Questions and conjectures

We have reviewed key ideas in string theory as exposited by some of the leaders in the field. I've puzzled over them, tried to deconstruct the mathematical logic, tried to understand. Every now and again, I've thought some new thoughts – well, notions that I haven't seen in the books or lectures or papers. Most likely, they've been proposed and rejected. Such ideas don't get published. But maybe they're worth writing down, just in case they light a new path. Not likely, but maybe.

Here are some of the questions.

What's driving universal expansion? What is it out there in the microscopic structure of spacetime that's pushing and shoving? What is it filling in the voids? If everything is string, it must be strings at work.

Two possibilities come to mind. Maybe it's extra dimensions unfolding. Or maybe it's strings unraveling. Or maybe the two are the same.

We've studied strings as if they exist on a background coordinate system. If we give it a name, that coordinate system must be spacetime. But if all is string, spacetime must be stringy stuff. Maybe those compactified dimensions are branes. Look at the projections of Calabi-Yau space for example. It's not too hard to imagine that those surfaces are branes, and where there are branes you can attach and embed strings.

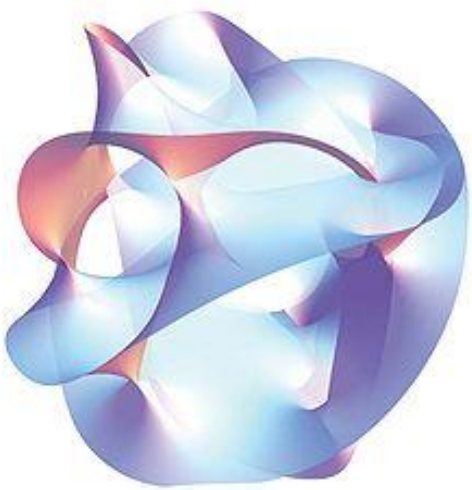

Figure 36.1. Two-dimensional hypersurface of the quintic Calabi-Yau three-fold. Created in Mathematica by J. Bourjai. Wikipedia public domain.

Calabi-Yau manifolds are multidimensional conformal invariant topologies, as required of strings. A simpler conformal invariant, and simpler in our present argument, is the torus. Unwrap a torus, the stuff of spacetime, and spacetime extends. It's still the same stuff. Same strings. But no longer wrapped and shrunk into those hidden dimensions.

To put some math behind it, looky here at the scale factor as a function of string parameters. We've shown that

$$a = e^{Ht} \tag{36.1}$$

From the field equations,

$$\left(\frac{\dot{a}}{a}\right)^2 = H^2 = \frac{8\pi G}{3}\rho_{vac} \tag{36.2}$$

From dimensional analysis and the logic of interaction coefficients

$$G = {l_P}^2 = g^2 {l_s}^2 \tag{36.3}$$

Dropping constant coefficients,

$$H = \sqrt{G\rho_{vac}} = g l_s \sqrt{\rho_{vac}} \tag{36.4}$$

and

$$a = e^{g l_s \sqrt{\rho_{vac}} t} \tag{36.5}$$

This makes some intuitive sense. If the universe is made of strings, the scale factor should be proportional to the fundamental string length. Presumably vacuum density measures the density of compactified stringy stuff. The greater the density, the more branes and strings are available to change the scale. And check out the interaction coefficient. If $g = 0$ (no string interactions), the scale remains constant $a = 1$. Nothing changes. No string joinings or unfoldings, no unwrapping of the wrapped up dimensions. Dull place.

On the other hand, if g is large (i.e. approaching 1), then there's all kinds of activity out there in stringy spacetime. Wound strings might bump into each other, interact, and unwind, producing Kaluza-Klein strings. The reverse, i.e. K-K strings winding around a torus handle in just the right configuration to produce wound strings, seems less probable. Without wound strings, perhaps the compact brane can unfold. (Or are the hidden membranes just as likely to curl back under the influence of large g ? I'm not smart enough to figure it all out.)

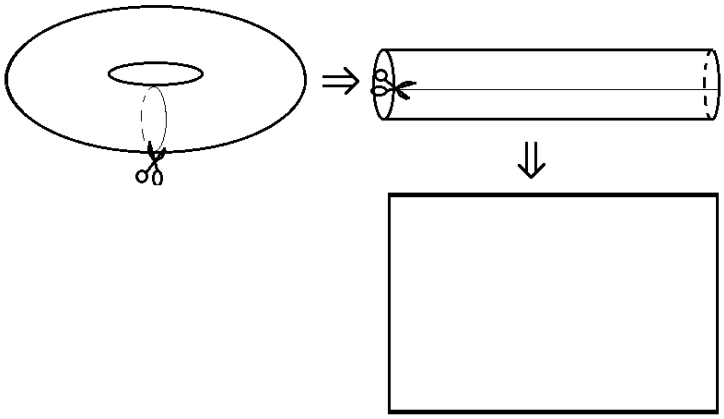

Figure 36.2. Without wound strings, perhaps the compact dimensions are more likely to unfold, expanding the larger spacetime in which they are embedded.

Come to think of it, maybe that's what's going on at the event horizon of a black hole, why we can describe a multi-dimension inside in a model with one less dimension – holography. Maybe that's really what happens at the horizon: one of the hidden dimensions unfolds at the horizon. Maybe the horizon is a phase transition from one multi-dimensional spacetime into another. Same physics – strings and branes and interactions and all – just unwound onto a broader surface.

And speaking of black holes, another question: what's the gravitational field inside a black hole? Depends, again, on the observer. Free-fall Alice drifts over the waterfall into the black hole, carried by spacetime. Outside, Bob sees everything piling up on the horizon. Stars and ironing boards and peanut butter sandwiches – everything glommed onto the event horizon.

Well, mass distributed uniformly in a spherical shell has net zero gravitational field inside. But, come to think of it, maybe Alice and Bob measure the same field after all. A free fall frame, no acceleration, has no field. Hmmm . . .

Next random thought. We live in a universe punched with holes, black holes, surrounded by a cosmic horizon with characteristics like the black hole event horizon. We're looking in on black holes, scattered around our Swiss cheese universe, at the same time we're looking out at a black hole. And all the while stuff is falling into the black holes and dark energy is filling spacetime as the universe expands, which then drops over the cosmic horizon . . . Maybe there's a connection between those horizons. Maybe some connections between the "holes" inside.

Simplify the structure. Consolidate all those black holes scattered around the universe into one. What is it? It's a sphere within a sphere, event horizon in the center, cosmic horizon out yonder. Does the topology of this system allow material falling into the black hole to re-enter the cosmic horizon? Can you turn this system inside out?

Finally (well, for now), is our multiverse fractal? Temperature fluctuations in the cosmic microwave background radiation appear scale invariant. Planets spin around stars spin around galaxies spin around galaxy clusters. Is it possible the Calabi-Yau Swiss cheese repeats at the

scale of black holes punching voids in our universe surrounded by a cosmic event horizon and repeats again at the scale of the multiverse punching universes in the bulk?

Stay tuned.

Vacaru, S. et al. 2006. Clifford and Reimann-Finsler structures in geometric mechanics and gravity. http://arxiv.org/pdf/gr-qc/0508023.pdf

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