

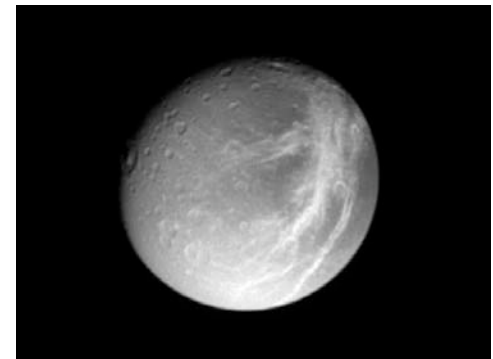
12/1/04

Final - Saturday, December 11, 7:00 PM

Painter Hall - 4.42 (NOT WELCH)

Review sheet for material since exam 4, will be posted this week.

Pic of the day: Saturn's moon, Dione



Extra credit sky-watch reports are due by 5 PM on Monday, December 6 (or earlier!!).

Office hours during finals week:

Dunham: M-F 3 - 5 PM (3 -4 Wednesday)

Wheeler: M-F 2 - 3 PM (or by appointment)

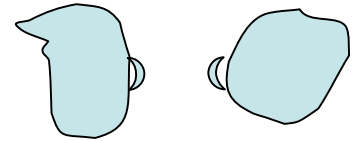
***Special Office Hours: RLM 15.216B***

***Tuesday 4 - 5 PM***

***Thursday 5 - 6 PM***

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.



## *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*

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

(or Tom  
Lehrer)

