

The Universe as a Multi-Dimensional Fractal

Recurring patterns through dimensional zooming

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 three sections show some examples of physical phenomena that re-appear in spaces with one dimension less or more. From section four onwards, they will be put in a broader context, covering all of Nature's forces and particles.

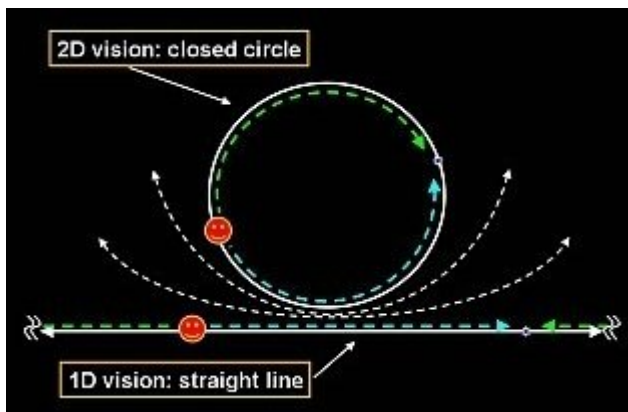
These ideas build on the articles on Euclidean relativity that can be found on www.euclideanrelativity.com.

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1. Positive and negative charges are two sides of the same 4D point

...explaining why the amount of positive and negative charge in the universe is exactly equal.



World perception of a point-shaped being

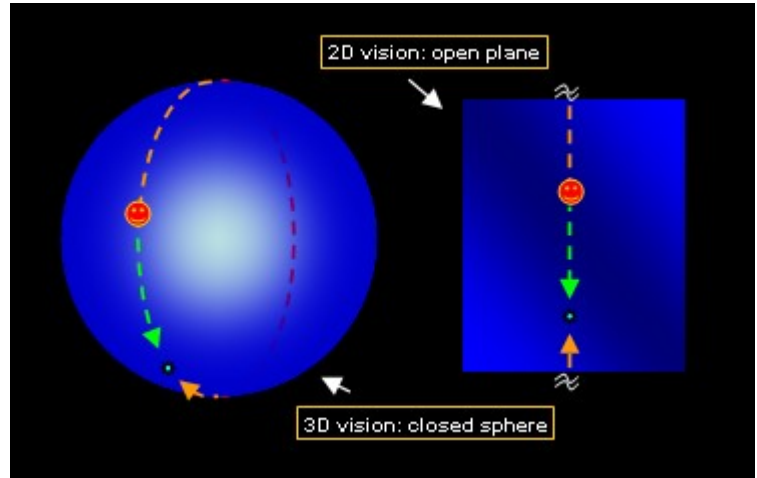
Some point-shaped being lives on a circle. His limited 1D vision makes the circle appear to him as a straight line. To actually see the extrinsic curvature he would need to have 2D vision. He is looking at a point in the distance in his circular world. Now he turns around and looks down his circle in the opposite direction. He sees "another" point but this is actually the same point again, looked at from the "backside".

You can extend this to 2D worlds, 3D worlds and so on. The basic principle remains the same. In any n -dimensional closed world or manifold (i.e., closed in yet another higher dimension), every point always shows two projections to our "eyes", provided our spatial vision is limited to those same n dimensions. The projections follow geodesics, 1D trajectories like the circular world of the point creature. Once our spatial

vision is extended with one more dimension, it becomes clear immediately that we are looking at a single point only.

Also for our own 3D world, assumed closed in the 4th dimension, this means that there should be "linked" points in pairs. The obvious candidate is electrical charge which always comes in pairs and is conserved. It does not mean that the link is necessarily between positive and negative charges in the same atom. On the contrary, the linked charges are very likely to be separated by large distances in 3D space.

Why then the asymmetry in mass between protons and electrons? Protons are compound hadrons while electrons are point-like leptons. Although a bit hard to visualize in 4D, a 3D analogue may suffice to get the idea. It's kind of looking at the top of a tetrahedron from above (electron) versus looking at the base of it from below (proton). The corners then more or less represent its 4 dimensions.



