The Arrow of Time

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Overview

- What is the arrow of time?
- Philosophical Impacts
- A Mind Bending Experiment
- What guides our interpretation of time.

A Normal Day

- You wake up in the morning as you normally do, get up, and take your morning shower. You drive to work, get through another day and find yourself , again, back at the foot of your bed ready to repeat as necessary.
- Everybody goes through life with a start, and progresses in their own unique way to the finish. But how about if one day your finish became your start, and your start your finish. Could time move in such a way? Would it be possible for events to occur in backwards succession and still have logical conclusions?

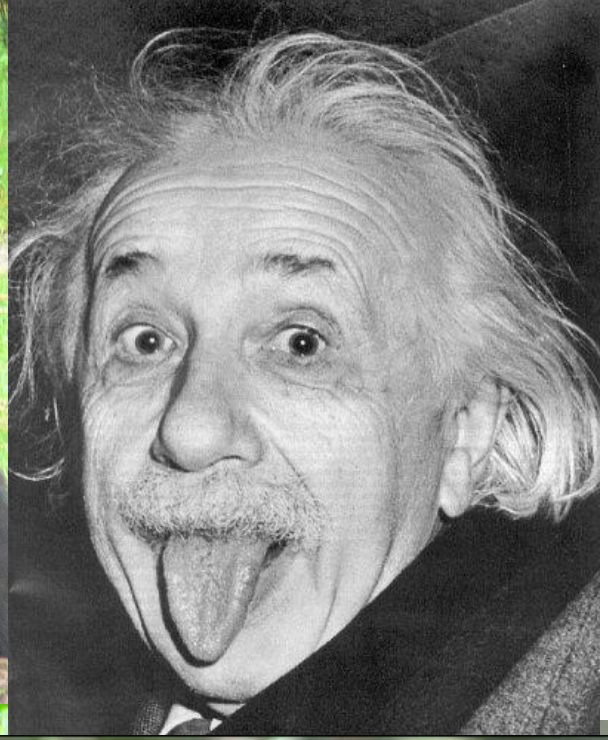
The Arrow

- Anti-Symmetric
  - Humans have unique access into the past yet claim no rights to the future.
- Symmetric
  - Maybe the time arrow could point both directions?

Philosophical Impacts

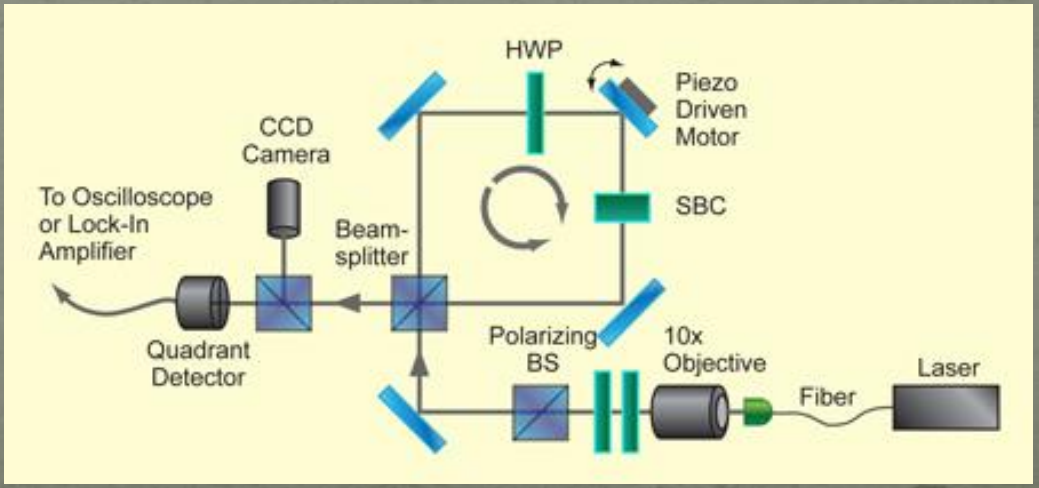
- Yah sure, my parents had some part in it, but you can actually thank my future self for where I am today.
- Uncertainty in our life may be due to our lack of understanding on future influences.
  - Heisenberg's uncertainty principal.

$$\Delta X \Delta P \geq \frac{\hbar}{2}.$$



A beautiful experiment

- Laser light was measured, then projected through a beam splitter. Part of the beam passed through, while part bounced off of a mirror moving ever so slightly. Weak measurements were taken to detect the deflection of the reflected laser light.
- Pre, intermediate, post measurements revealed amazing results.

