12/6/06

Reading: Chapter 12 in the Book, revised posted chapters 13 (worm holes and time machines), 14 (quantum gravity, string theory, large extra dimensions).

Fourth SkyWatch extra credit due by this Sunday, December 10

Final Exam Information:

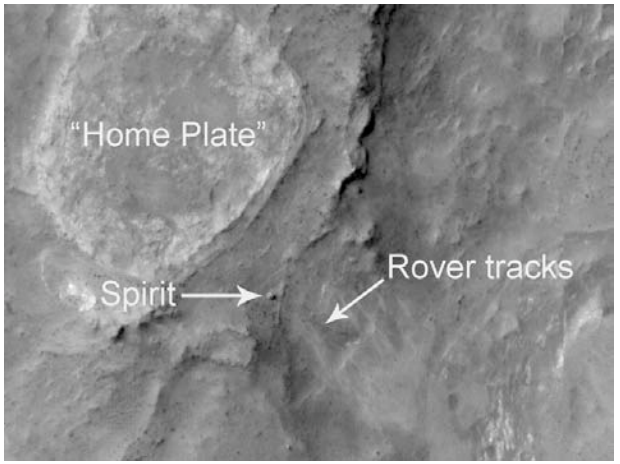
1 PM CLASS - MONDAY, DECEMBER 18, 9-12 AM, MEZ 1.306

2 PM CLASS - FRIDAY, DECEMBER 15, 2-5 PM, RLM 4.102

100 multiple choice questions,

News: NASA to put permanent base at South lunar pole

Pic of the day: Mars rover from orbit



Course survey is now available in the eCIS system at https://utdirect.utexas.edu/diia/ecis/

Should get automatic email

Experiment to do electronically

The University, the Astronomy Department and I all pay attention to these.

Please take the time to fill out the evaluation form.

Background - pre-Einstein late 19th, early 20th Century

Where does space curve to?

Riemann (1826 -1866), Lobachevsky (1792 - 1856)

Theory of curved space, non-Euclidian geometry

Notions of 4D hyperspace affected art/culture turn of 20th century

Tesseract - 4D hypercube (Elegant Universe link)

3D “unfolding” of tesseract in Salvadore Dali’s

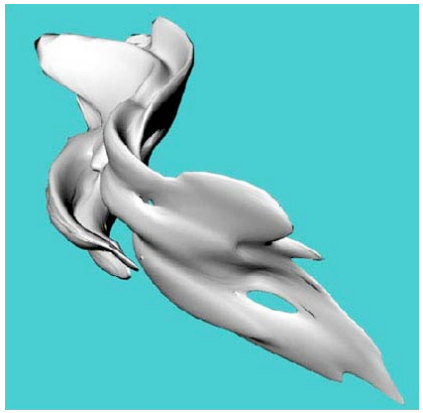
Crucifixion (Corpus Hypercubas)

Notions of seeing from different directions at once

Perspective of Cubism

Picasso -

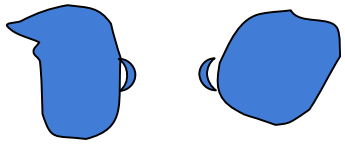
Deschamps - *Nude Descending A Staircase*



Contemporary Brazilian artist Marcos Novak -
3D projections of 4D objects

Hyperspace Perspectives (reflected in cubism?)

2D creature - another 2D creature sees the front



From 3D, we see front, back and ***inside*** simultaneously

In our 3D space we see the front of another 3D creature

A being living in a 4D hyperspace would see all of our surface, front and back, and our insides, all at once!

A 3D creature passing through a 2D Universe would start as a point, grow to a finite ***area***, then decrease to a point and disappear.

A 3D creature passing through our 3D Universe would start as a point, grow to a finite ***volume***, then decrease to a point and disappear.

Classic Quantum Theory

Particles are points (electrons) or are made up of point-like particles (three quarks in a proton or neutron), that also have wave-like properties.

Quantum view of forces - the quantum theory (mathematically) views all forces as resulting from an exchange of particles, with different exchange particles representing different forces.

Photons are the exchange particles for the electromagnetic force, other exchange particles account for the weak and strong nuclear forces.

String Theory

Best current candidate for a quantum gravity "theory of everything."

Particles like e-, p, n are not "points" but strings, loops that vibrate in different modes

The different modes of vibrations give all the well-known particles and ***more***

Download from "links" the recent editorial by Brian Greene on the status of string theory: The Universe on a String