World perception of a flatlander



4D geometry of positive and negative charges

This has some interesting implications. The "spontaneous" emission of a photon by a charge would have its origin in the simultaneous absorption of a photon by its linked companion charge. Since the distance between the two linked charges is arbitrary (albeit depending on the geodesic connection between them), this means an instantaneous transformation of information in 3D. That 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 must be involved in the link.

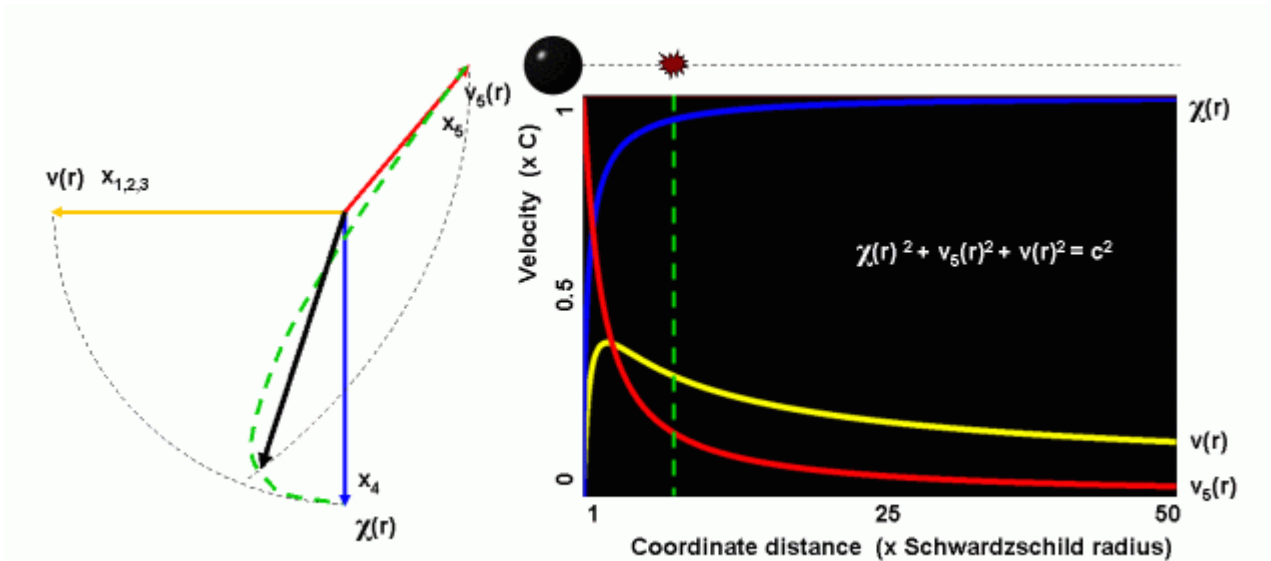
In the next two sections, a similar absorption process as found with charges and photons will be worked out, but now the 5th dimension plays the role as linking dimension, like the 4th did with electrical charges.

2. Photon absorption by electrical charges is the 4D equivalent to mass particles falling into 5D black holes

In Euclidean relativity, the velocity vector of any particle has constant magnitude c . When a mass particle approaches the Schwarzschild radius of a black hole along a geodesic path, its velocity vector is subject to a 3-dimensional rotation, eventually fully rotating to the axis of x_5 , leading to a zero velocity in both space and proper time. In a way, the particle "teams up" with the black hole's velocity c in x_5 (see Section 3 in [2]). So we talk here about 5-velocity rather than 4-velocity.

