

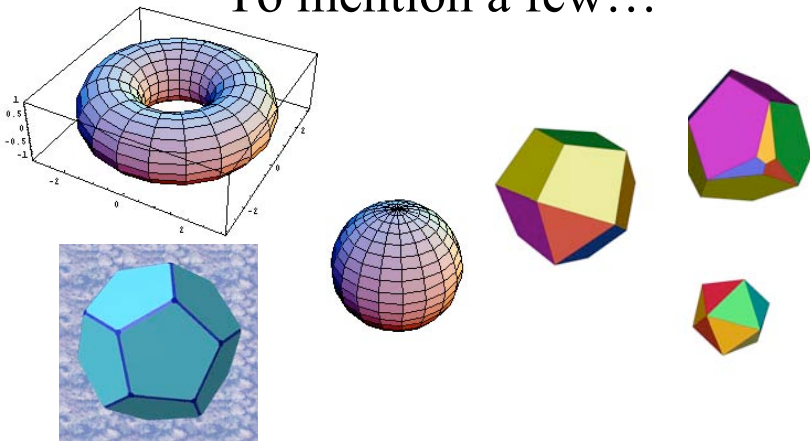
Other Principles

- Perfect Cosmological Principle
 - No special locations exist in space **and time**
 - Perfect symmetry (often encountered in physics)
 - Should time be symmetric?
 - The principle which led to the “*steady-state universe*”
- Anthropic Principle
 - Why is the universe the way it is?
 - Because we exist.
 - Why do we exist?
 - Because the universe is the way it is.
 - Do you think this is a ridiculous principle?
 - Try to answer **why** the speed of light is 299,792.458 km/s, or **why** the gravitational constant is $6.67300 \times 10^{-11} \text{ m}^3/(\text{kg s}^2)$

The Edge of the Universe?

- Q. If the universe is infinite, is there any edge?
 - A. No.
- If the universe is finite, where is the edge? What is there beyond the edge?
 - A. **There is no edge, even if the universe is finite.**
- HOW COME?!
- The state of “nothing” does not exist.
 - “Space” and “Time” are both very physical.
 - “No space” does not make any sense.
 - Does “no time” make any sense to you?
- This consideration restricts the shape of the universe to certain classes, if the universe is indeed finite.

To mention a few...



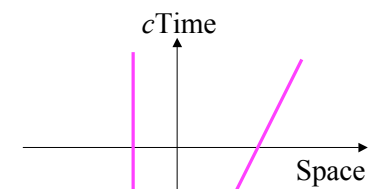
- Reminder: we are living on the **3-dimensional** surface. Since it is not possible to visualize the 3-d surface, here are shown the 2-d ones.

Four Dimensions

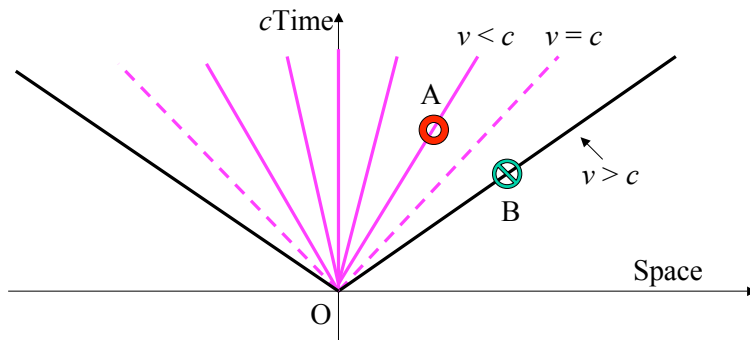
- Cartesian coordinate : (x,y,z)
 - $\text{Distance}^2 = (x \text{ interval})^2 + (y \text{ interval})^2 + (z \text{ interval})^2$
- Fourth dimension is **time**
 - More general coordinate = **spacetime** : (x,y,z,t)
 - $(\text{Spacetime distance})^2 = c^2(t \text{ interval})^2 - [(x \text{ interval})^2 + (y \text{ interval})^2 + (z \text{ interval})^2]$

- Spacetime Diagram

- Event
- Worldline

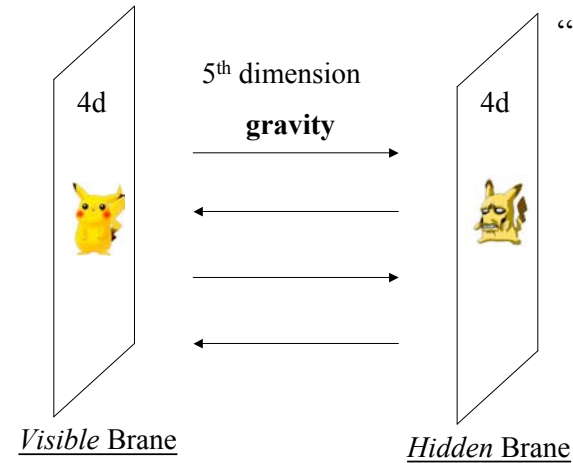


Velocity and Light cone



- The steeper the slope is, the larger the velocity is.
- The lines with 45 degrees tilt represent the “light cone”
- Since nothing can travel faster than light...
 - O and A can communicate, but O and B cannot communicate
 - This diagram shows a “causal structure”

“Brane” Cosmology



- There may be another world, and there may exist the 5th dimension...
 - Only gravity can communicate between the two “branes”
 - (“brane” came from “membrane”.)