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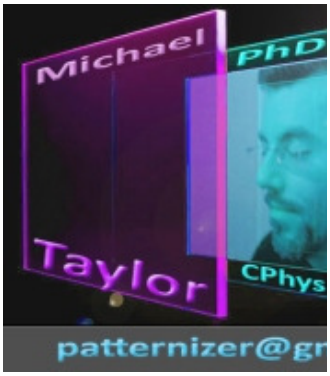
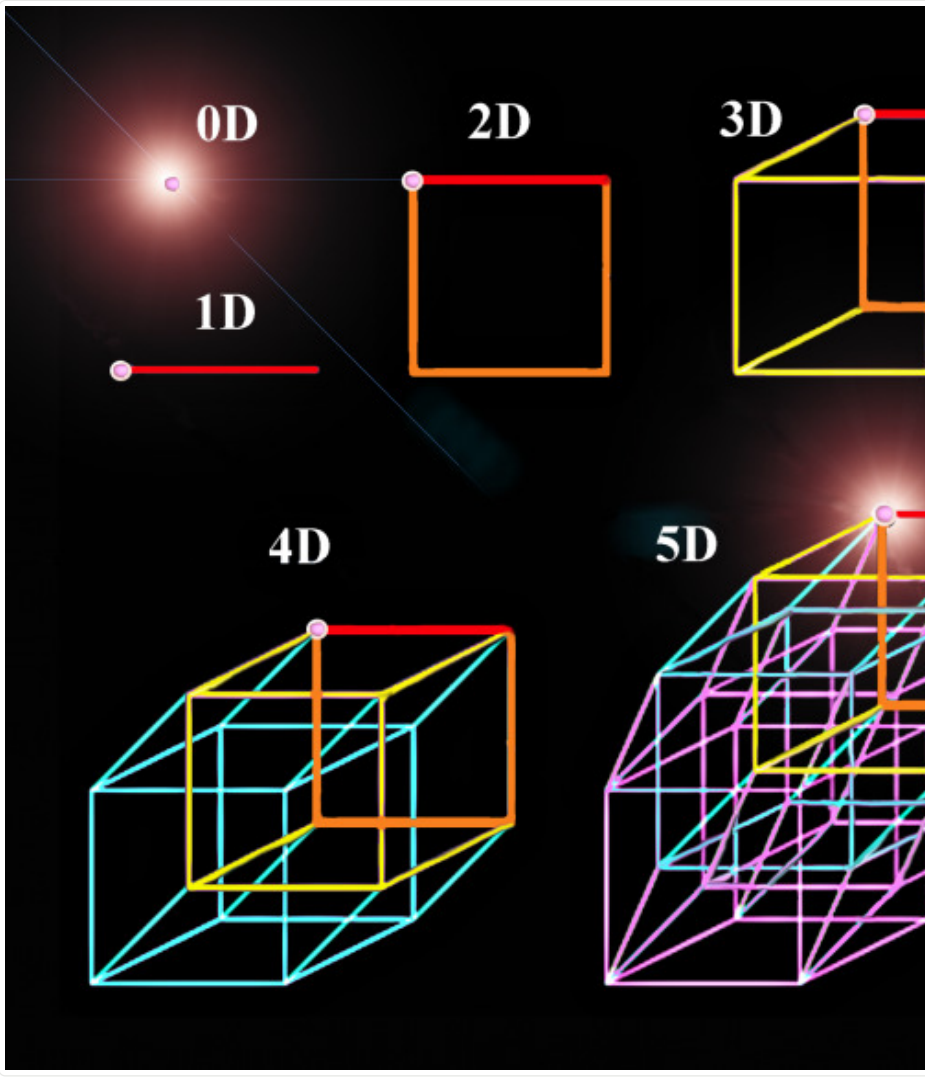


Posts Tagged M-theory

How many dimensions is your world?

