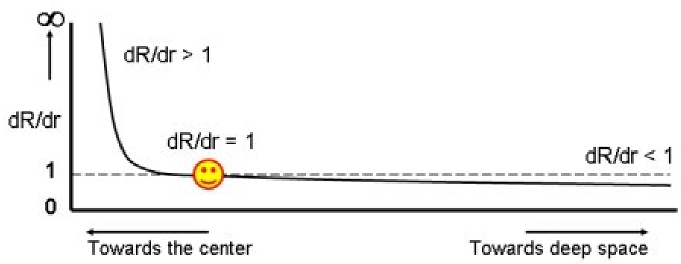
But if the 4D space-time of our universe is closed in the 5th dimension, curvature on a cosmological scale must exists everywhere, even with a total absence of mass, and at infinity ***dR/dr*** will *not* be equal to ***1*** (the classical formula would need an extra component to account for this).
In a 5D, or even a 4D closed space, curvature will appear asymmetric to an observer with 3D observational skills as a result of geometric projection effects. This can be illustrated by using an example of the effect as perceived by a Flatlander, living on a horn torus (see the pictures below).



Curved surface as perceived by observer with 3D vision



Flat surface as perceived by the Flatlander with 2D vision

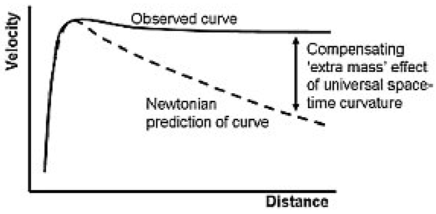


Near a massive object (for the Flatlander that is the center of the horn torus) the curvature deviates from ***1*** (***dR/dr >1)*** according to the Flatlander who uses his observation point with ***dR/dr=1*** (i.e., zero curvature) as a reference. But it will *also* deviate from ***1*** when observing deep space (where ***dR/dr <1).***

Consequently, the velocity vector of an object in that far distance will show components in space and time, similar to the situation at the black hole as explained above. After all, the object will only appear to be at rest relative to an observer at those places where ***dR/dr =1***. Its observed spatial speed goes up both when ***dR/dr <1*** and ***dR/dr >1***.

Universe with accelerated expansion
The conclusion is that in a closed universe, objects in the far distance of that universe should show *velocity* in a flat 3D coordinate space. They are kind of 'falling' towards deep space. The observer will however interpret this as an *expanding* universe in flat 3D coordinates. The rate of this expansion is not linear with distance. It depends on the curvature as perceived by the observer in 3D and the speed *increments* should therefor be measured as *declining* with increasing distance. This is indeed what is observed empirically today, but it is traditionally explained as a *physically* expanding universe where the rate of the expansion has been increasing over time (the declining increments are explained as an accelerated expansion over time, since the measurents represent properties from the objects as they were in the past).

Missing mass
If the presence of mass curves space-time then it is obvious that whenever space-time *is* curved, the effect of that should *resemble* the presence of mass. In other words, even when no mass is actually present in the empty space between stellar clusters, the curvature of 4D space-time that results from its closure in the 5th dimension will make it appear like there is extra mass around. This could explain, or perhaps partly explain, the missing-mass problem in the rotation curves of galaxies, where in the outer circles the universal curvature of space-time would then gradually take over the role of the real mass in the inner circles.



Universal curvature of space-time accounting for missing mass in galaxies

The inside of black holes
In view of the similarity in space-time curvature near the Schwarzschild radius of black holes on one hand, and the curvature of space-time in deep space on the other hand, we could now speculate that the "edge" of the universe is in fact the "inside" of all black holes together, thus closing the 4D universe in a 5th dimension. It is exactly like the Linelander who was looking at the same point from two sides and the Flatlander who was looking at the same line from two sides: we are looking at the same surface from two sides.

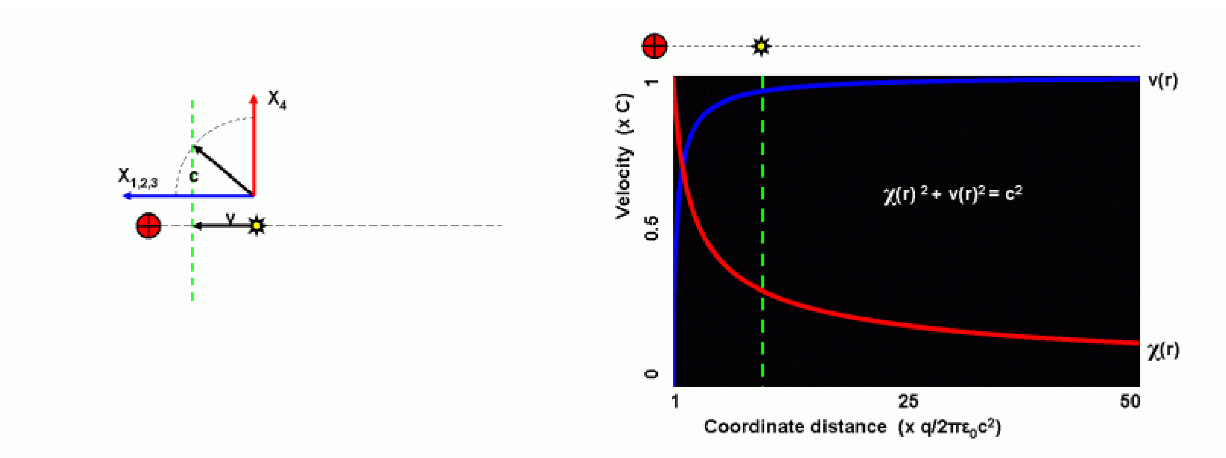
It means that whatever falls into a black hole will appear again instantly at the edge of the universe. It defines the edge of the universe as a gigantic "white hole" which should therefore *radiate energy* (cosmic background radiation?). The universe then resembles a 5D, multi-hole torus, or *n*-torus.

