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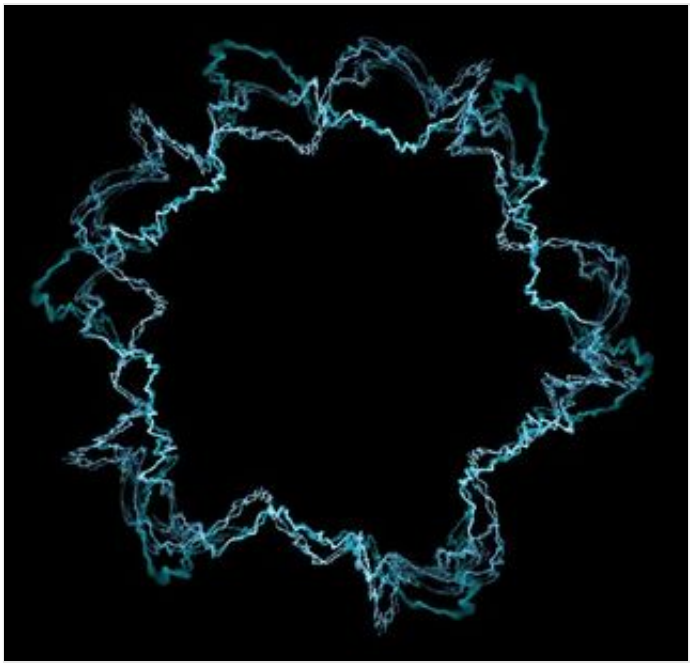
What a Few Extra Dimensions Can Do

by Tasneem Zehra Husain



In today's world, no matter what you do, success seems to depend on how you project and market your 'brand'. Surrounded constantly by advertisements, full of startling images and clever one-liners, it is only natural that most of us adopt the same vocabulary; painstakingly, we hone our physical and digital selves to come as close as possible to magazine perfection. When we practice our elevator pitches, we cast around for the catchiest phrases - those that will have the maximum staying power. As a theoretical physicist, I find myself quite at odds with this social phenomenon. When asked to describe the work that obsesses my thoughts, I have often caught myself searching for the mildest words I could possibly use in a given context. For instance, when I talk about the 10 dimensional space-time mandated by superstring theory, I will never refer to the invisible (or unfamiliar) six as 'higher' dimensions, but instead by the physicists' preferred term of 'extra' dimensions.

At first, it might seem like I am merely splitting hairs, but if you think about it, the word 'higher' carries connotations of hierarchy - as if there are some dimensions that are more exalted than others. 'Extra' sounds - to me, at least - far more down to earth. It is a matter-of-fact way of referring to something that is left over - in this case, from the visible world.

It was an unconscious reflex, this definite preference for one term over the other, but even as I first became aware of it, I knew instantly why it was so important to me. The ideas I deal with are so far removed from every day experience, that they can quite easily be made to sound fantastic. It takes very little skill to package them as exotic, almost mystical, phenomena bordering on the supernatural. But these ideas are worthy of more. They deserve to get attention not for their sensational packaging, but for the depth and beauty of what lies within.

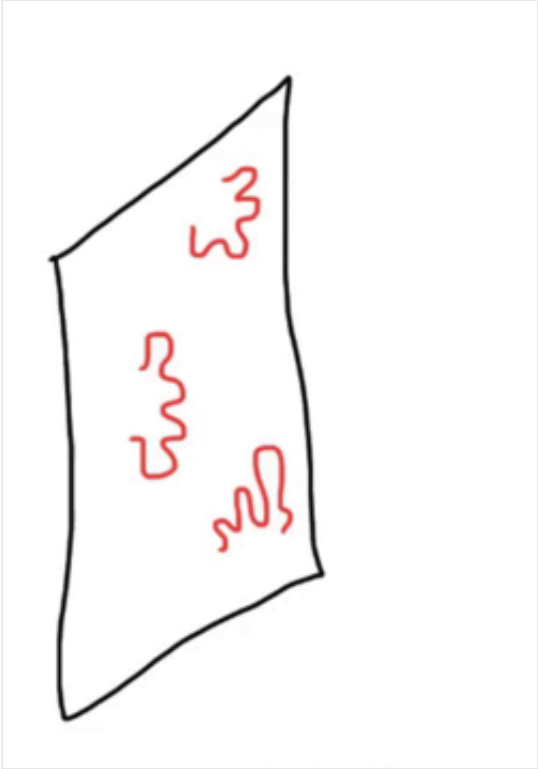
And so, with that long preamble, let me now introduce you to these extra dimensions.