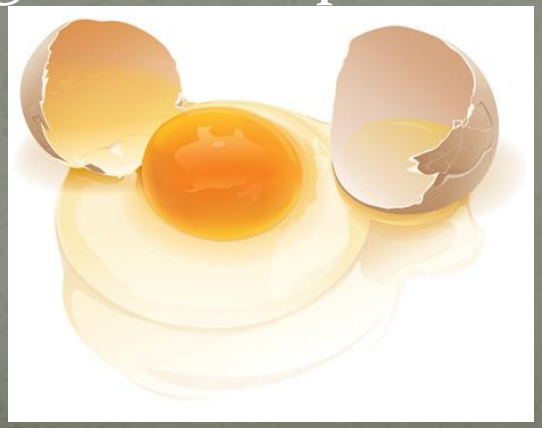


Time Reversibility

- Time reversibility exists all over the microscopic scale (through parity changes and exchanging particles for anti particles.)
- The problem lies with the macro, our universe and its ever expanding nature which we observe.
- Why is it that time seems to move one way?
- Is it a matter of observational error?

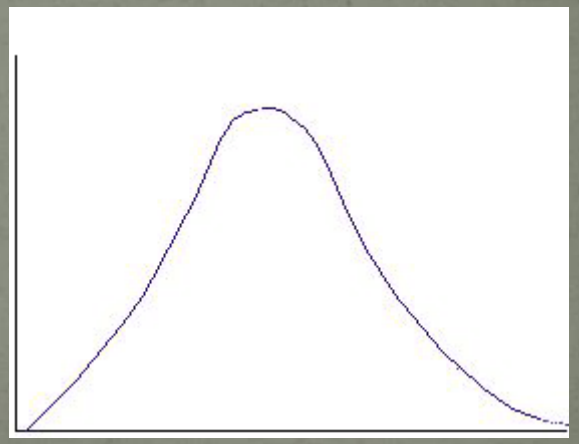
Entropy

- **Entropy** is a measurement of how organized or disorganized a system is
- Second Law of Thermodynamics-the entropy of an isolated macroscopic system never decreases
- Big Bang low entropy state
- Our universe can be seen as a egg being broken, seeking a static equilibrium.