Posted by patternizer in cognition on November 12, 2010



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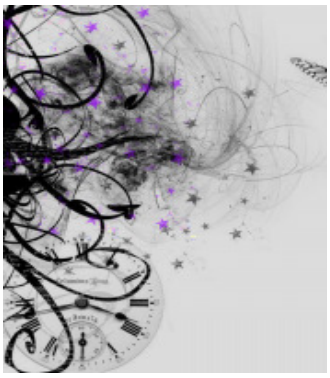

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- *We do not grow absolutely, chronologically. We grow sometimes in one dimension, and not in another; unevenly. We grow partially. We are relative* — ***Anais Nin***
- *An attempt at visualizing the Fourth Dimension: take a point, stretch it into a line, curl it into a circle, twist it into a sphere, and punch through the sphere* — ***Albert Einstein***
- *Design in art, is a recognition of the relation between various things, various elements in the creative flux. You can't invent a design. You recognize it, in the fourth dimension* — ***DH Lawrence***

There are many things we take for granted. Take, for example, the world around us. How many dimensions is it? You might say, easy – that's three, as in 3D. In a sense (literally) that's right. We pass every hour of our lives in a 3D space – at least the one represented by our mind's eye. We may move from here to there or perhaps we just sit still, letting time go by. Without hardly realising it, another dimension has entered the picture – time itself. At the very least, we see that our lives take place in a world made up of 3D spatial dimensions plus 1D time. 4D. We know instinctively that if we stand still on the same spot for long enough, we will age. But what about if somebody were to tell you that our world is 5D or 11D? And, that the number of dimensions don't have to stop there – it is quite possibly ∞D?

Chatting yesterday with someone about the number of variables needed to map the temperature of the ocean, they asked: *why, if it's all made of the same stuff, are only three variables needed for points on the surface while we need four for points in the interior*? Good question. I thought for a moment and then answered that the water surface is a (very noisy and complicated) function of two spatial variables (positions x and y) whereas the water's interior requires three spatial variables (x,y and z) relative to some origin – *plus* the temperature measured at each point. Since the surface is just the top of the ocean, it is a special case of the interior representation where the height is a constant value (something that can be made to equal zero with a suitable choice of origin and axes). In other words, the surface space can be embedded in the whole ocean space. The same is true for many other things in nature that occupy volumes like air temperature, atmospheric pressure and wind speed. Maps of these things are all 4D (x,y,z plus the value of the temperature, pressure or speed). Indeed, elevation contour maps we use when we go out hiking and isobars on weather maps are just slices taken at different heights or pressures. These 4D maps are not so strange once you get your head around them. If now, we add time as an extra dimension so as to allow things like temperature, pressure and air speed to change at different points in space, then all of a sudden we are talking 5D. Ok, you may say, this may be so but aren't there still only three spatial dimensions? Yes. But do you see what I mean? Extra dimensions can creep in very easily when we start to extend our description of the world around us. A good example of this is thermal imaging.

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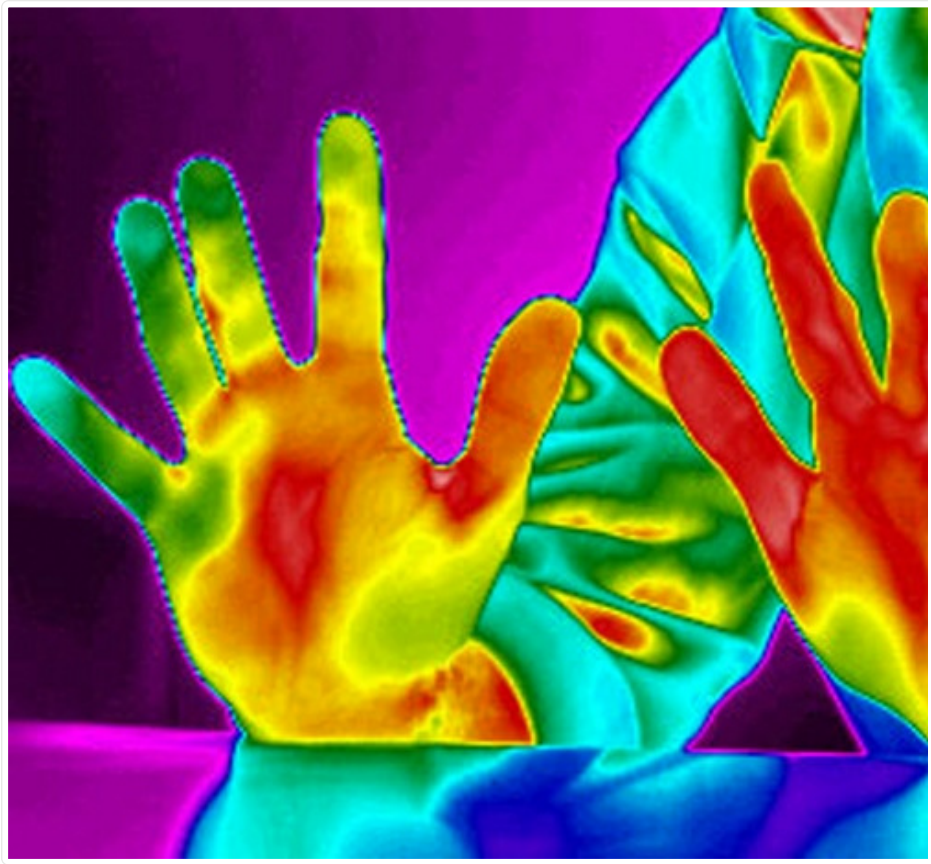