The animation shows the three different speed components of a mass particle 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 r in a flat 5D coordinate system as used by an observer at infinity:

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



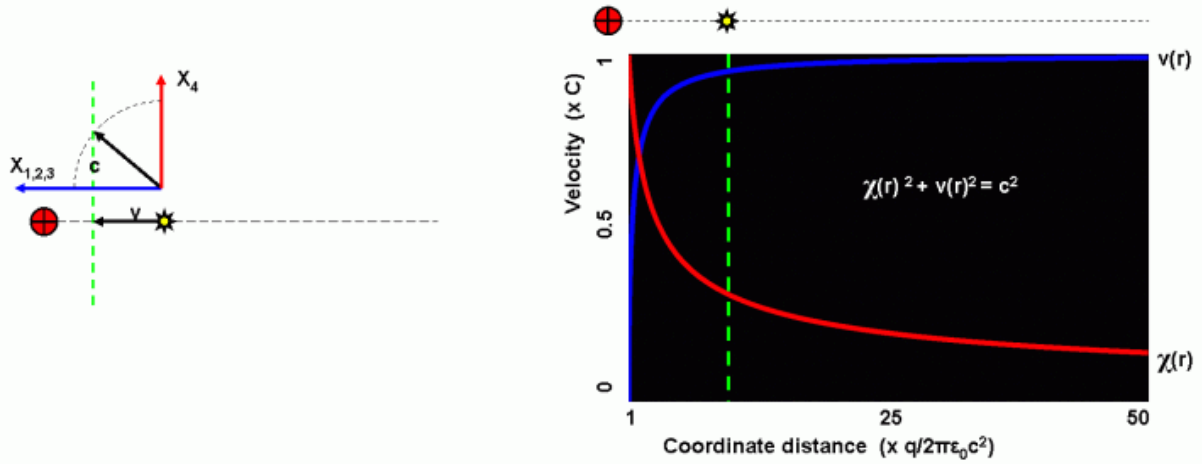
5D velocity vector and speed components of an object falling radially towards a black hole

The absorption of a photon by an electrical charge also involves a rotation of the photon's velocity vector. This time it rotates into the 4th dimension, leading to a full stop in 3D at the moment it reaches the charge. A trajectory close by the charge leads to a slowdown of its velocity in space. So again, the photon's velocity "teams up" with the charge that, in rest, has 4-velocity \mathbf{c} in \mathbf{x}_4 (which is the proper-time dimension in Euclidean relativity).

Although this may seem an explanation of why light slows down in a medium, this is not the primary reason. The slowdown in a medium can be explained quite well in terms of the electromagnetic interaction between the fields inside the medium and the electromagnetic fields of the photon, leading to an only *apparent* slowing down [1]. The description above should therefore seek a different physical justification and the effect might only take place at distances that are extremely close to the charge.

Very close to the charge the 4D electromagnetic field dimensions are curved in a similar way as the 5D gravity dimensions are curved nearby a massive object, causing the slowdown of any spatial coordinate speed of photons. Since the photon's speed \mathbf{c} in 3D is equivalent to the speed \mathbf{c} of mass particles in 4D (see Section 3 in [2]) one may assume that there will also be an equivalent mathematical expression for it. If we bluntly replace mass by charge in the math this results 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 (note that this is just an *example* formula; the exact formula must be determined empirically):

- the coordinate speed in the spatial dimensions \mathbf{x}_i ,
$$v(r)_{\text{photon}} = c \sqrt{1 - \frac{2q}{4\pi\epsilon_0 r c^2}}$$
- and the coordinate speed in the proper time dimension \mathbf{x}_4 ,
$$\chi(r)_{\text{photon}} = \sqrt{c^2 - v(r)_{\text{photon}}^2}$$



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

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 would be in the order of 2×10^{19} N!

The next section shows that the parallels between photon absorption and mass particle absorption can be extended to the emission process in black holes too.