Can't make notes with grains of sand, but with strings, you have Mozart

From Brian Green - The Elegant Universe

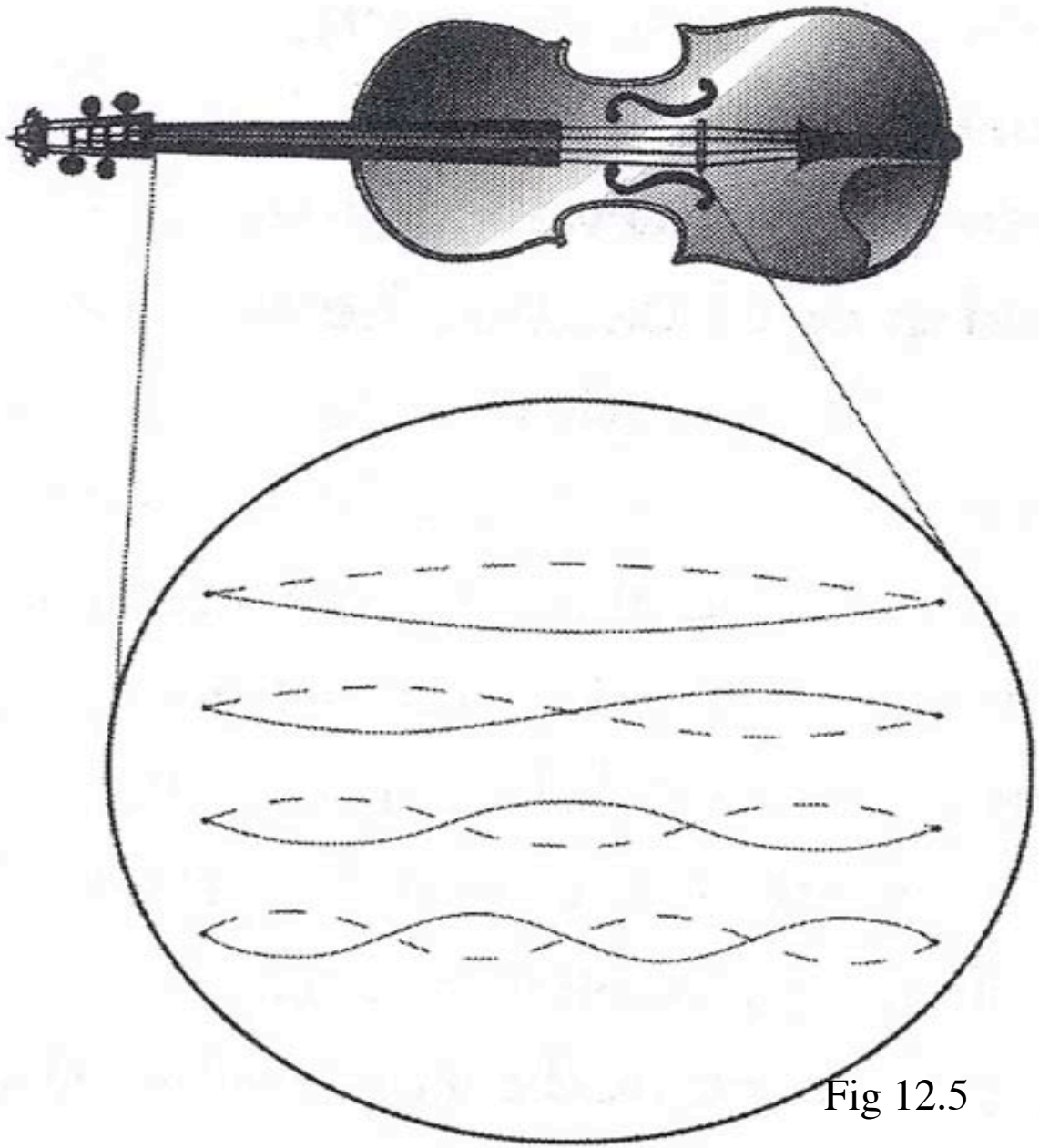
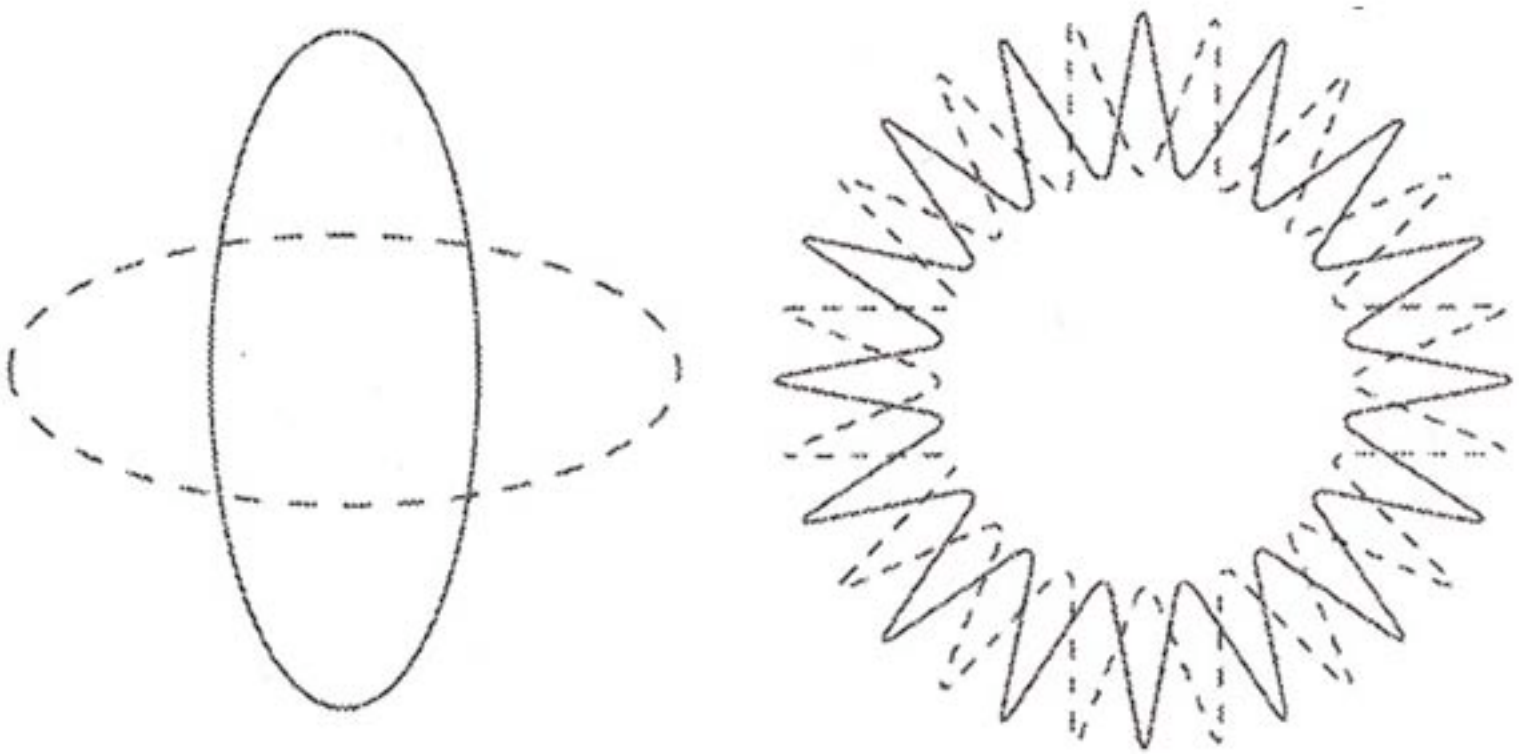


