Preface to Presentation

- I gave a presentation last October about time travel, warp drive, travel to a “Goldilocks Planet” etc. to provide some possible place to escape a possible dying world
- I mentioned that there might be the ability to warp time and space to allow faster than light travel
- I discussed new data that showed a bruise in the cosmic ray background radiation that has been used by theoretical physicists to suggest the possibility of multiple universes
- I mentioned gravity waves as a key to our understanding of the universe.

Well, We Have a Conundrum

- If physicists could watch gravity waves ripple across the universe in response to the movement of large masses, they could hypothetically see through such obstructions and watch black hole collision directly.

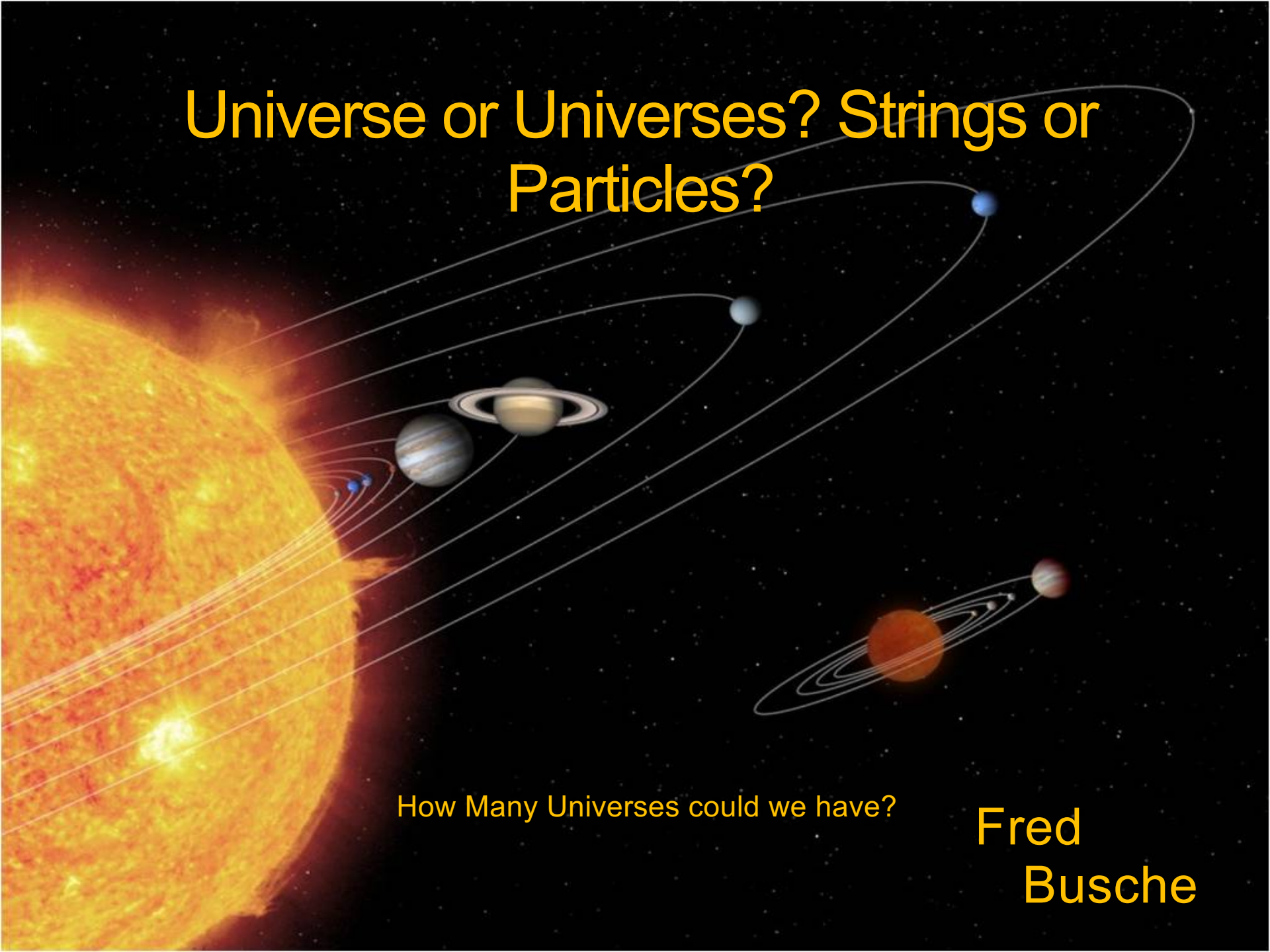
- Just as stars drown out black holes with light, black holes can drown out stars with gravity. (Gravitational lensing) This causes a problem

- Are the black holes not there? Are they not colliding as predicted? Maybe, but honestly unlikely

- We now think the collisions may be occurring much more quickly than predicted, generating major gravitational waves for a much shorter period of time and eluding the pulsar method of detection.