From Brian  
Green - The  
Elegant  
Universe

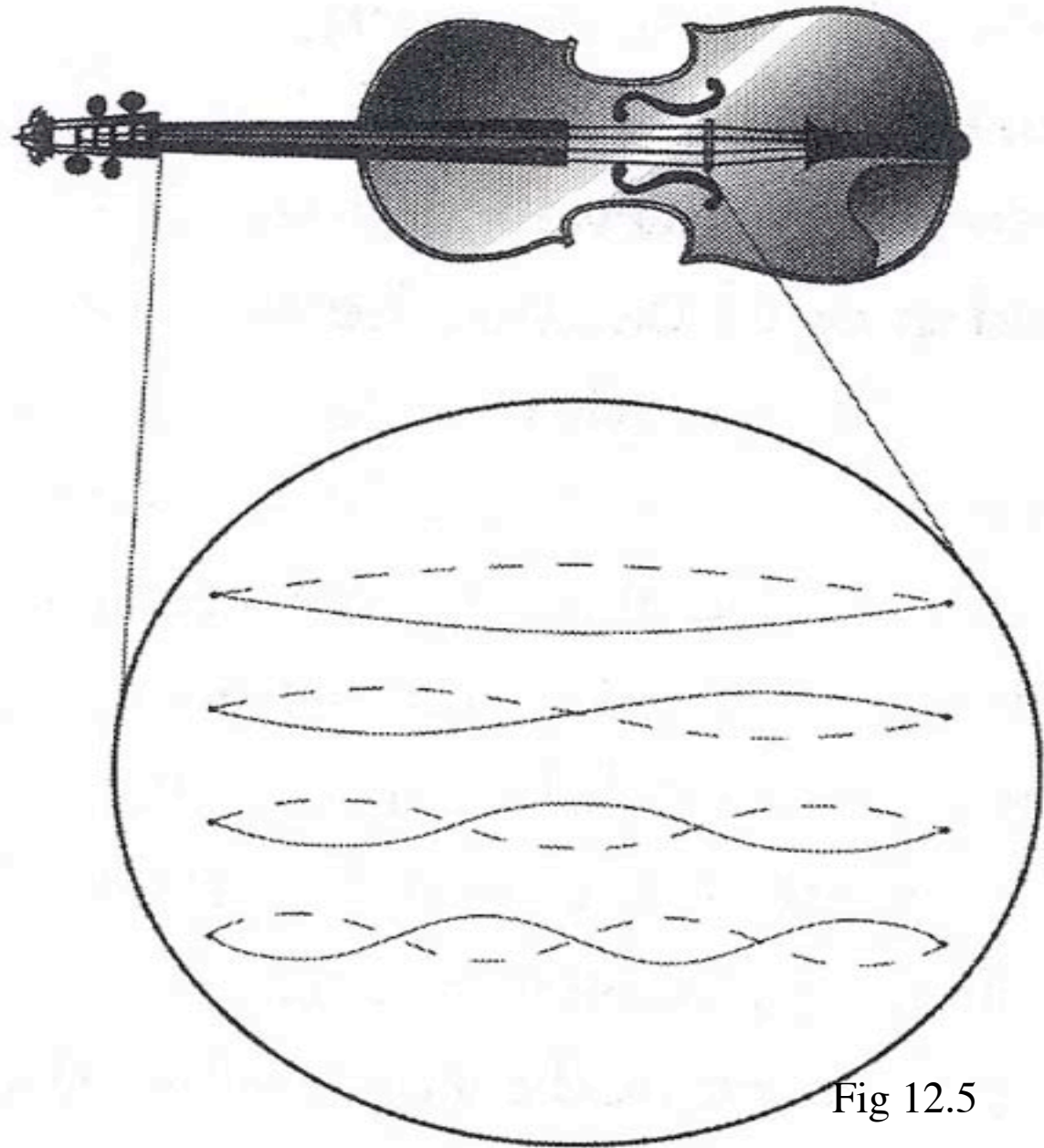
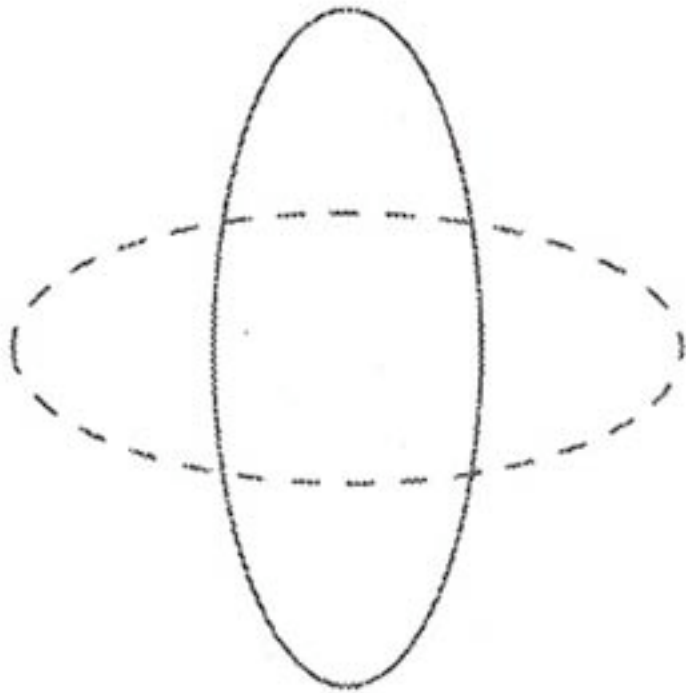
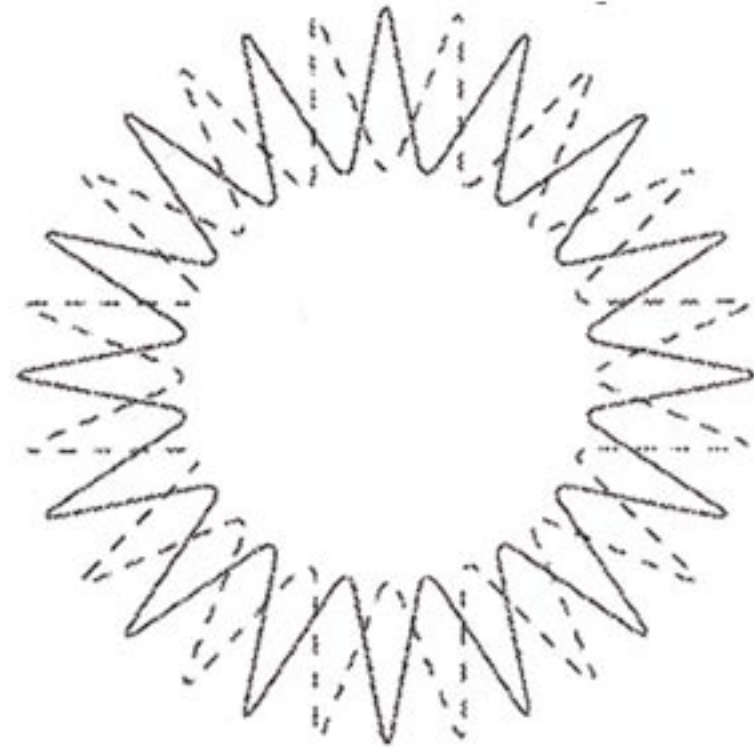