Fig 12.5

One particle

A different particle



Same fundamental loop of string

From Brian Green - The Elegant Universe

To be mathematically self-consistent

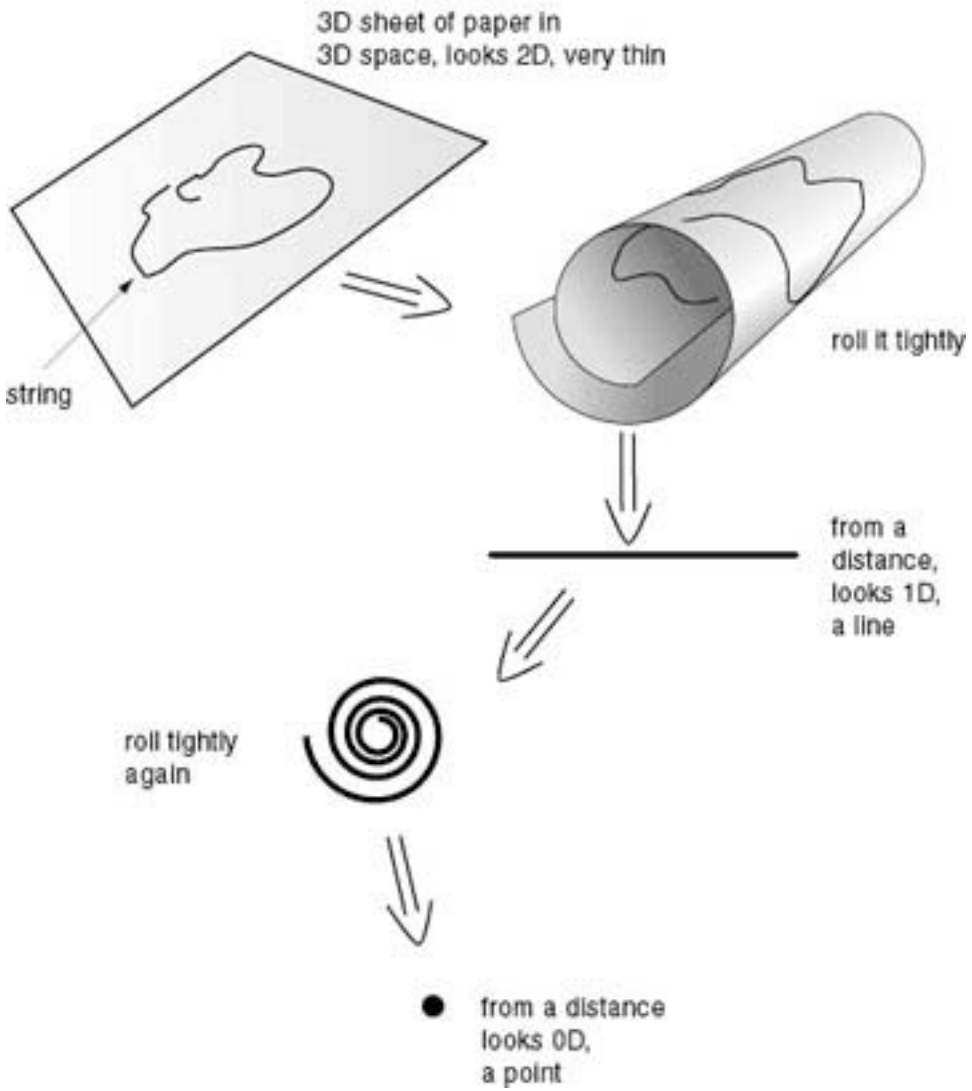
Space in which strings vibrate has ***10 space dimensions*** + time

First notions:
3 big space dimensions + time

Other 7 dimensions "wrapped up" on "string length scale," not known precisely, somewhat larger than the Planck scale, but very tiny so we cannot easily "see."