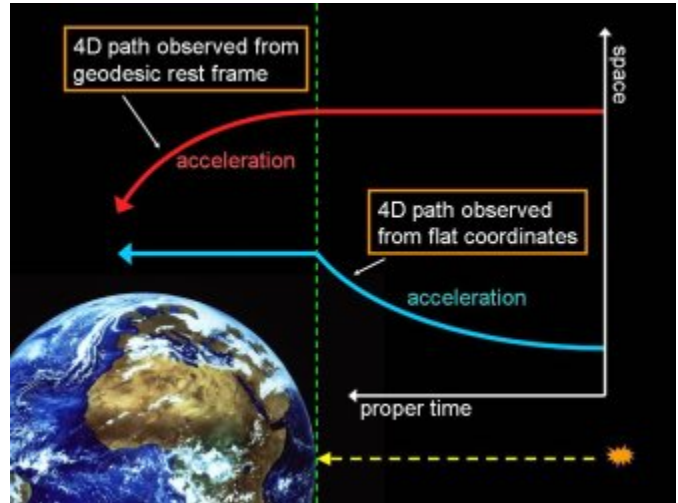
3. From a 5D perspective the Schwarzschild horizon and the "edge" of our universe are two sides of the same surface

Section 2 showed that the velocity vector of a falling particle begins to rotate in 5D under the influence of a gravity field or curved space. When an object is in rest, this vector has magnitude c in the proper time dimension. 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 additional rotation towards the 5th dimension.

When a falling object hits the surface of a planet that it falls to, the rotation of its velocity vector in 5D stops and it resumes its velocity c in the proper time dimension in a straight path in 5D. At least that is what is observed in a flat coordinate system by an observer at infinity. In Riemannian geometry however the geodesic path of the freely *falling* object is a straight path. That means that from the perspective of a geodesic rest frame of a continuously co-falling observer it is the 5D path of the object in rest on the surface of the planet that is curved and, as a consequence of this, that object must sense a (gravitational) acceleration according to the observer. During its free fall the object feels no acceleration, since it is following a straight path in 5D with constant speed c .

The difference in the shape of the observed paths is visualized in the picture on the right. Here an approximation in 4D space-time is chosen (sufficiently accurate in the neighborhood of ordinary planets) and the curvatures are exaggerated. The object's speed is always c in 4D space-time and only its direction rotates (take note of the labels of the space-time axes!).

The example shows that, in a flat 3D coordinate system, an observer at infinity is indirectly able to *perceive* the curvature of space-time in the neighborhood of the planet because he observes the acceleration of a falling object. If our universe is closed, its 4D space-time must be curved on cosmological scale as well (and closed in the 5th dimension). Common sense then says that the observer should see the same effect of that curvature as he did near the planet, i.e., objects in the far distance of the universe should show *velocity and acceleration* in his flat 3D coordinate space. The observer will interpret this as an *expanding* universe in flat 3D coordinates while the rate of this expansion is *accelerating*. This is indeed what is observed empirically today, but it is traditionally explained as a *physically* expanding universe.



Observed 4D path of a falling object: from geodesic rest frame and from flat coordinate space



A mass particle cycling the universe via a black hole

Extending the considerations from section 1, where we closed 3D and 4D worlds, we could now speculate that the "edge" of the universe is in fact the "inside" of all black holes together, thus closing the circle in 5D. The universe then resembles a 5D, multi-hole torus, or n -torus. It means that whatever falls into a black hole will appear again instantly at the edge of the universe in a similar way as photons that are absorbed by charges appear instantly as spontaneously emitted photons by opposite charges (as explained in section 1). It defines the edge of the universe as a gigantic "white hole" which should therefore *radiate energy* (cosmic background radiation?). The "black-hole / edge-of-universe" combinations on its turn form the conserved charges (fermions) of gravity while mass particles (=energy) represent gravity's bosons (see Section 4 in [2]).

In the next section, this principle will be generalized across multiple dimensions and types of particles.

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

...explaining why mass particles can still be bosons in 5D gravity.