4. Closed 3D worlds once more: Photon absorption and emission by electrical charges

It is here assumed that electrical charges and their electric field represent the 3D world, closed in the 4^{th} dimension. Close to the charge its dimensions will be curved in a similar way as the 5D gravity dimensions are curved nearby a black hole. Consistency between *n*-dimensional models then implies that the absorption of a photon by an electrical charge will also involve a rotation of the photon's velocity vector, which in free space has constant magnitude ***c*** in space while its temporal component is zero. This time the rotation will be towards the 4^{th} dimension (proper time), eventually leading to a full stop in 3D at the moment it reaches the charge.

As an *example* formula for the velocity vector components (the actual formula must be determined empirically) we could bluntly replace mass by charge, resulting in the following speed components expressed as a function of the radial coordinate distance ***r*** to the charge in a flat 4D coordinate system as used by an observer at infinity:

- the coordinate speed in the spatial dimensions $x_{1,2,3}$: $v(r)_{photon} = c\sqrt{1 - \frac{2q}{4\pi\epsilon_0 rc^2}}$
- and the coordinate speed in the proper time dimension x_4 : $\chi(r)_{photon} = \sqrt{c^2 - v(r)^2_{photon}}$



4D velocity vector and speed components of a photon being absorbed by an electrical charge (example)

In this example, one Coulomb of charge would thus slow down the photon's velocity in space for about 1% at a distance of about 10^{-5}m. So far, no such effect was ever recorded through experiment but putting a net charge of one Coulomb in such a tiny volume is a challenge on its own and may very well prohibit an easy setup of such an experiment. The force involved in this example would be in the order of $2x10^{19}$ N!

The "spontaneous" *emission* of a photon by a charge could have its origin in the simultaneous *absorption* of a photon by another charge, linking charged particles through the 4^{th} dimension in a similar way as the black holes and the edge-of-universe were linked through the 5^{th} dimension. This would implicate an *instantaneous* transformation of information in 3D, which on its turn brings the EPR experiment to mind where something similar happens with two "linked" photons. The seemingly instantaneous information transfer in this experiment indicates that, again, a higher dimension may be involved in the link and that the two photons might actually be one and the same, looked at from two opposite sides.

5. Ordering Nature's particles and fields in n-dimensional worlds

What looks like a fermion from "below" (e.g. 3D) looks like a boson from "above" (e.g. 4D).

The meaning of "above" and "below" here depends on the number of spatial dimensions that an observer is able to see. We, humans, can see 3 spatial dimensions so when we look at a 2D world (Flatland) we look at it from "above". On the other hand, when a Flatlander looks at a 3D world (he can of course only see its *projection* to his 2D world), he looks at it from "below".

The tables below gives an overview of how particles and fields may be observed from various dimensional "levels". When observed as a boson, the particle will follow a path equivalent to a null geodesic for that dimensional level and its speed will be measured as ***c***, otherwise its path is timelike with speed **<*c***.

"Particle"	*For a Flatlander with 2D vision it looks like a:*	*For a Spacelander with 3D vision it looks like a:*	*For a Hyperspacelander with 4D vision it looks like a:*
Gluon	long range boson	short range boson	short range boson
Photon	fermion	long range boson	short range boson
Electron	black hole	fermion	long range boson
Black hole	universe	black hole	fermion
Universe	???	universe	black hole

When we look at mass particles like e.g. an electron, we see it as the fermion for the electromagnetic field. If we would have been Hyperspacelanders with 4D spatial vision we would always see these electrons move with velocity ***c*** in our 4D space and they would behave like bosons (of gravity) [3]. It's like *dimensional zooming out*, not by changing magnification but by changing the number of dimensions that are observed.