Rubber band - 1D, paper - 2D (wrap rubber band in paper, make 1D, 0D spaces still containing the rubber band)

Fig 12.3


3D sheet of paper in
3D space, looks 2D, very thin
string
roll it tightly
from a
distance,
looks 1D,
a line
roll tightly
again
from a distance
looks 0D,
a point

String Theory

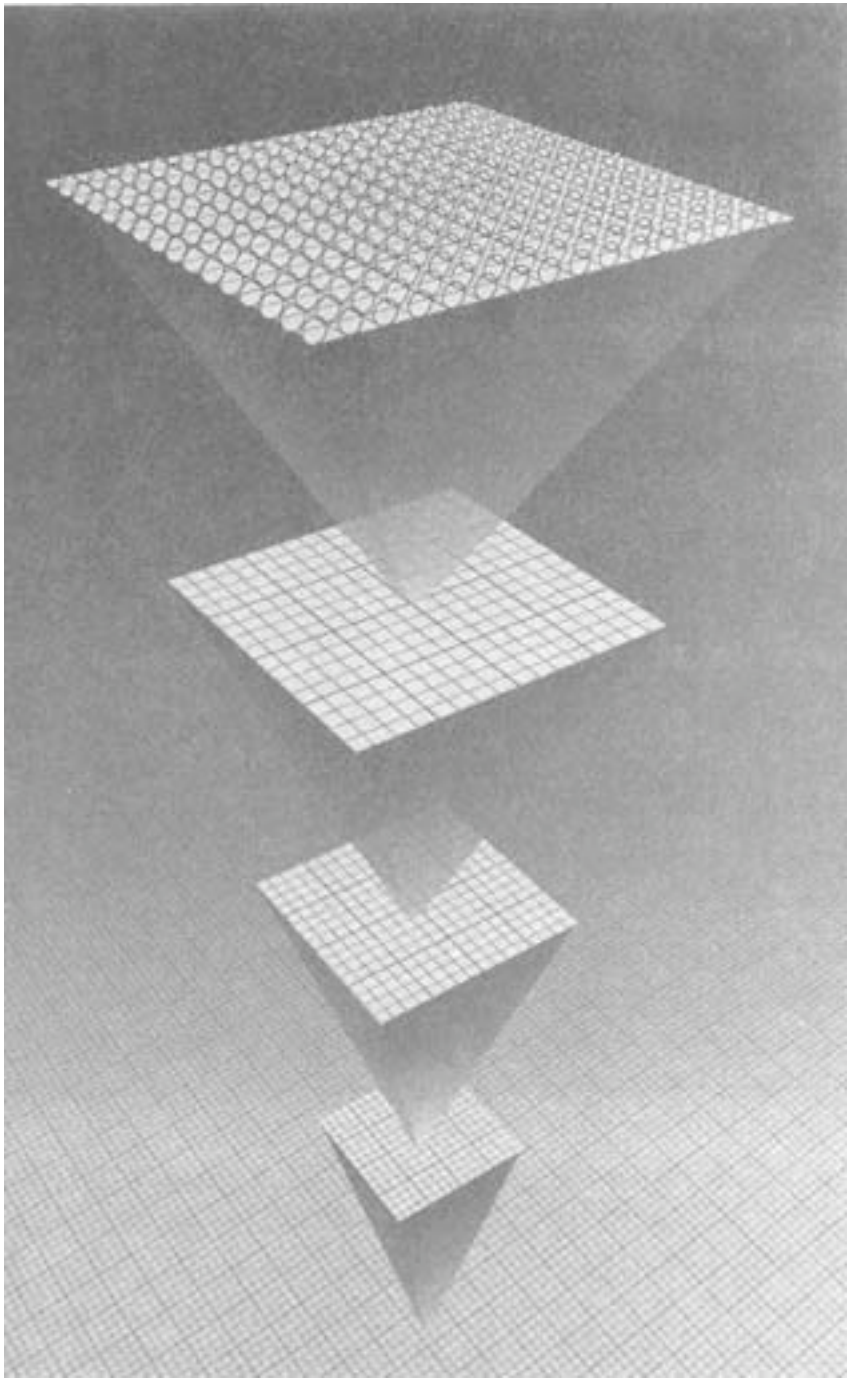
History - in 1960's physicists recognized that the equations corresponding to the strong nuclear force also described entities that could stretch and wiggle - strings