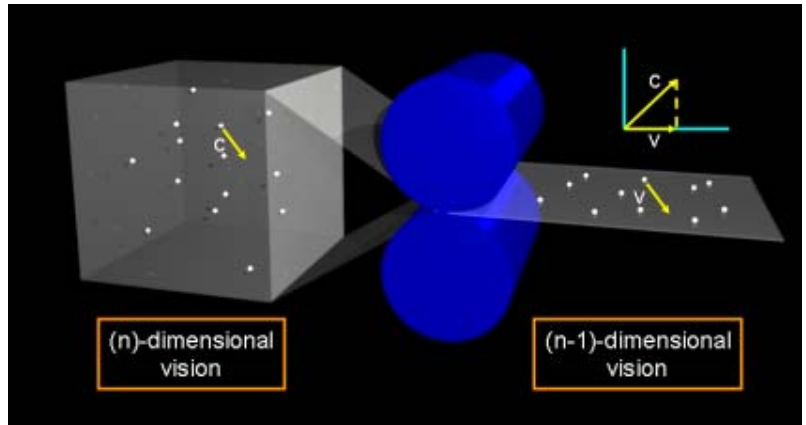
The meaning of "above" and "below" here depends on the number of spatial dimensions that an observer is able to see. We, humans, can see 3 spatial dimensions so when we look at a 2D world (Flatland) we look at it from "above". On the other hand, when a Flatlander looks at a 3D world (he can of course only see its *projection* to his 2D world), he looks at it from "below". The table below gives some examples of how objects and particles 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 $<c$. (see Section 4 in [2])

"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

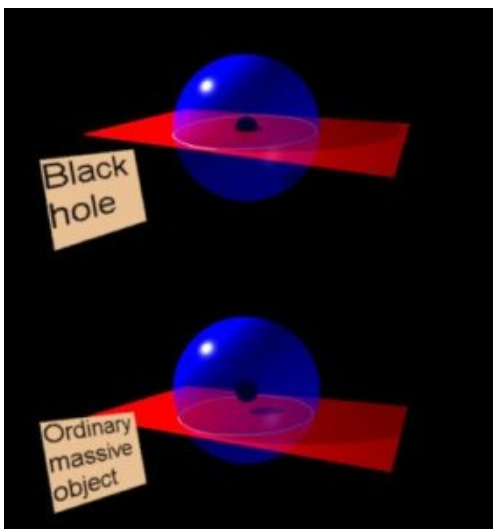
The universe as a giant fractal. An alternative kind of supersymmetry?

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)^(*). It's like *dimensional zooming out*, not by changing magnification but by changing the number of dimensions that are observed.

The picture on the right 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. Note that the n^{th} spatial dimension does not disappear! It gets fully contracted 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*.



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



Properties of massive object determined by 4D intersection of 5D gravity environment

From the table above it shows that black holes are actually 5D fermions (the fifth dimension is "proper time" for the Hyperspacelander) and are the gravity "charge". Being the fermion for the 5D gravity field, black holes should have velocity c in the fifth dimension.

Should not every massive object be a black hole then? Yes, but what we usually see of it is a 4D section of the 5D gravity environment that does not contain the coordinates of its center. We only see the swarm of (virtual) bosons around it which makes up its mass. It's like a plane that does not contain the center of a sphere that it intersects, as shown in the animation on the left. The red plane is supposed to be our 4D space-time, while the blue sphere represents the 5D gravity environment of a massive object.

The next section will extend the dimensional classification that was given for particles into the four forces of nature.

^(*)See also [3]

5. The four forces of nature can be ordered hierarchically, based on their number of dimensions

...combining all that was said before and more.

The logical order is (see Section 4 in [2]):

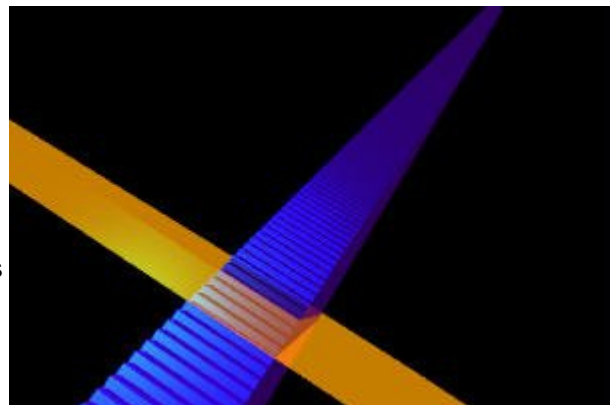
Force	# dimensions	fermions (# dim)	bosons (# dim -1)
Weak nuclear	2 (any subset of 2 out of our 4D space-time)	gluons and ?	W, Z, ?
Strong nuclear	3 (any subset of 3 out of our 4D space-time)	photons and quarks ^(*)	gluons
Electromagnetic	3+1 (our 4D space-time)	electrically charged particles	photons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

