April 27, 2011

Reading: Chapters 12, 13, 14

Failed to record some grades for 4th sky watch. Please check your grade online. If it is incorrect, return your sky watch and we'll fix it.

Electronic class evaluations. Please respond. This feedback is very valuable to me and to the TAs.

Astronomy in the news: Shuttle launch scheduled this Friday will carry the Alpha Magnetic Spectrometer, an expensive, controversial device to search for Dark Matter in cosmic rays.

Scientists have made anti-helium, two anti-protons and two anti-neutrons.

Pic of the day: 21st anniversary of launch of Hubble, new photos, colliding galaxies Arp 223

Goal:

To understand how Einstein's theory predicts worm holes and time machines and how we need a theory of quantum gravity to understand if those are really possible.

Ultimate resolution - will not know if worm holes can be constructed, even in principle, without a theory of ***quantum gravity***.

Hawking - vacuum fluctuation energy (from uncertainty principle applied to vacuum) can go into wormhole, come out in past, pile up at mouth where began, quickly build up huge energy density, curve space, slam worm hole shut.

Maybe, but cannot actually compute that process without a theory of quantum gravity to handle the change in the "connectivity" of space time - must space time be smooth, or can it be laced with "tunnels" in space and time?

One Minute Exam

The Novikov Consistency Conjecture says:

 Worm holes cannot lead to the future

 Worm holes cannot lead to the past

 Worm holes cannot exist

 Worm holes cannot lead to time travel paradoxes

Need quantum gravity theory of singularity, quantum foam, worm holes

The best current candidate for a theory of Quantum Gravity is String Theory

See Brian Greene - The Elegant Universe

(http://www.pbs.org/wgbh/nova/elegant/)

Read ***The Universe on a String*** editorial by Brian Greene posted under links -> string theory

Hyperspace is an intrinsic aspect of string theory - 10 dimensions of space, plus time.

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

Flatland - Edward Abbott

Tesseract - 4D hypercube (Elegant Universe link)

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

Crucifixion (Corpus Hypercubas)

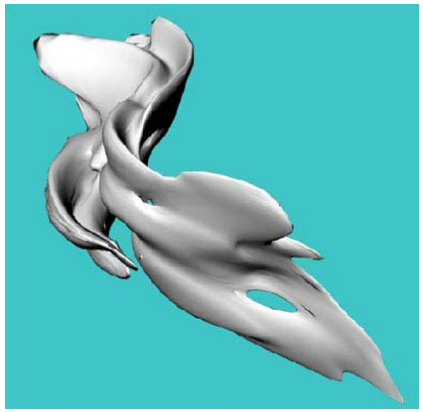
Notions of seeing from different directions at once

Perspective of Cubism

Picasso - Les Demoiselles d'Avignon

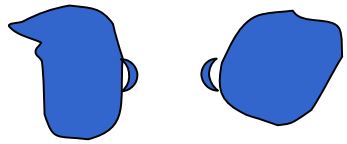
Deschamps - *Nude Descending A Staircase*

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 4D creature passing through our 3D Universe would start as a point, grow to a finite ***volume***, then decrease to a point and disappear.

Sagan YouTube

Living and perceiving different dimensions

http://www.youtube.com/watch?v=Y9KT4M7kiSw

Nota Bene: even if hyperspace exists, that does not mean it is populated with living creatures, that notion is just to help us gain perspective.

One Minute Exam

A five-dimensional creature intruding into our space would appear to us to be

 One-dimensional

 Two-dimensional

 Three-dimensional

 Four-dimensional

Goal:

To understand how string theory represents the current best candidate to be the needed theory of quantum gravity

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 of energy that vibrate in different modes

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

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.