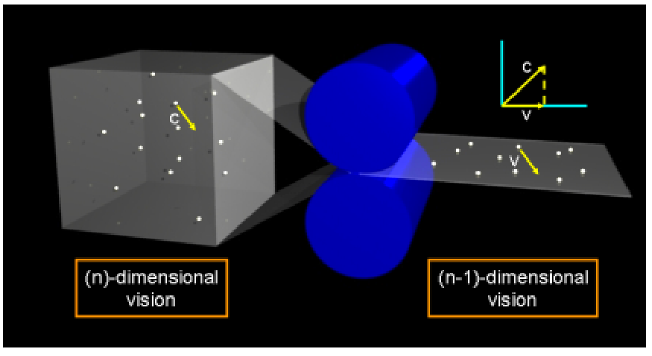
Force	*# dimensions*	*fermions (# dim)*	*bosons (# dim -1)*
Weak nuclear	2 (any subset of 2 out of our 4D space-time) (1)	gluons and ?	W, Z, ?
Strong nuclear	3 (any subset of 3 out of our 4D space-time)	photons and quarks (2)	gluons
Electromagnetic	3+1 (our 4D space-time)	electrically charged particles	photons
Gravity	3+2 (our 4D space-time + a higher dimension)	black holes (3)	massive particles

(1) : The nuclear forces consist of a 2 or 3 dimensional subset of our 4D space-time. They may however *rotate* in 4D and thus occupy any of the 4 dimensions at a given moment.

(2) : If the strong nuclear force is indeed the field to be associated with a 3D Euclidean space-time and bosons and fermions are mutually dual between dimensional levels then the bosons of the electromagnetic field must be the dual of the fermions of the strong nuclear field, i.e., a photon might just be another variation of a quark.

(3) : Black holes are actually 5D fermions and are the gravity "charge"

Dimensional zooming out and in
The picture below visualizes the effect that a "downgrade" of spatial vision (*dimensional zooming in*) would have on the way particles show themselves to an observer with *n*-dimensional vision.



"Downgrade" of spatial vision from (n) dimensions to (n-1) dimensions

Note that the n^{th} spatial dimension does not disappear! It gets fully contracted, curled up if you like [4], in the lower-dimensional space (hence the massive rollers) and becomes the proper time dimension for the observer with (*n-1*)-dimensional vision. Also for us, Spacelanders, the proper time dimension is fully contracted into our 3D space, which explains why we can "see" relativistic non-simultaneities in moving objects and also have no problem observing time dilation in moving clocks. But it also says that *all* bosons in 4D remain visible for us as fermions in 3D. A similar effect takes place in the world of the Flatlander: *all* photons of our 3D space will still exist as fermions in his 2D space.

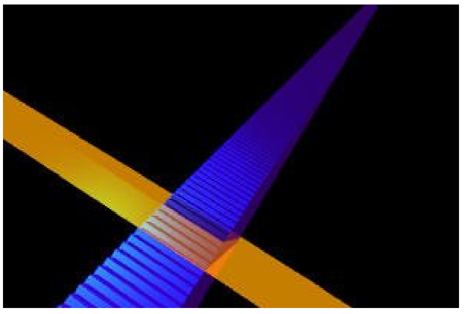
6. The ever-lasting Big Bang

The list of fields may continue with fields that have 6 or more dimensions but have so far not been observed. There may also be a 1-dimensional field with hitherto unknown properties. I dare to suggest that even 0-dimensional and negatively-numbered-dimensional fields exist. After all, who are we to say that our familiar 4 dimensions are at the bottom of the list? The fact that we number them 1 - 4 doesn't mean a thing. We could have numbered them 2.356 - 2.359 just as well. If we can't see the fifth dimension why would we be able to see dimension 0 or dimension *-12* ?

Imagine now a being that is able to observe dimensions -1, 0, 1 and 2 (so also four in total). For that being, the picture is complete for *his* four forces, making *our* weak nuclear force look like electromagnetism in the eyes of this "shifted-dimensional" being. Similarly, what we call gravity may be any other kind of field for another shifted-dimensional being.

So is this all nonsense? Looking at articles on braneworlds, induced matter theories, supersymmetry and so on, these ideas do not seem to be any more exotic whatsoever. The more spiritual minded reader may even recognize in this model ancient descriptions of 'layered' worlds. Perhaps the most interesting contribution of the fractal-universe model based on Euclidean relativity is that quantum gravity results from it naturally. The full quantum description of electromagnetism based on a 4D Euclidean space-time can in principle be ported one-to-one to gravity based on a five dimensional Euclidean space-time with mass particles acting as its bosons.

And what if individual dimensions were created a fraction after each other in climbing order? That process might *still* be ongoing with the creation of yet more higher dimensions. Our Big Bang as a snapshot in an ever-lasting Bang that started much earlier already?



Our own 4D slice (yellow) popping in existence during an ever-lasting Big Bang, continuously creating new dimensions along the 'stairs'.

Bibliography

[1] R.F.J. van Linden, "*Euclidean Special Relativity*", available at www.euclideanrelativity.com (Sep 2017)

[2] R.F.J. van Linden, "*Minkowski versus Euclidean 4-vectors*", available at www.euclideanrelativity.com (Feb 2006)

[3] Paul Wesson, *"In Defense of Campbell's Theorem as a Frame for New Physics"*, arXiv.org gr-qc/0507107 (July 25th 2005

[4] Brian Greene, *"The elegant universe"*, W.W. Norton and Company (Feb 1999)