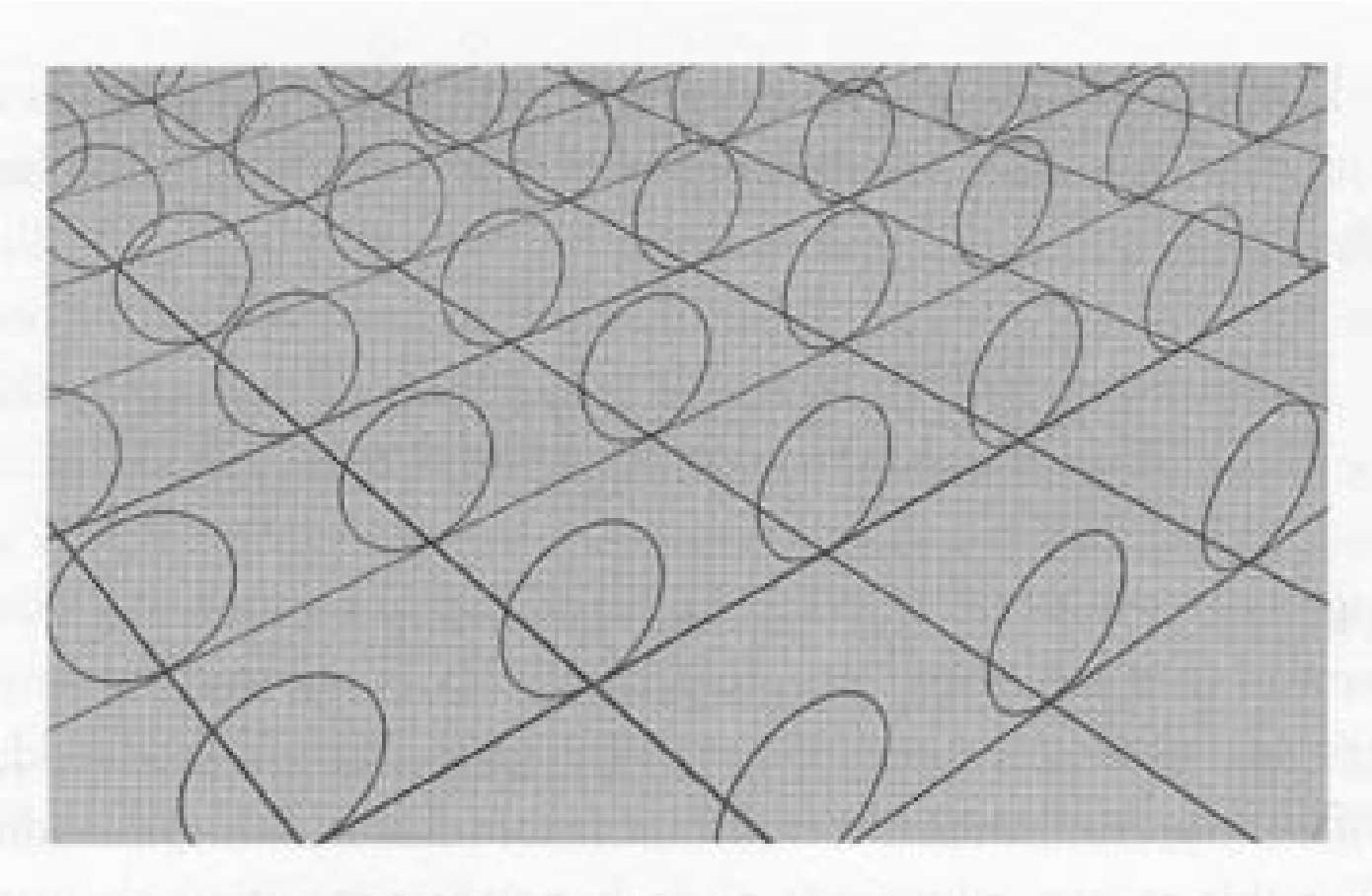
Space in which strings vibrate has ***10 space dimensions*** + time

Shape of wrapped-up space determines how strings vibrate, what particles they represent.

