Dark Energy: A Universe Out of Control

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Ferdinand Magellan (1519-1521)

Magellan's voyage around the world

- Atlantic Ocean
- Pacific Ocean
- Strait of Magellan
- Magellan died here April 27, 1521
- Philippine Islands
Our Universe
The most profound observation in modern cosmology is ?
Why is the sky black at night?

Olber’s Paradox
Weird stuff about the Universe

• When you look deep into the sky
  – it is the same everywhere
  – galaxies we see in one direction have not seen the galaxies we see in the other direction
• It is expanding and has an age of 14 Billion years.
• Pushing mass is the same as gravitational mass
• Where is the anti-matter?
• Where is there no magnet with a N pole but not a S??
• 96% of the stuff out there we cannot see with light. “The Universe is 96% dark.”
• It is flat
More weird stuff

• We can see the Big Bang as the cosmic microwave background radiation which is 3 degrees above absolute zero.
• The Universe is expanding – “the Hubble expansion” (or is it?)
• The fundamental values of physics – speed of light, gravitational constant, do not change in time.
• What causes time?
• Why is the Universe not more chaotic? $\log_{10}(S)$-120 but we observe 80.

• WHERE ARE THEY?
• I’m getting tired here...
Lots of weird stuff in the Universe
To me – the weirdest

The Universe is basically dead.
What is the Universe expanding into?
The Local Universe

• 73% dark energy
• 23% dark matter (about 3 H m$^{-3}$)
• 3% missing “baryons” (i.e. normal matter)
• 1% is us

• This is too weird? Maybe we are fooling ourselves??
• And why is Dark Energy ~ Dark Matter
Dark Energy

There is no picture...
So I will wave my hands a lot here.
What we discovered in 1998

- 73% dark energy
- 23% dark matter (about 3 H m⁻³)
- 3% missing “baryons” (i.e. normal matter)
- 1% is us.

- This is too weird? Maybe we are fooling ourselves??
- And why is Dark Energy ~ Dark Matter
Here I wave my hands a lot about Dark Energy

Supernova!
Let’s run the clock back

- Milky Way 20,000yr
- Andromeda Galaxy 1Myr
- Galaxy cluster 1Gyr
- Hubble Ultra Deep Field 10Gyr
- The Dark Ages 12.5Gyr
- The Cosmic Background 13.3Gyr
What Happened at t=0?

• Inflation?
• We can’t see t=0 really
• There is no t=0?
• Maybe there are two types of time?
Inflation
Now run the Universe forward

- Dark Energy drives it faster and faster
- Dark Matter is too dilute
- The small amount of gas in galaxies is used up
- The galaxies move farther and farther away until we don’t see them.
The Big Rip...
Describing Our Universe

95% of the universe is unknown!

New Stuff

Old New Stuff

Us

Heavy Elements: 0.03%

Neutrinos: 0.3%

Stars: 0.5%

Free Hydrogen and Helium: 4%

Dark Matter: 25%

Dark Energy: 70%

Us

STScI
Our Universe