(^{*}): See next section

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. Compare this with the Lorentz boost in Euclidean relativity that rotates our 3D space in SO(4) when accelerating (see Section 2 in [4]).

The list 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. This makes the model partly relational, or background-independent. Depending on one's place on the "ladder", the lower dimensions are mutually indiscernible and relational, while the higher dimensions form an absolute background. However, for a hypothetical being with infinite-dimensional observational skills, *all* dimensions are relational.



Our own 4D slice popping in existence during an ever-lasting Big Bang, creating a universe with infinite dimensions

So is this all nonsense? Looking at recent 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. 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?

The next sections will discuss some additional details that may be deduced from the basic principles that have been worked out in the previous sections.

6. Photons are free quarks

If the strong nuclear force is indeed the field to be associated with a 3D Euclidean space-time X_3 and bosons and fermions are mutually dual then the bosons of the electromagnetic field must be the dual of the fermions of the strong nuclear field, i.e., a photon is just another variation of a quark.

	x_1	x_2	x_3	t	
1	e	e	v	-	photons
2	e	v	e	-	
3	v	e	e	-	
4	e	e	-	v	up/charm/top quarks?
5	e	-	e	v	
6	-	e	e	v	
7	v	e	-	e	down/strange/bottom quarks?
8	v	-	e	e	
9	-	v	e	e	
10	e	v	-	e	
11	e	-	v	e	
12	-	e	v	e	

Dimension table for 3-dimensional particles

The table on the left shows a possible ordering of such 3D particles in a 4D world. Each 3D particle has speed c in the proper time dimension of its own rest frame. This dimension is indicated by the letter "v" ("velocity" dimension). The other two dimensions are indicated by "e" ("existence" dimensions). The quarks rotate in 4D, which may be the background of their Cabibbo mixing. Charge is determined by the number of existence dimensions in our 3D space. Each existence dimension represents $\frac{1}{3}$ unit of charge (positive or negative). In fact, charge only becomes "real" and measurable charge once the three "e" dimensions come together. That's why photons show no "real" charge.

Mass (energy) is determined by the velocity dimensions. The total mass of a compound particle may ultimately be determined by the sum of all velocities of all sub-particles, sub-sub-particles and so on. A 3D quark may on its turn be a bound state of yet more fundamental 2D particles (W, Z, neutrino's?).

Quark combinations must always lead to a compound particle consisting of all four dimensions.

Possible examples:

$$2 \times "4" + "9" = 2u + d = \text{proton}$$

$$"4" + 2 \times "9" = u + 2d = \text{neutron}$$

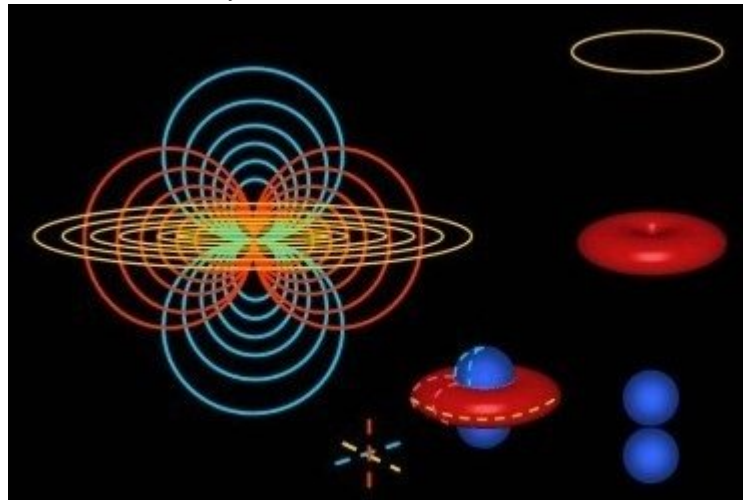
$$"4" + \text{anti-} "8" = u + \text{anti-}d = \text{anti-}p^+$$