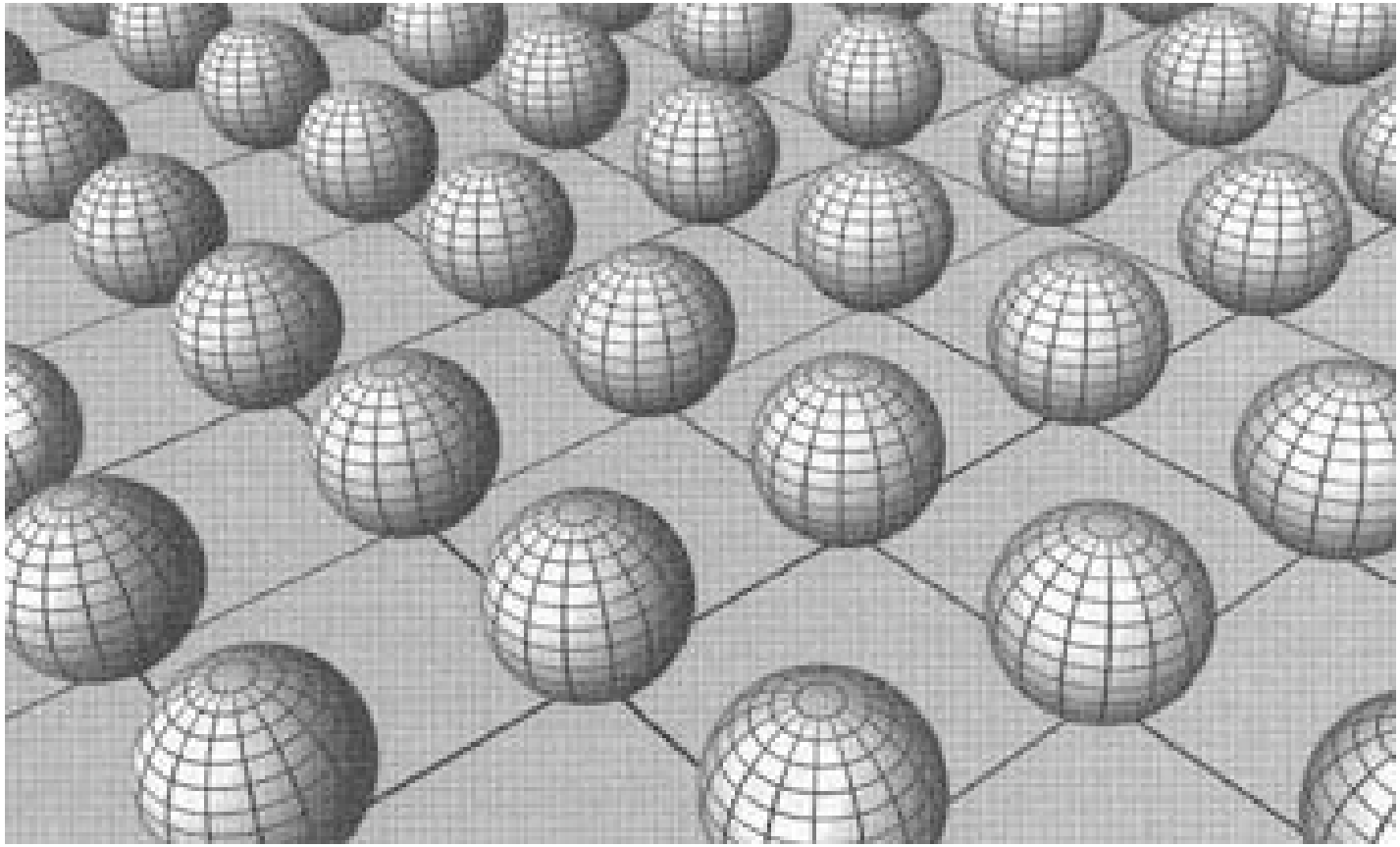
Schematic illustrations of how tiny “wrapped up” extra dimensions could be associated with our 3D space - something like an embedding diagram of the higher dimensional space, so our 3D space is reduced to 2D and the higher dimensional wrapped spaces are reduced to 3D.