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

From Brian Greene - The Elegant Universe

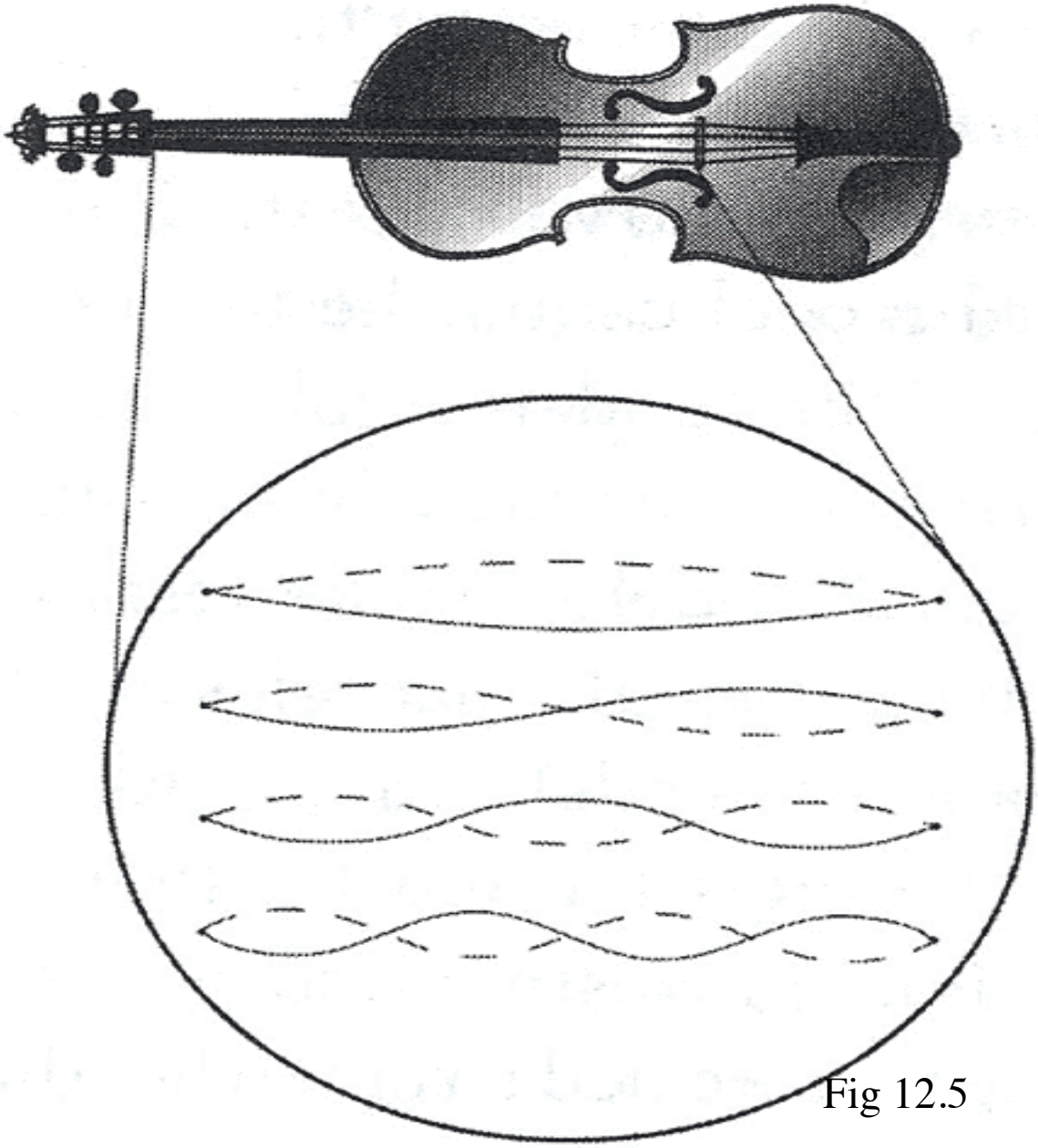
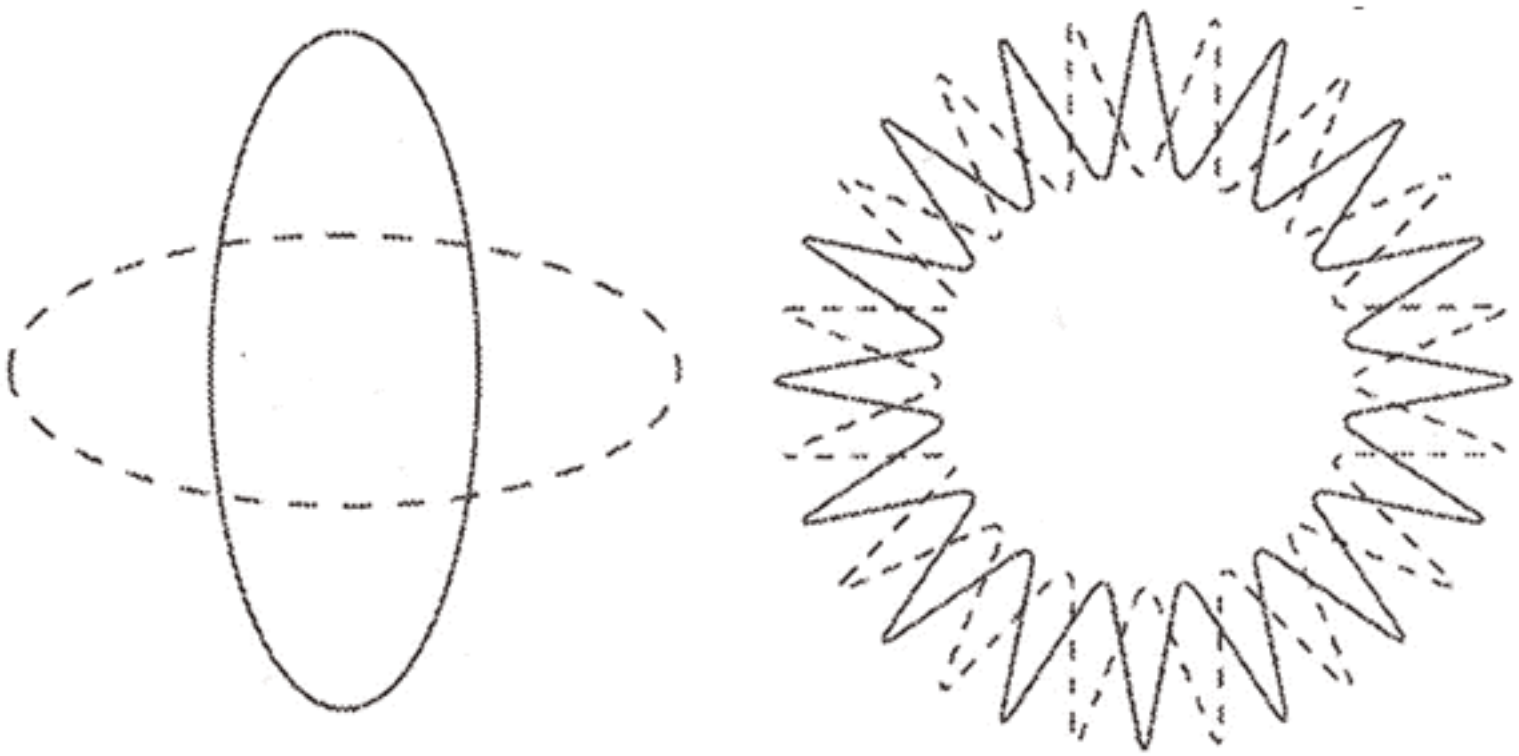