Image Credit: *Anon*

It appears to me, that there is a very personal and highly-subjective element to dimensions too. Ponder this thought for a moment – that we actually live in a high-dimensional world, one where, in addition to the three standard dimensions of space and one of time, we could add dimensions representing colours, sounds, smells, touch pressure, vibrations of different frequencies, temperature, orientation, age and possibly a whole host of other social constructs like vitality and happiness too. People who may lack one or more of these dimensions may (and probably do) compensate with other dimensions. In this sense, we really do all live in a different microcosmos. A blind person doesn't perceive the ring of a bell the way a seeing person does. Their perception uses many other dimensions to approximate what we may think of as standard visual perception. Our brains work in weird and wonderful ways that we are only just starting to understand. Take synaesthesia for example. It is a neurological condition in which stimulation of one sensory or cognitive pathway leads to automatic, involuntary experiences in a second sensory or cognitive pathway. It can cause us to hear colours, see sounds or even to associate different colours with different smells. Over 60 types of synesthesia have been reported. It has even entered common language with cross-sensory metaphors like "loud shirt", "bitter wind" or "prickly laugh".

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Many animals and insects have very different senses than we do and live in other dimensions as a consequence. Elephants can feel vibrations that are of much lower frequency than we can and many insects can see in the infra-red and ultra-violet spectrum. Sharks can detect small fluctuations in electricity and birds can sense fluctuations in gravity. Language is another source of difference in dimension. One culture or language may represent colours in a different way that another. Japanese has two words for blue compared to our own. Their rainbow has a blue and light blue region that are each the same size as “blue” in English – we see blue as a wider part of the rainbow because we have less rainbow colour words than Japanese. In science, we like things to be objective, repeatable and measureable. After all, this is how so much progress has been made by our species. Through idealisations, we can eliminate subjective or relative aspects so that we can compare the effect of changing one

parameter at a time. But, as we know, this is, and always will be, only an approximation of reality. It is the price we pay for being able to build models.

Mathematics, unlike the physical sciences, has the luxury of pure abstraction. Ironically, the theoretical tools it has created provide the language and syntax needed by subjective approaches to dimension. Dimension to a mathematician means orthogonal – i.e. each higher dimension is perpendicular to the lower one(s). A point is zero dimensions, 0D. But slide the point along an axis and you get a 1D line. Translate the line in a direction 90 degrees to the line and you get a 2D rectangle. Drag the rectangle vertically and you get a 3D cuboid. See? It doesn't have to stop there either! Mathematicians deal with infinite spaces or nD (n-dimensional where n is a positive integer 0,1,2…) spaces as comfortably as Chinese people use chopsticks to eat. All cubes, for example, of dimension >3 are called hypercubes. Logically, there are also hypercones and hyperspheres. You can watch an animation of a hypercube to see if you can visualise it. The good news is that higher dimensional spaces can be drawn even thought they are harder to envision.