From Brian Green - The Elegant Universe

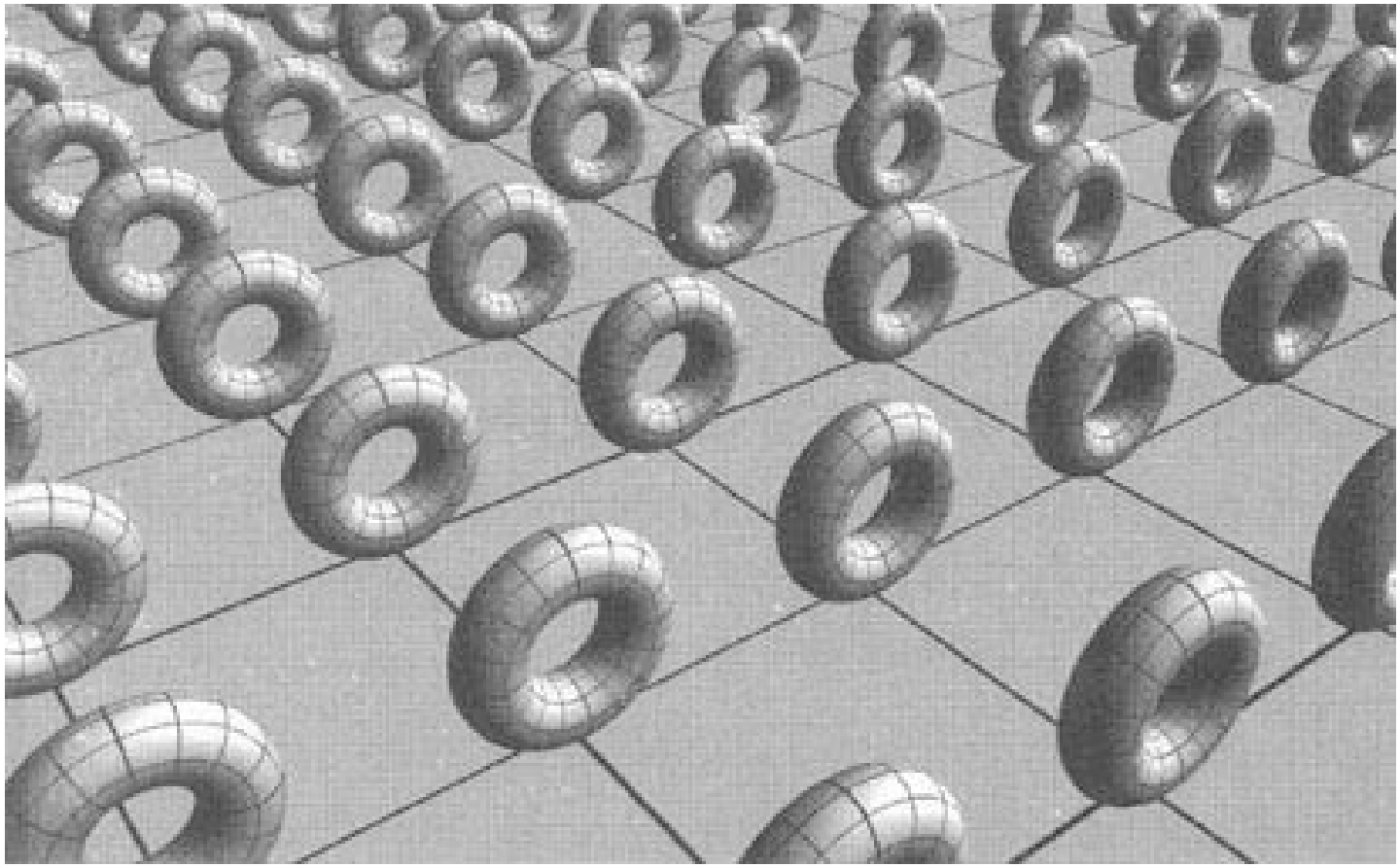




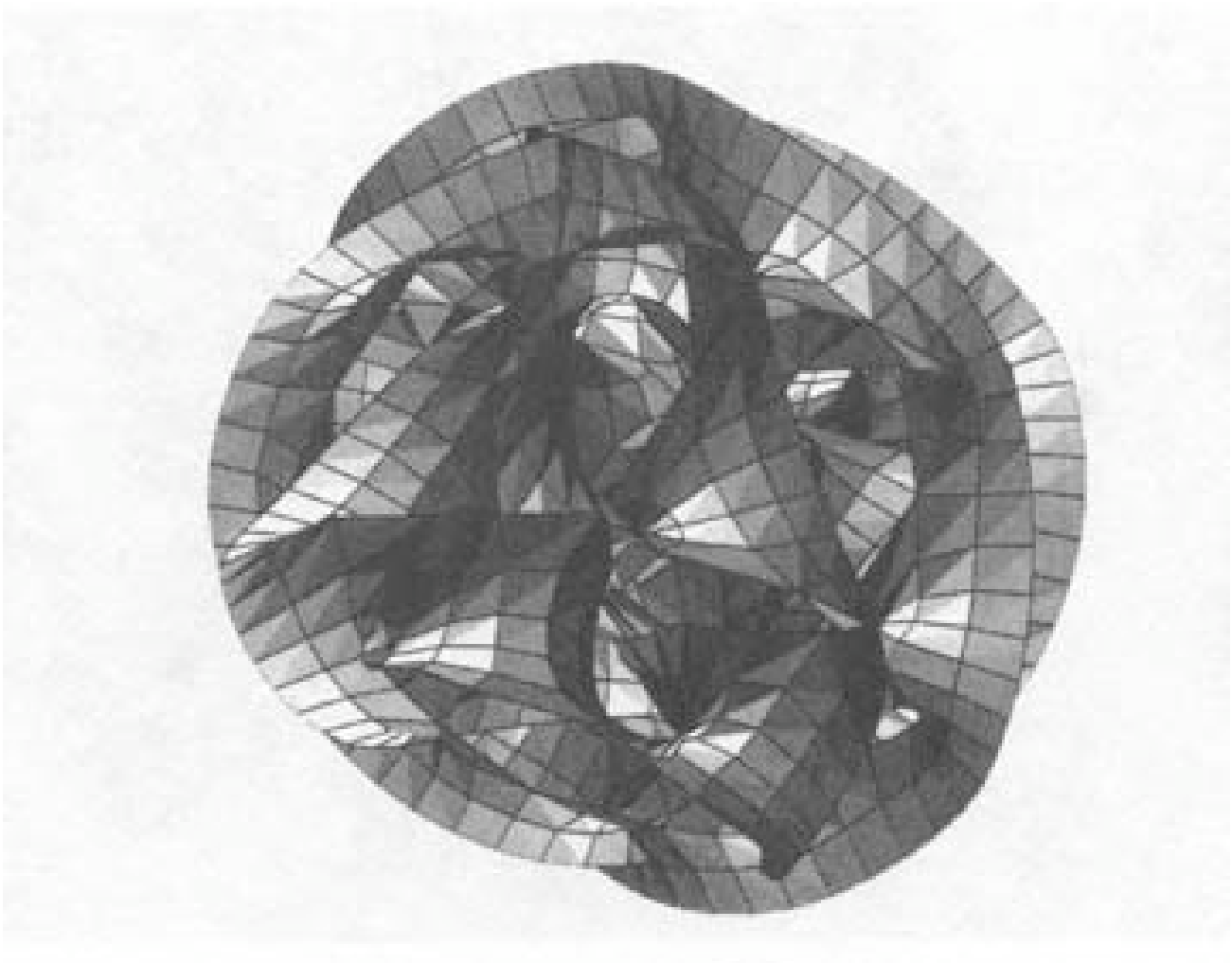
At each point in the 2D space (not just at the intersections of grid lines), there is a little 1D loop of one wrapped up extra dimension. From Brian Green:The Elegant Universe