- The traditional understanding of black holes says that their collision should be a rather lengthy dance — but now it seems that might not actually be the case.

Universe or Universes? Strings or Particles?

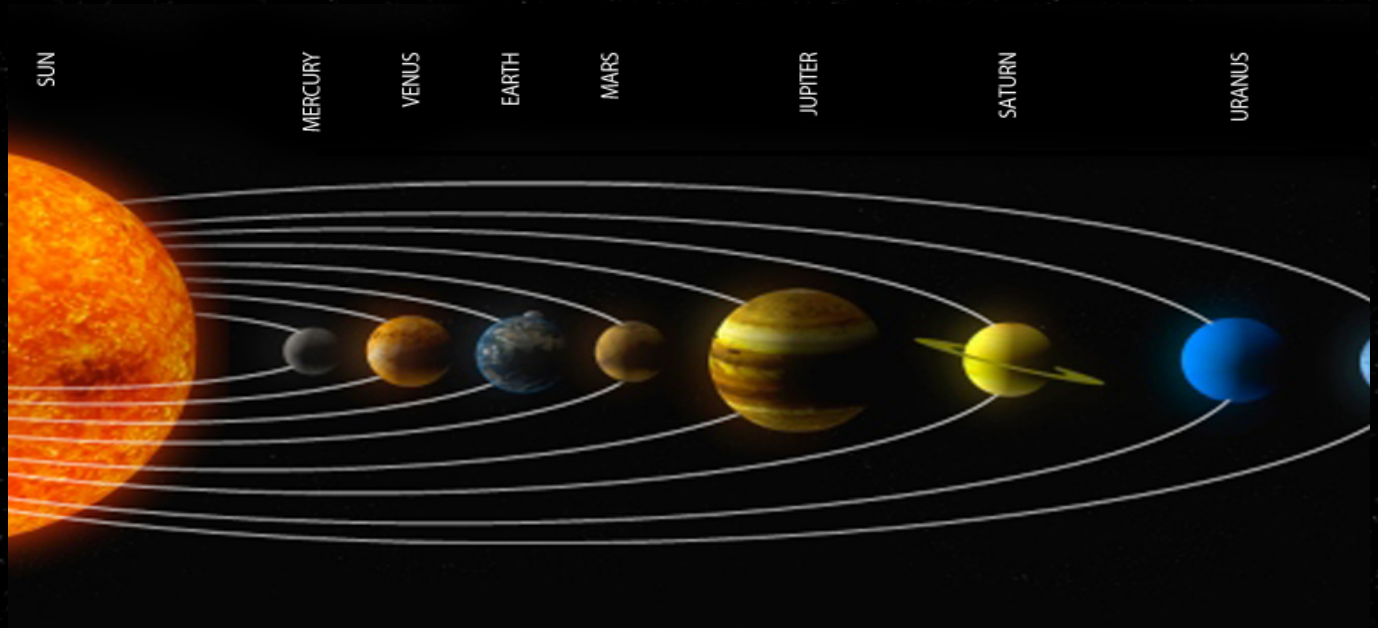


How Many Universes could we have?