And then there are the non-integer dimensional spaces called fractals – FRACTional dimensionALS. The idea is not so bizarre as it sounds. Imagine a ball of string. The 1D string (a line) winds around following a crazy path on a 2D surface until it ends up almost filling a volume in 3D space. When viewed from far enough away, you can't see the gaps between the strands and it appears as a flat 2D disc. But, we know it actually is ball-like and occupies a large fraction of a spherical region of 3D space. It's actual dimension is therefore between 2 and 3 depending on how much of the volume it fills. The surface of the lungs almost entirely fills a volume and has been measured at 2.97D. Likewise, a coastline is a 1D line that fills a proportion of 2D space (an area) and we would expect it to have a dimension somewhere between 1 and 2. The coastline of Great Britain, for example, has a measured fractal dimension of 1.25D while that of Norway is 1.52D. Mathematicians are compiling a list of the fractal dimensions of various shapes. Space-filling curves, areas and volumes are everywhere. There is an algorithm called the Minkowski-Bouligand box-counting algorithm for calculating the fractal dimension of objects like balls of string, clouds, mountains or even clusters of galaxies.

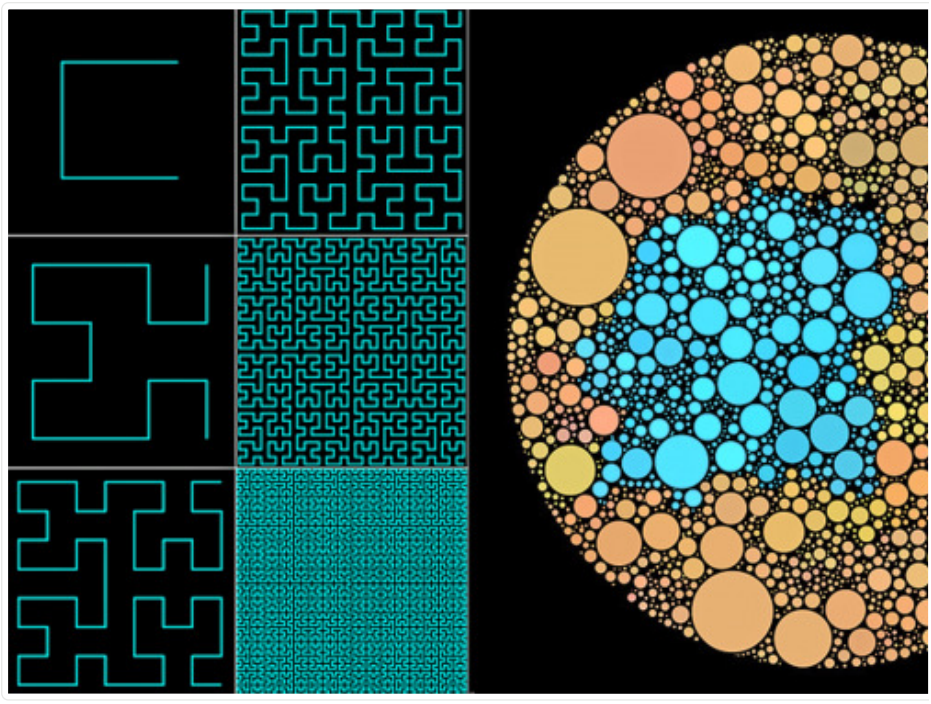

Image Credit: *Michael Taylor*

But, it is in the realm of particle physics and cosmology that higher spatial dimensions really have found their place. After the German mathematician Felix Klein first discovered in 1882 how to construct and embed in nD-space, a single-sided surface! It is interesting that the Klein Bottle was discovered only 11 years after Lewis Carroll published *Through the Looking-Glass, and What Alice Found There* (1871). In theoretical physics, an *Alice Universe* is a hypothetical universe with no global definition of charge. What a Klein bottle is to a closed two-dimensional surface, an Alice universe is to a closed three-dimensional volume. The upshot of this is that an Alice universe allows for two topologically-distinct routes between any two points (it is doubly connected) – one is a normal spatial connection, the other is a wormhole. Once these two connections are made, it is impossible to distinguish between matter or antimatter because, just like the Möbius strip, once the two distinct connections have been made, we can no longer identify which connection is “normal” and which is “reversed”. A particle might appear as an electron when viewed along one route, and as a positron when viewed along the other. You can see a wonderful video of a cyclist traversing a Klein Bottle thanks to the work of Berkeley university mathematicians.