Fig 12.5

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

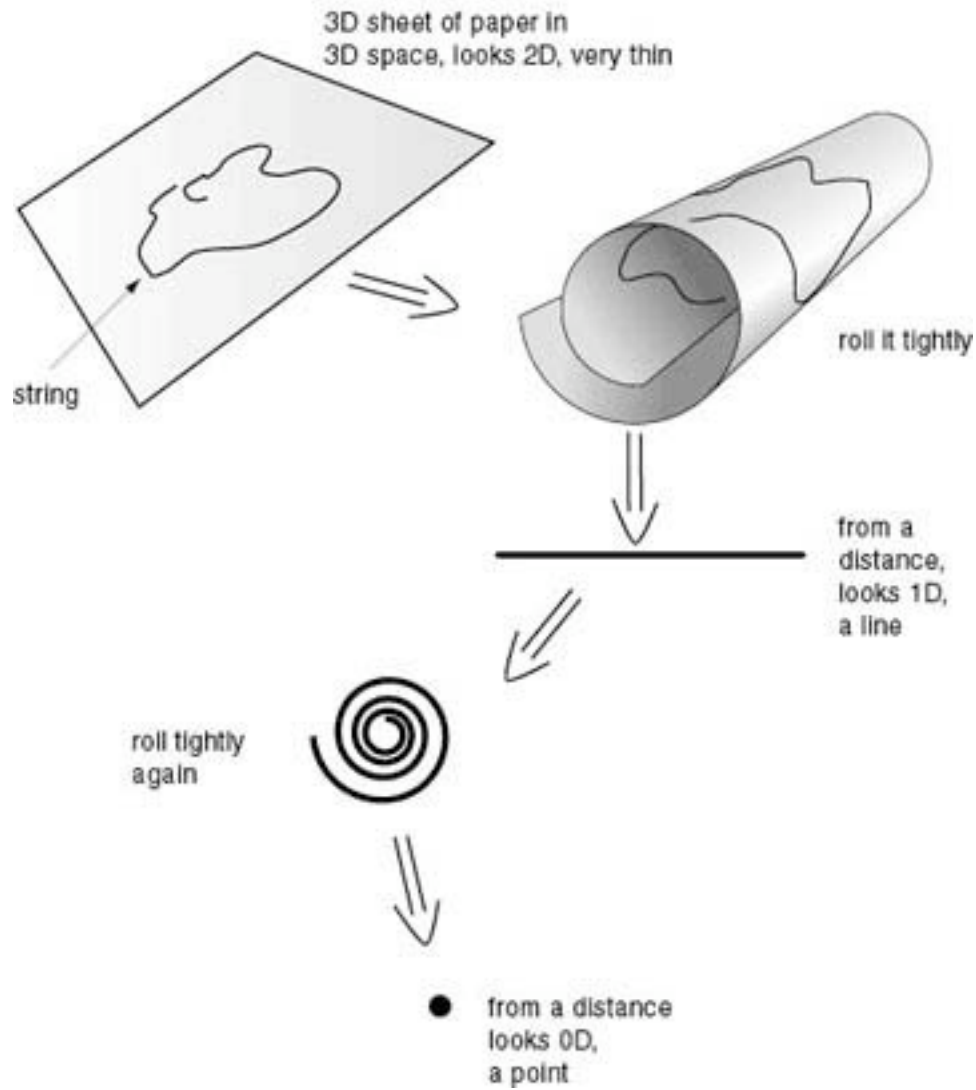
First notions:

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





To be mathematically self-consistent

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

First notions:

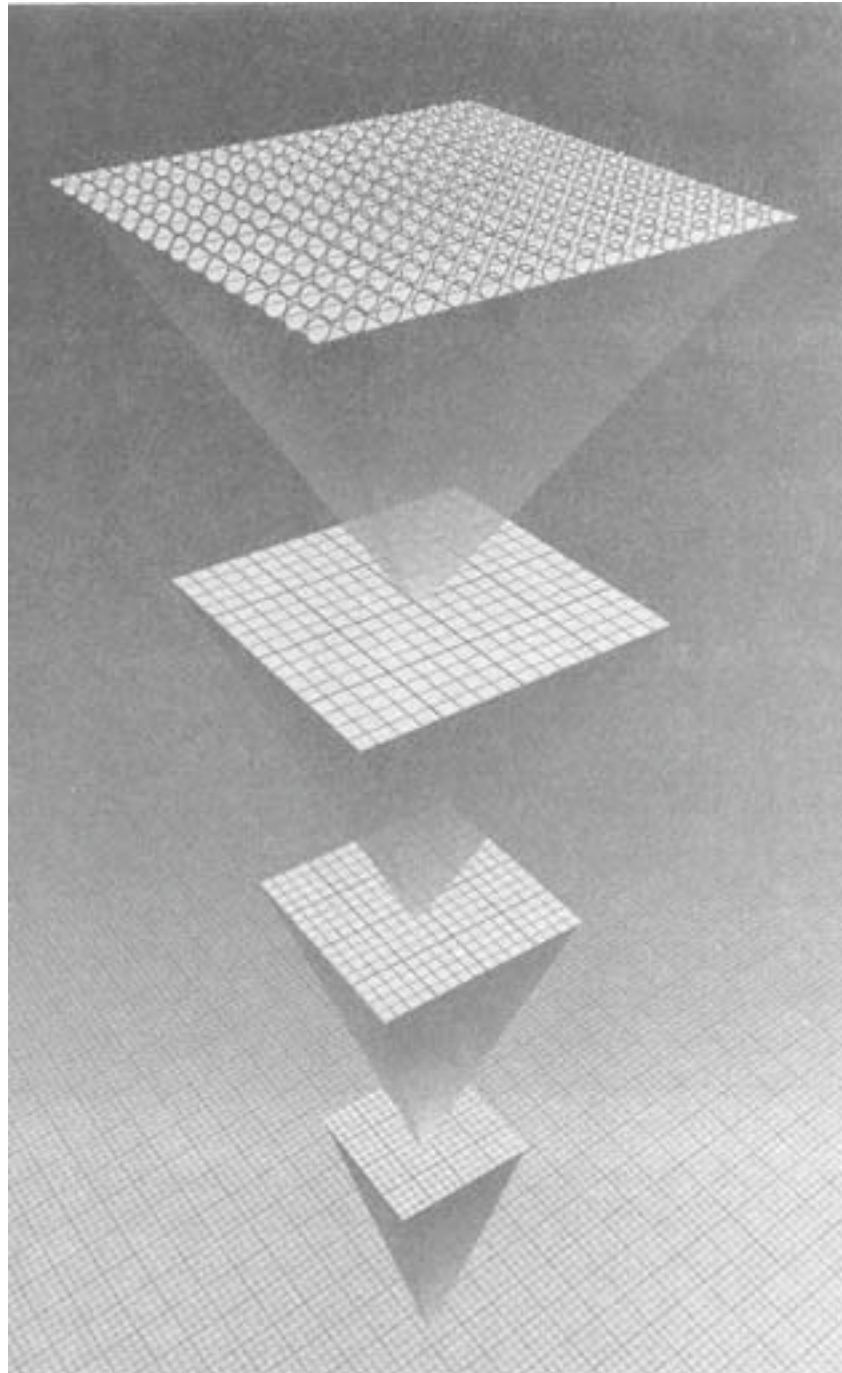
3 big space dimensions + time

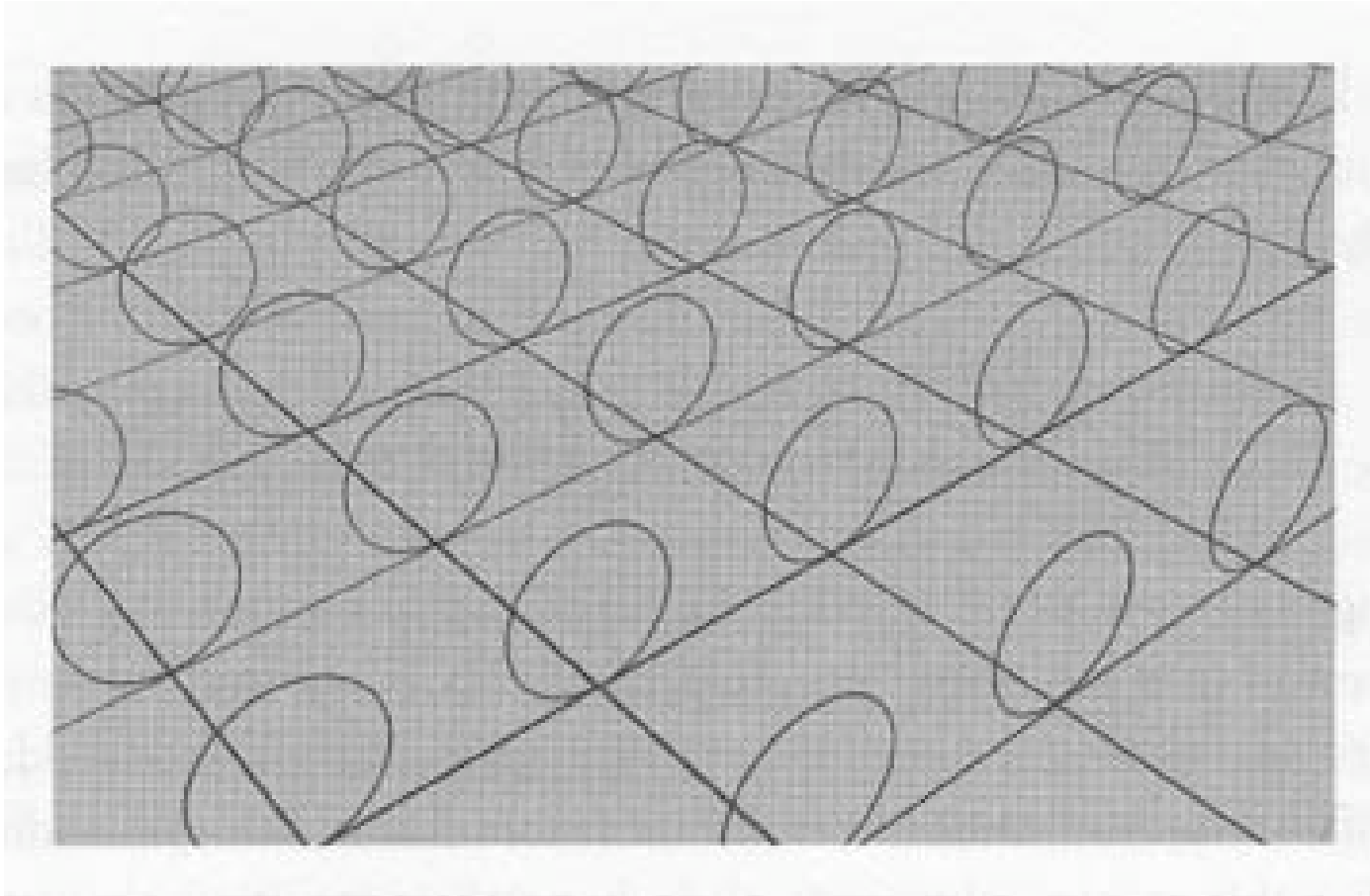
Other 7 dimensions “wrapped up” on “string length scale,” not known precisely, somewhat larger than the Planck scale, but very tiny so we cannot easily “see.”

Rubber band - 1D      paper - 2D (wrap rubber band in paper)

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.