Fred Busche

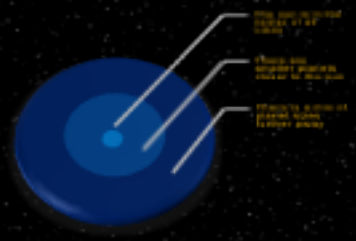
Presentation Overview

- Particle and String Theory
- What We Used To Think
- What Do We Think Now
- Where Do We Go Next



Particle Theory

- Theoretical physicists today still use the calculus pioneered by Sir Isaac Newton
  - Newton's Three Laws of Motion
    - A Body in motion tends to stay in motion
    - A body's mass and acceleration equals applied force or F=ma
    - For every motion there is an equal and opposite reaction
  - Technology of Electromagnetism sparked the movement to Classical Field Theory
    - Electron discovery gave rise to Quantum Mechanics and experimental observation
    - Deduced that all particles fell into two categories
      - Bosons – Particles that transmit force Higgs talked about last year
        - Many can occupy the same state at the same time
      - Fermions – Particles that make up mattter
        - Only one can occupy the same state at a given time
        - Therefore particles cannot pass through each other
        - Can't walk through a wall – Pauli repulsion
    - Observational evidence indicated that light
      - Is Electromagnetic radiation
      - Travels at one fixed speed
        - In every direction
        - According to every observer
    - Now we have Einstein's Special Theory of Relativity to explain it
    - Combined with Newton's theory of Gravity becomes the General Theory of Relativity
- Everything is fine why do we need strings?