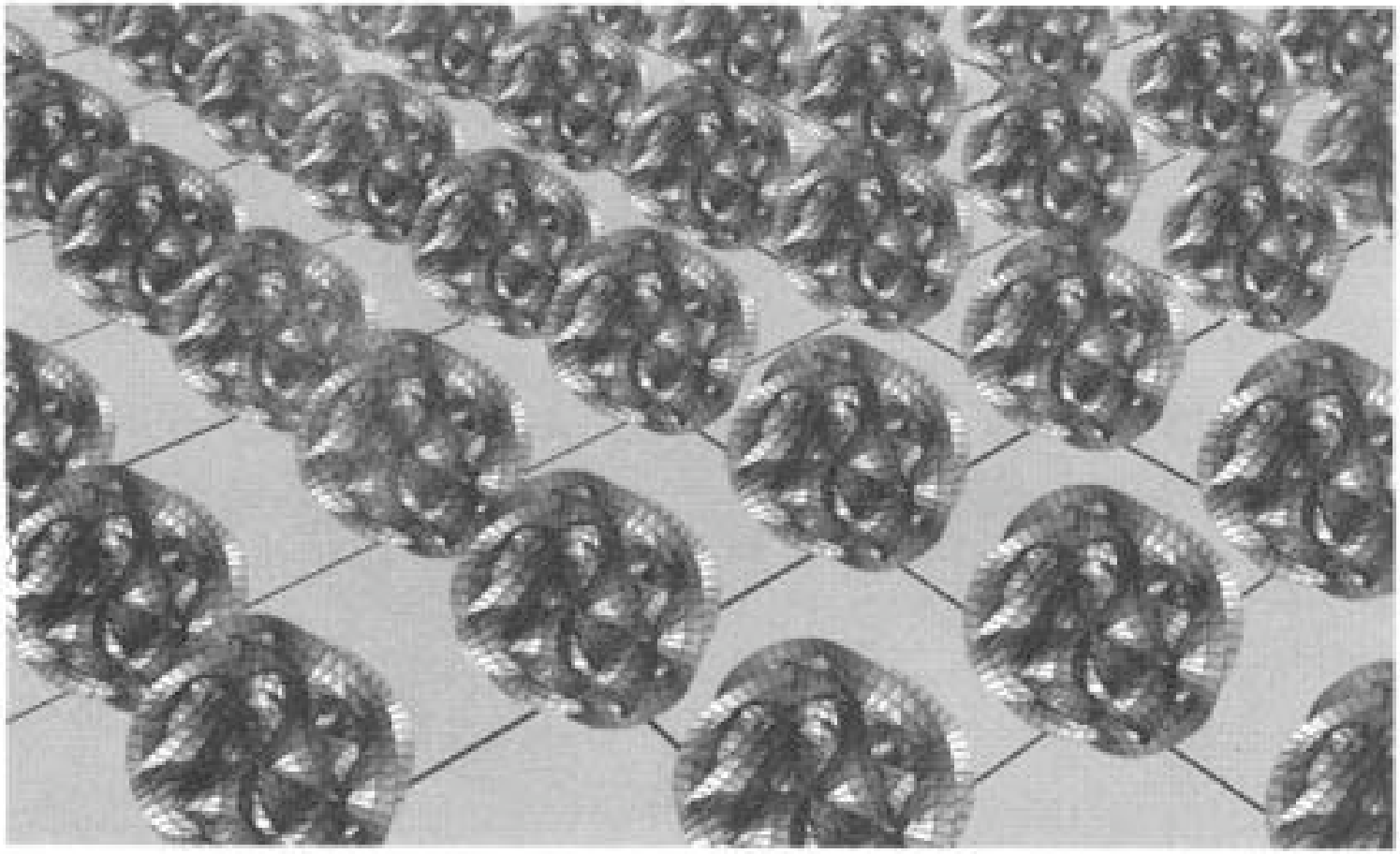
At each point in the 2D space (not just at the intersections of grid lines), there is a little 2D “sphere” of two wrapped-up extra dimensions. From Brian Green: The Elegant Universe.



At each point in the 2D space (not just at the intersections of grid lines), there is a little 2D “torus” of two wrapped-up extra dimensions. A torus has a distinctly different “topology” or “connectedness” than a sphere. From Brian Green: The Elegant Universe.



Representation of a Calabi-Yau space, with 6 wrapped-up extra dimensions. From Brian Green: The Elegant Universe.



At each point in the 2D space (not just at the intersections of grid lines), there is a little 6D Calibi-Yau space of six wrapped-up extra dimensions.
From Brian Green: The Elegant Universe.