

# Transcript

## Gravity and Branes

A few introductory words of explanation about this transcript.

This transcript includes the words sent to the narrator for inclusion in the latest version of the associated video. Occasionally, the narrator changes a few words on the fly in order to improve the flow. It is written in a manner that suggests to the narrator where emphasis and pauses might go, so it is not intended to be grammatically correct.

The Scene numbers are left in this transcript although they are not necessarily observable by watching the video.

There will also be occasional passages in blue that are NOT in the video but that might be useful corollary information.

There may be occasional figures that suggest what might be on the screen at that time.

### **105 Intro**

Why is gravity so weak? Why can a small magnet pull or push something away from the entire earth?

There IS an idea that may explain it, but before we go there, let's explore some preliminary ideas.

The most popular quantum gravity theory of today describes all fundamental particles as vibrating strings of energy. And the theory is constructed in a whopping nine or ten spatial dimensions instead of the three that we experience in our everyday lives.

### **110 Dimensions**

But what is a dimension?

A line is a familiar geometric figure. It can be completely described by giving its length. It is a one-dimensional object. It can be imagined that the dimensionality of an object can be created by taking an object of one less dimensions and moving it at a right angle to that dimension. You can create a line in your imagination by thinking of taking a point and moving it.

Next consider a SURFACE...

A surface is also quite familiar. A surface has both length and width and requires two measurements to define it and therefore is a two-dimensional object. Similar to the generation of a line from a point, we can generate a two-dimensional surface by taking a line and moving it in a direction other than the direction of its length.

And a SOLID figure is the stuff of everyday life. It has length and width and depth and requires three measurements to describe it, and is a three-dimensional object. And like the generation of a surface from a line above, we can generate a three-dimensional object like a cube by taking a square and moving it in a direction other than the directions of its length and width. Cylinders, cubes, and spheres are three-dimensional objects.

And now the hard part... the higher dimensions are created by moving a three-dimensional solid in a direction OTHER than its length, width or height. And while that is easy to do mathematically, it is IMPOSSIBLE for us to picture it.

### **115 Intensity**

So let's examine how we might detect these other dimensions. We begin with a bright light spreading out in a spherical shell. The intensity of the light at any one point will fall off as the square of the distance from the source, because the surface that the light covers grows as the square of the distance from the source.

But that is only true in three-dimensional space. In four-dimensional space, the light will grow dimmer as the cube of the distance and in five dimensions it will grow dimmer as the 4-th power of the distance. And in ten dimensions, it will grow dimmer as the 9-th power of the distance.

### **120 Strings**

Now back to strings

If this membrane represents the three dimensions that we live in, then particles like quarks and electrons are strings that have their endpoints forever attached to those three dimensions. They might look like this.

But the particle that is the force carrier for gravity, the graviton, is a closed loop. It has no ends that are constrained to our three dimensions. So if there are other dimensions, gravity will propagate freely there as well as in our familiar three.

And THAT might explain why gravity seems so weak to us. We experience only a tiny fraction of gravity's true strength because so much of it is leaking out into the other dimensions!

### **125 Hiding Dimensions**

But where are these dimensions hiding?

One possibility (but not the only one) is that they are all around us but are incredibly tiny.

If you look at a wire or a string from far enough away, it looks like a line...a one-dimensional figure. But if you get closer or if you were a lot smaller than the thickness of the wire, then you would easily see that it has other dimensions.

On the tiniest of scales, space has extra dimensions at every point. It might look something like this if we were small enough to see it.

### **130 LHC**

Accelerators like the LHC at CERN smash protons against anti-protons at enormous energies... perhaps enormous enough to produce gravitons. And if they do, then perhaps we might just be able to see them form in our limited three-dimensional world and slip quickly and quietly away into those hidden dimensions!