Now We Complicate Things

Is Light a Particle or Wave

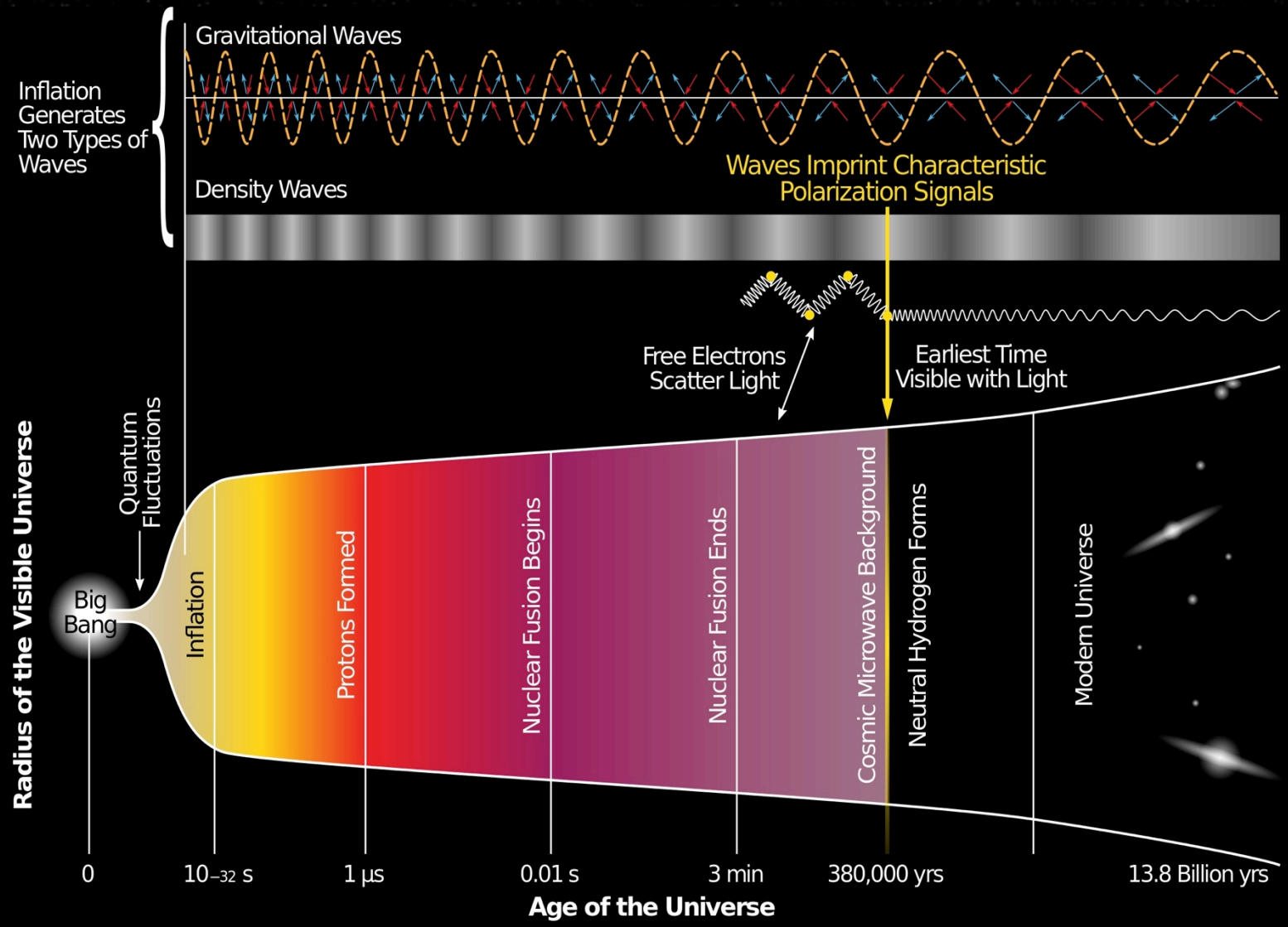
Here Come the Strings

- What we have just seen works well to describe
  - Observed behaviors
  - Properties of elementary particles
  - But only works when we have no gravity and Quantum Mechanics is not needed to **DESCRIBE** Nature
  - Strings close the gap
    - **Originally used to explain relation of mass and spin of hadrons – Proton and Neutron**
    - **Didn't work so back to the drawing board**