Superstring theory has been called the holy grail of physics, because it performs the theorist's ultimate objective of reducing the multiplicity of phenomena in this vast universe down to a single cause. The rich diversity of matter and forces we perceive, are merely the manifestations of the range of motion of quivering, fluttering, infinitesimal strings. The modes of oscillation of a string appear to us as distinct particles, and the gymnastics strings perform, as they split and recombine, are interpreted by us as particle interactions. Since string theory reduces all we know to a common origin, it also - as a corollary - unifies general relativity and quantum mechanics, two theories that were wildly successful on their own, but had been thought for decades to have ‘irreconcilable differences'. The price string theory demands in return for executing this coup, is that it must live in ten dimensions. The mathematics is simply inconsistent otherwise.

The problem with this, of course, is that we see only four - three spatial dimensions, and time. What happens to the rest? One explanation as to why we do not perceive the other six, is that for some reason, they are not accessible to us. But since this is science, and not a circus trick, a mere sleight of hand won't do. Physicist are imaginative, not gullible. If we are to accept that these extra six dimensions are there, their presence must serve a purpose. They must make possible that which, in their absence, would remain inexplicable. And they do.

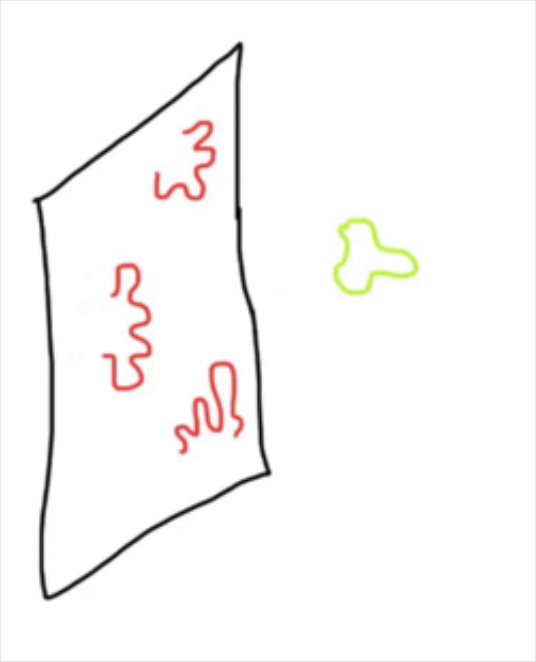
In fact, the existence of these extra dimensions could solve a mystery that has confounded us for a very long time: the so-called hierarchy problem. There is a ridiculously large discrepancy between the strengths of the four fundamental forces - gravity, electromagnetism and the strong and weak nuclear forces. Of them all, gravity is by far the weakest. That might seem counter-intuitive, because gravity is the force we are most aware of. It keeps us rooted, and pegs the planets in orbit around the Sun; but the fact remains that gravity is inexplicably feeble. To gain an appreciation of how lop-sided the situation is, consider this: the electromagnetic repulsion between two electrons is one hundred million trillion trillion times stronger than their gravitational attraction. The nuclear forces are even stronger, but they are far closer in scale to the electrostatic force than it is to gravity. The fact that gravity is separated from the other forces by such a large gap in their relative strengths, seems rather ad hoc - until you buy into the concept of extra dimensions, where there is a rather neat solution to the problem.

In string theory, the strong, weak and electromagnetic forces are described by so-called open strings, (which can be pictured as little shoelaces, with definite end-points) whereas gravity is mediated by closed strings (little rubber band like loops). String theory also contains objects known as branes - hyper-dimensional membranes that trap the end points of open strings, almost as if these end-points were magnetic, and the brane were a refrigerator door. These end-points can move freely along the extent of the brane, they just can't be lifted off it.



Open Strings on Brane

In this set-up, the weakness of gravity comes about quite naturally. Suppose we live on a brane that spans a four-dimensional slice of space-time. For starters, this explains why we see the world as we do. Also, since the nuclear forces and electromagnetism are described by open strings, which are constrained to live upon the brane with us, we feel their full impact. Gravity, however, being carried by closed strings, can wander off into the extra dimensions (or what is called the 'bulk'), and so we sense only a fraction of its effect. In fact, if we were able to view the situation from a proper ten-dimensional space-time point of view, we would find that gravity is not weaker in the absolute - it just appears that way to us, from our limited perspective here on the brane.



Gravity Escapes Brane

This ‘brane world' scenario is just one of the ways in which extra dimensions could be realized. Various other models have also been proposed. These vary widely in their particulars, but on one point they are unanimous: even though the extra dimensions themselves are not directly visible, they should have tangible, observable manifestations. Some of the predictions made by these models might perhaps be testable at the LHC, once it turns on again this Spring, at higher energies than before. In its previous run, the Large Hadron Collider brought us proof of the existence of the long postulated Higgs Boson. In a few months, it might begin to probe dimensions thus far hidden from view.

When you realize that these are the issues under consideration, it no longer seems surprising that theoretical physicists are conservative in their choice of words. When the truth itself is so mind-blowing, no fanfare is needed.

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