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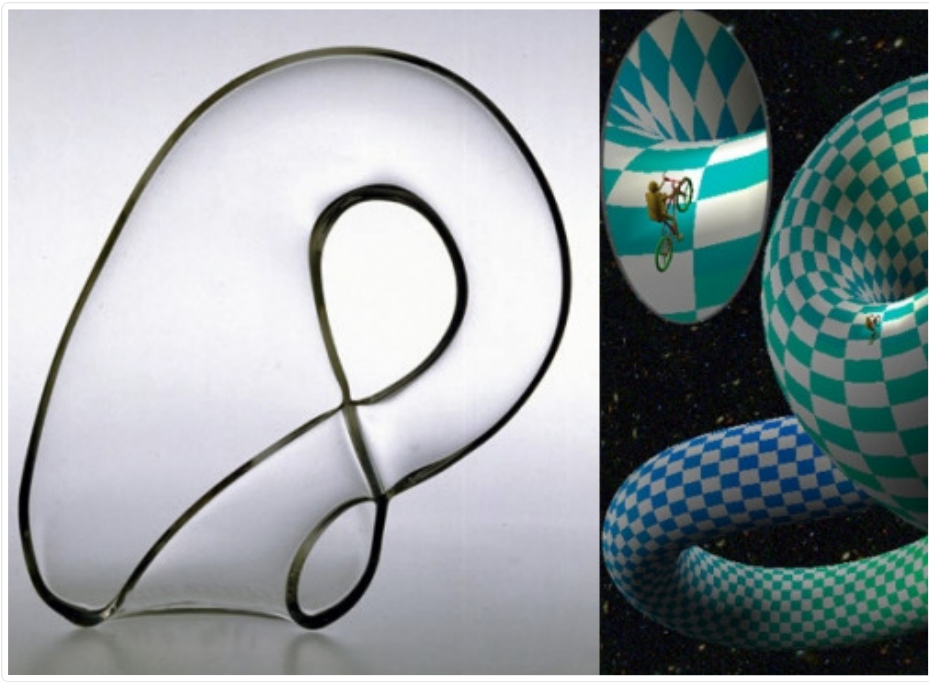

Image Credits: *Alan Bennett & Nerius Landys and Shad Roundy of the Klein Bottle Project (University of California, Berkeley)*

Particle physics theories like string theory and M-theory go even further and have introduced 10 and 11 dimensions with the extra dimensions being spatial. While it has been suggested that while the extra dimensions are “curled up” on the subatomic scale (possibly at the quark/string level of scale or below), not a single physical experiment has confirmed the existence of spatial dimensions beyond 3. Here, the mathematics definition of dimension based on orthogonality helps us through the maze of confusing concepts like “parallel” universes. Philosopher Immanuel Kant offers words of wisdom that we shouldn’t so easily forget,

> *That everywhere space (which is not itself the boundary of another space) has three dimensions and that space in general cannot have more dimensions is based on the proposition that not more than three lines can intersect at right angles in one point. This proposition cannot at all be shown from concepts, but rests immediately on intuition and indeed on pure intuition a priori because it is apodictically (demonstrably) certain — Immanuel Kant, Prolegomena, § 12 (1783).*

Two of the best introductions to visualising and perceiving dimensions are the 1884 novel *Flatland* by Edwin Abbott and Rudy Rucker’s *The Fourth Dimension*. Fascinating reading!

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I would also highly recommend seeing the following videos *Imagining the Tenth Dimension* Part I and Part II. One place where higher dimensions uses the mathematical construct is statistics. In particular, when mining for parameters associated with a set of data, independent variables are identified by principal components analysis as lying along different orthogonal axes.

So, while mathematics, physics, statistics and the social sciences are making huge advances in our understanding of dimensions, the question still remains: how mnay dimensions is your world? It seems that the world of particles is very different from the world of people. The use of descriptive dimensions like colour and flavour, while present are less than our subjective human reality it seems. While the search is still on for the dimensionality of the universe, there is one thing that is less clear (at least to me) – and that is our own sensory perception of dimensions. How many each individual perceives seems to vary a lot. Whatever the answer is for, may you experience many and mysterious dimensions, and may they fill yours senses.

11D , 4D , higher dimensions , hyperspace , Klein bottle , M-theory , Rudy Rucker , string theory , synaesthesia

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5) the Oakland Athletic outfield baseball player
6) the former Executive Vice President of Atomic Energy Canada Limited
7) from Ossett with alleged demonic possession
8) the discoverer of Hyperion, the tallest tree in the world
9) the co-producer of Battlestar Gallactica
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