How to imagine such 3-dimensional particles and the dimensions that they consist of? The picture on the right and the animations below try to visualize this.

A basic property of the model is that all dimensions are orthogonal in every point and closed. The model has some similarities with p-branes in stringtheories. It starts with a simple model for a particle with zero "e" dimensions and 1 "v" dimension. That results in the yellow circle in the top right corner of the picture. The actual particle is a zero-dimensional point, moving around in the circle with velocity c , like in the first animation. That circle represents the proper time dimension for the particle.

The next step is the red horn torus below the yellow circle. This represents a particle with 1 "e" dimension and 1 "v" dimension (note that a *sphere* does not fulfill the model's requirement on orthogonal dimensions). The actual particle is a 1D circle, orientated like the yellow circle in the previous model. It moves along the surface of the horn torus, in the direction orthogonal to the circle, with velocity c (second animation). The circle thus shrinks and stretches depending on it's position on the surface. Once it passes the center of the horn torus, it's diameter will be instantly zero, while the diameter will reach it's maximum when the circle passes the outer edge of the horn torus. The surface of the horn torus represents the proper time dimension for the particle.

Finally, we can visualize a particle with 2 "e" dimensions and 1 "v" dimension (e.g. a quark). This is shown in the combination of the red horn torus with the blue balls. A single instance of the pair-of-blue-balls is drawn here; the complete model actually consists of an infinite number of blue-ball-pairs with growing diameter that together represent the third (proper time) dimension. The torus now represents the actual 2D particle, while it moves along



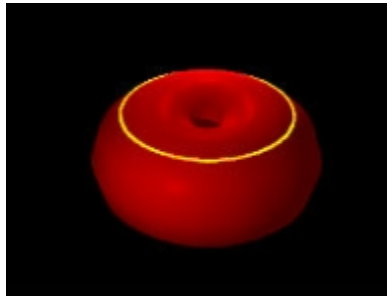
Conceptual overview of elementary particles and the dimensions that they consist of

the surface of the blue balls with velocity c . The net effect is that the torus inflates until it reaches an infinite size when it reaches the top of the blue ball, and then begins to deflate again until it reaches the point where the two blue balls touch. It's size is zero then. After that, the whole cycle repeats itself. The "infinite" size that the torus reaches at a certain instant, is a result of the fact that we cannot observe the higher dimensional space that the whole construction is embedded in. For an observer with 4D spatial vision, the size would always remain finite, like we always observe the size of the moving circle as finite in the previous model.

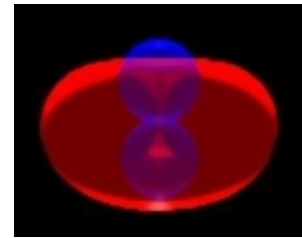
Note that the way that this model would really show itself to us totally depends on the actual dimensions that play the roles of "e" and "v". The description of the third model in fact applies to a photon (because all 3 dimensions exist in our 3D space). The instants of zero size correlate with the moment of absorption or emission of the photon by a charged particle while the intermediate states represent it's journey between emission and absorption. The instant of infinite (undefined) size allows the change of its path towards another charged particle (the animation actually shows a scene where the photon is emitted and absorbed by the same charged particle). The surface of the horn torus reflects the quantummechanical probability spread of the photon's position in space. At the moment of absorption (read: measurement) this probability instantly converts to 100% at the position of the absorbing particle.