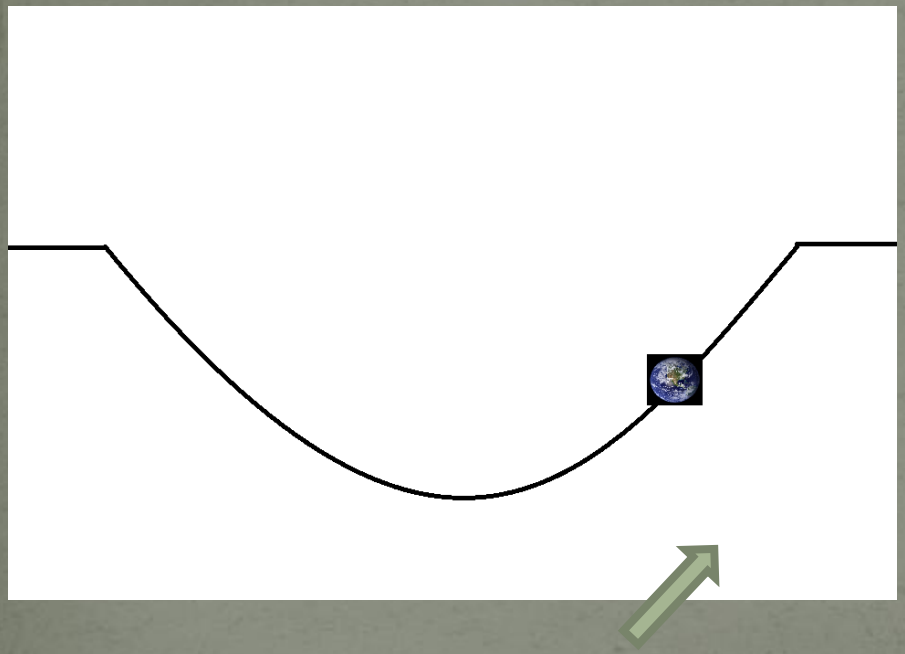


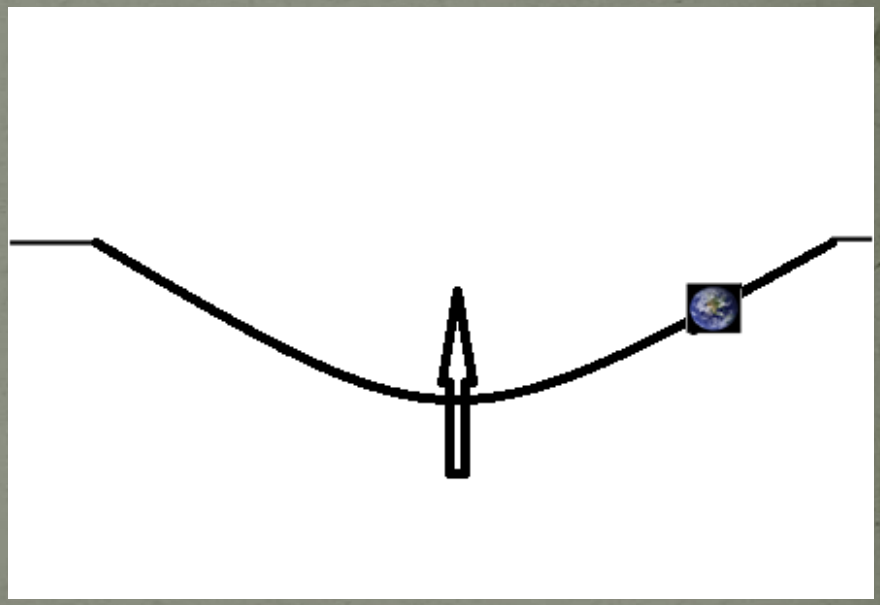
Boltzmann to the rescue…maybe

- Boltzmann's distributions proposed interesting ideas that our universe is guided with nearly extreme precision in one direction, with no chance of free will.
- The more particles in a system, the less chance of deviation.
- Says that there is so many ways to make a high entropy state it must be the solution to the universe's expansion.



- Boltzmann claimed that our universe stems from a ripple in the entropy of a bigger universe.
- Our Entropy gradient points in one direction making time appear one dimensional as our universe expands to flatten to a lower energy state.





Problem

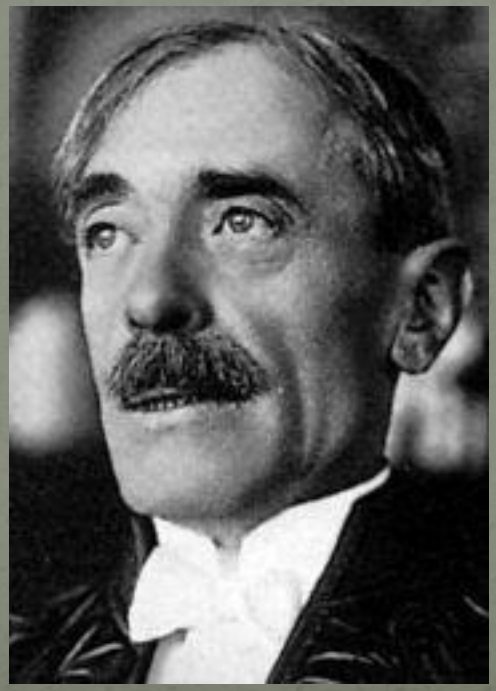
- If the big bang was a low entropy state, wouldn't the chance of that being created in the first place be wildly unlikely.
- Answer: Quite simply, yes.
- Our universe is unimaginably unique.
- We are all but a ripple that shouldn't be, and in due time, we will smooth back into the particles we were born out of.

Notables

- The arrow of time shows that the future may influence our present more than we know, pulling us to a state of higher entropy, a loss of information and a lower energy state.
- Weak measurements may shed some light onto the effects of future on our present.
- Entropy plays a very crucial role in our view of time.
- Critics devour this idea by simply stating that under Boltzmann's logic, our existence is a mathematical impossibility, or near to.

Questions?

- “The trouble with our times is that the future is not what it used to be.”- French Philosopher Paul Valery



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