Fig 12.5

One particle

A different particle



Same fundamental loop of string

From Brian Greene - The Elegant Universe

To be mathematically self-consistent

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

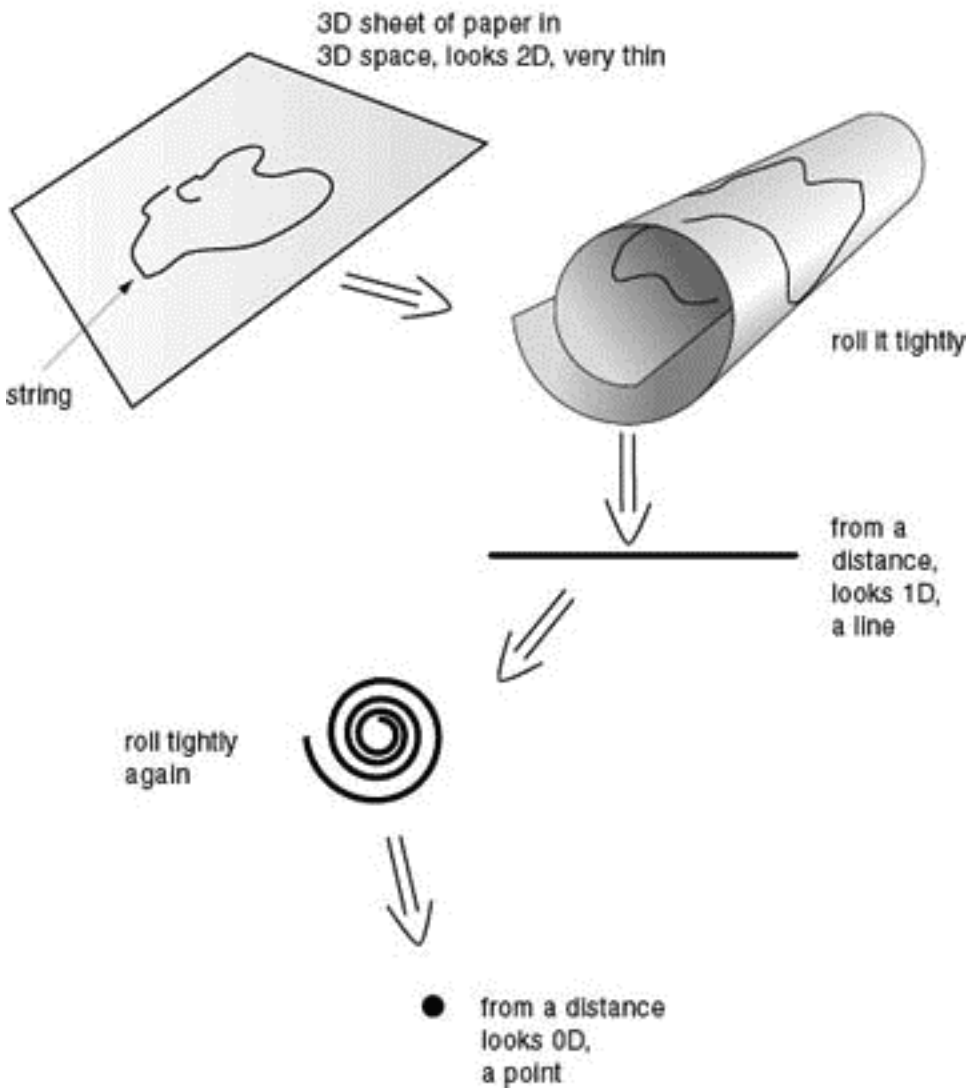
First notions:
3 big space dimensions + time

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."

Dimensions of rubber band, sheet of paper.

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