Particle with 0 e and 1 v dimension



Particle with 1 e and 1 v dimensions

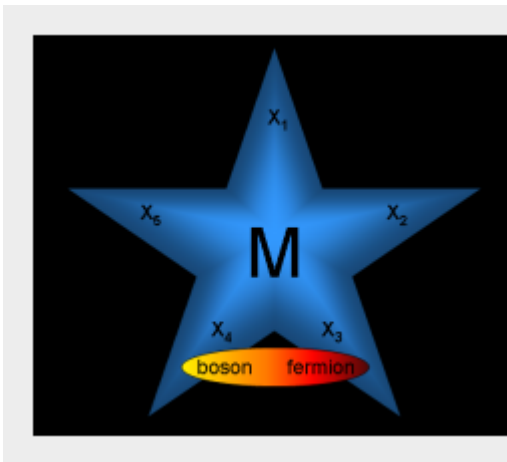


Particle with 2 e and 1 v dimensions

7. Parallels with stringtheories

...that anyone who *really* understands stringtheories perhaps torpedoes in an instant.

There are a number of parallels that I see between the fractal-like Euclidean model of the universe, as described on this page with its fundamental forces and particles on one hand and stringtheoretical concepts on the other hand. A couple of examples:



M-Theory with corresponding dimensional viewpoints $X_1 - X_5$

- The fractal-universe can be "observed" from different dimensional viewpoints^(*) which would each give a different mathematical model as well, each being associated with a unique number of dimensions. For the "closest" dimensional viewpoints, i.e., the one from our own X_4 , together with X_1 , X_2 , X_3 and X_5 , this would result in rather concrete theories (5 in total), while the more "distant" viewpoints would be less obvious, but nevertheless mathematically possible. I see here some links with the theoretical possibility of many more stringtheories (in particular in Euclidean space-times) while there must exist a dimension-independent overall description (obviously M-theory) of the basic principles of each of them.
- Dualities in stringtheories could be associated with the dualities that I have described between fermions and bosons. Each fermion in X_n corresponds to a boson in

X_{n+1} , i.e., they are physically the same entity but described from a different dimensional viewpoint. This may perhaps also be a basis for supersymmetry. In principle, each particle should have a mathematically describable and associated counter-particle from its neighboring dimensional viewpoint. It would however be the same particle in fact, observed from another (higher or lower dimensional) side.

- P-branes may be directly linked to particles in n dimensions as listed in the table of section 5 and shown in the animations of section 6.
- "Curled up" dimensions in Calabi-Yau space is consistent with the way the proper time dimension shows itself as fully contracted in the spatial environment of an observer in X_n (see description in middle of section 4). Each point in space contains *all* coordinates of the proper time dimension. The Euclidean model assumes such dimensions to be closed and thus circular.

The added value of Euclidean relativity lies in the fact that the Euclidean space-time, extrapolated to the fractal-like model of the universe, is far better equipped to support this "visually", allowing natural interpretations of various elements of stringtheory, the lack of which seems to have been hampering stringtheories from the beginning. The inherently confusing Minkowski geometry is not really helpful in visualizations.

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.

(*) The following conditions (see Section 2 in [2]) define the *dimensional viewpoint* in X_n :

- Observers in X_n have the skill to observe dimensions 1 to $n-1$ as spatial dimensions.
- The dimension n is the equivalent for 'proper time' for observers in X_n .

This definition means that we are observers in X_4 where x_4 is our proper time dimension but that for instance in 3D Euclidean space X_3 , observers are 'Flatlanders', *i.e.*, they live in a 2D space. They experience the third dimension x_3 as their equivalence of proper time, while their basis for speed measurements is x_4 .

8. Bibliography

- [1] R.P. Feynman, "*The Feynman lectures on physics*", Vol. 1 Ch. 31, Addison-Wesley publishing company (1963)
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- [4] R.F.J. van Linden, "*Dimensions in Special Relativity Theory - A Euclidean Interpretation*", Galilean Electrodynamics Vol 18 nr 1 (Jan/Feb 2007)