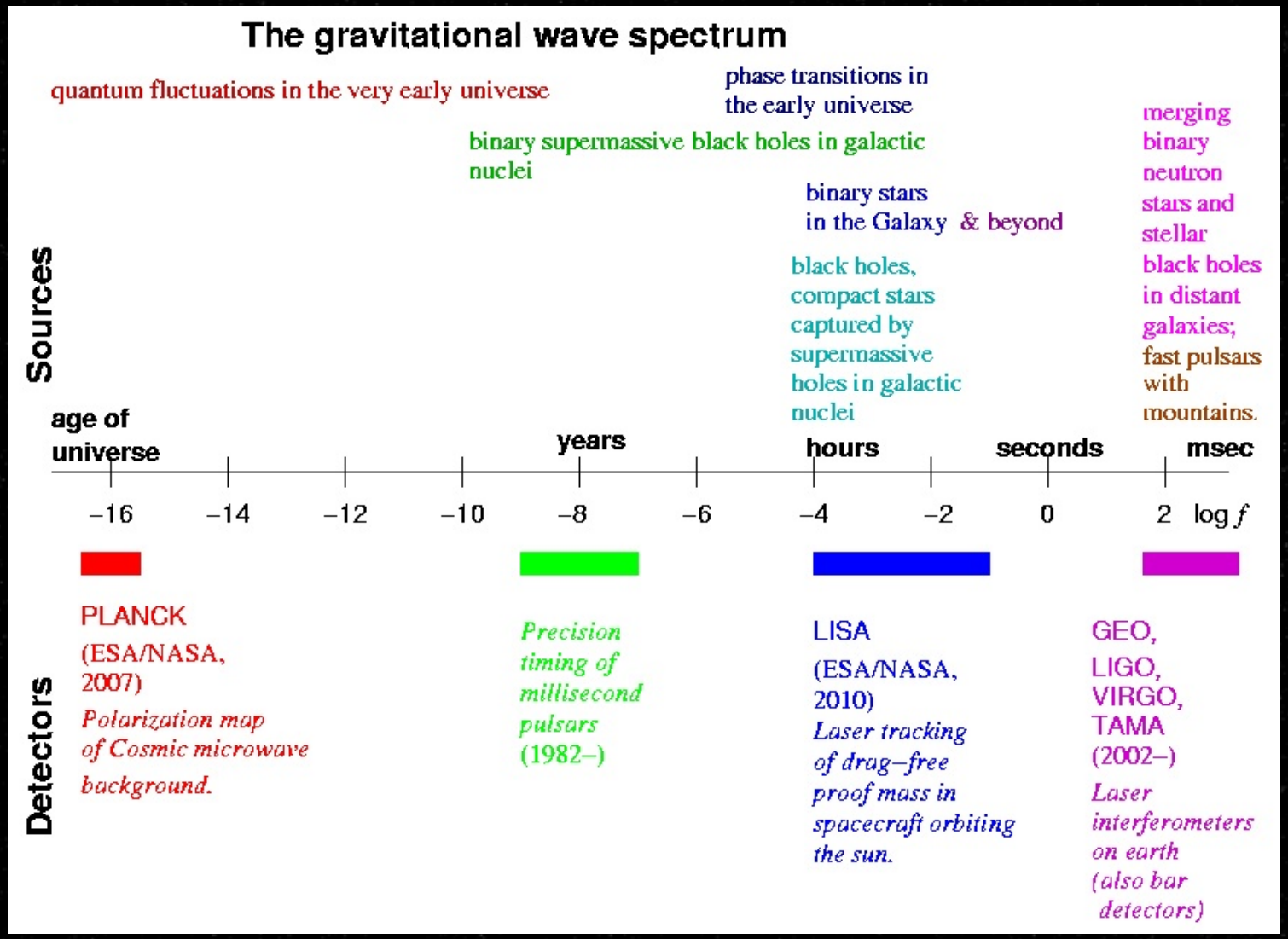
String Theory

- A particle now can be described as excitations of a string
  - Zero mass and 2 units of spin
    - Good quantum theory of gravity would have a particle with exactly this
    - Particle would be called a Gravitron
  - Problem – particle interactions occur at a single point of space-time at zero distance between particles
    - Uh oh – particles cannot occupy the same space at the same time according to Quantum Mechanics
    - Strings collide over a small distance and this makes sense
  - Solution – combine Quantum Mechanics and gravity have strings carry the gravitational force
- Ah – now we can feel much better

Gravity Waves



Gravity Wave Spectra



The Different String Theories Allow for Different Numbers of Dimensions

A Brief Table of String Theories

Type	Spacetime Dimensions	Details
Bosonic	26	Only bosons, no fermions means only forces, no matter, with both open and closed strings. Major flaw: a particle with imaginary mass, called the **tachyon**
I	10	Supersymmetry between forces and matter, with both open and closed strings, no tachyon, group symmetry is **SO(32)**
IIA	10	Supersymmetry between forces and matter, with closed strings only, no tachyon, massless fermions spin both ways (nonchiral)
IIB	10	Supersymmetry between forces and matter, with closed strings only, no tachyon, massless fermions only spin one way (chiral)
HO	10	Supersymmetry between forces and matter, with closed strings only, no tachyon, heterotic, meaning right moving and left moving strings differ, group symmetry is **SO(32)** 32
HE	10	Supersymmetry between forces and matter, with closed strings only, no tachyon, heterotic, meaning right moving and left moving strings differ, group symmetry is $\mathbf{E_8 \times E_8}$ E8 x E8

BOTTOM LINE THEN:

Particle Theory limits us to 3 dimensions and must follow Newton's Three Laws of Motion

String Theory allows for many dimensions and a way to have simultaneous existence of matter at the same place and same time

So What is This Theory and Where Does it Lead

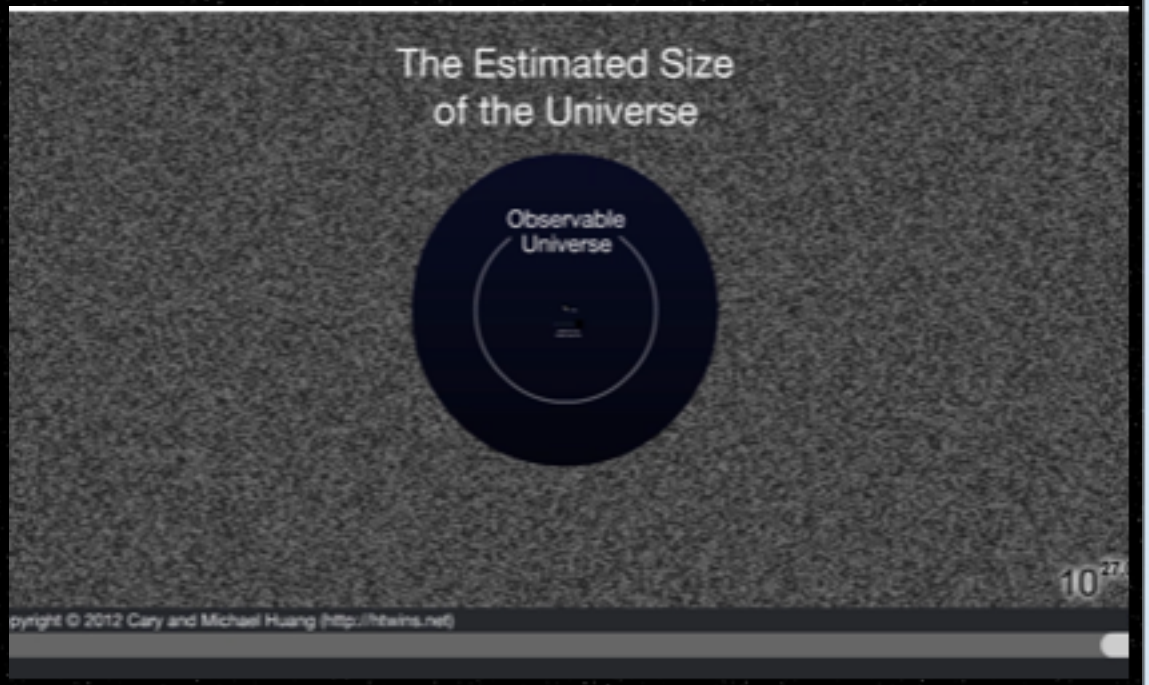
Definitions of the Three Universe Types

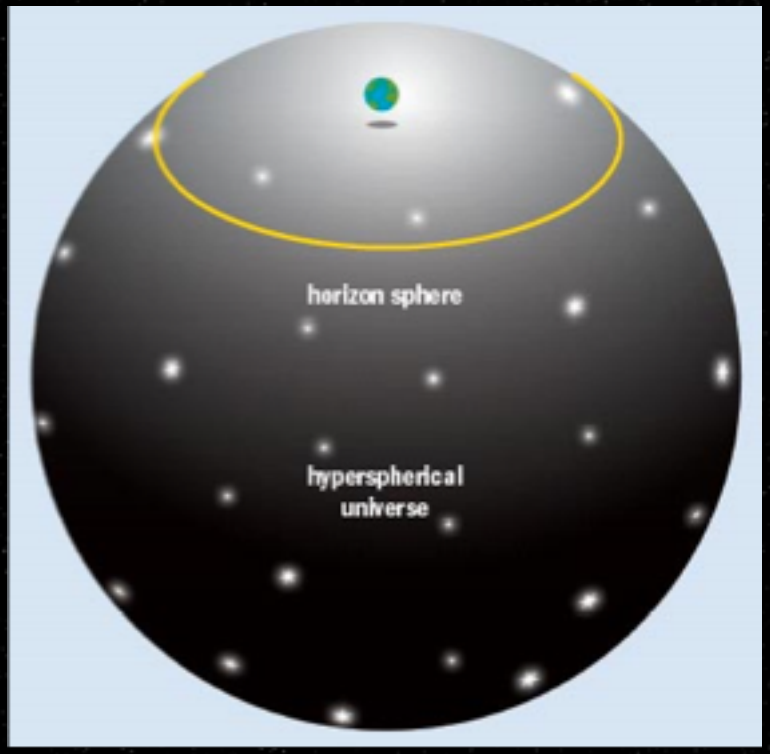
- Observable Universe
- Observable and Non Observable Universe
- Multiverses or Multiple Universes

Observable Universe

- The observable universe consists of
  - The galaxies and other matter that can be
    - observed from Earth in the present day
    - because light and other signals from these objects has had time to reach us
  - The distance to the edge of the observable universe is
    - the same in every direction
    - a spherical volume (a ball) centered on the observer
    - every location in the universe has its own observable universe, which may or may not overlap with the one centered on Earth.
  - The best estimate of the age of the Universe is 13.798 ± 0.037 billion years
  - Because of expansion of space
    - we are observing objects that were originally much closer
    - the edge of the observable universe is about 46–47 billion light-years away
    - we cannot see the whole observable universe
    - Time – space is curved so part of the observable universe is over the horizon of the curvature

Observable Universe





Mass of The Observable Universe – Particle Theory

- Only four per cent of the mass of the Universe is in the atoms that make up you and me, the stars and planets.
- We will only ever see half of that with our telescopes.
- 23 per cent of the mass of the Universe is invisible, “dark”, matter.
  - We know of its existence only because its gravity tugs on the visible stars and galaxies.
- 73 per cent of the mass of the Universe is dark energy.
  - This invisible stuff fills all of space and it has repulsive gravity.
  - To say that we really do not understand dark energy is a bit of an understatement.

Whole Universe

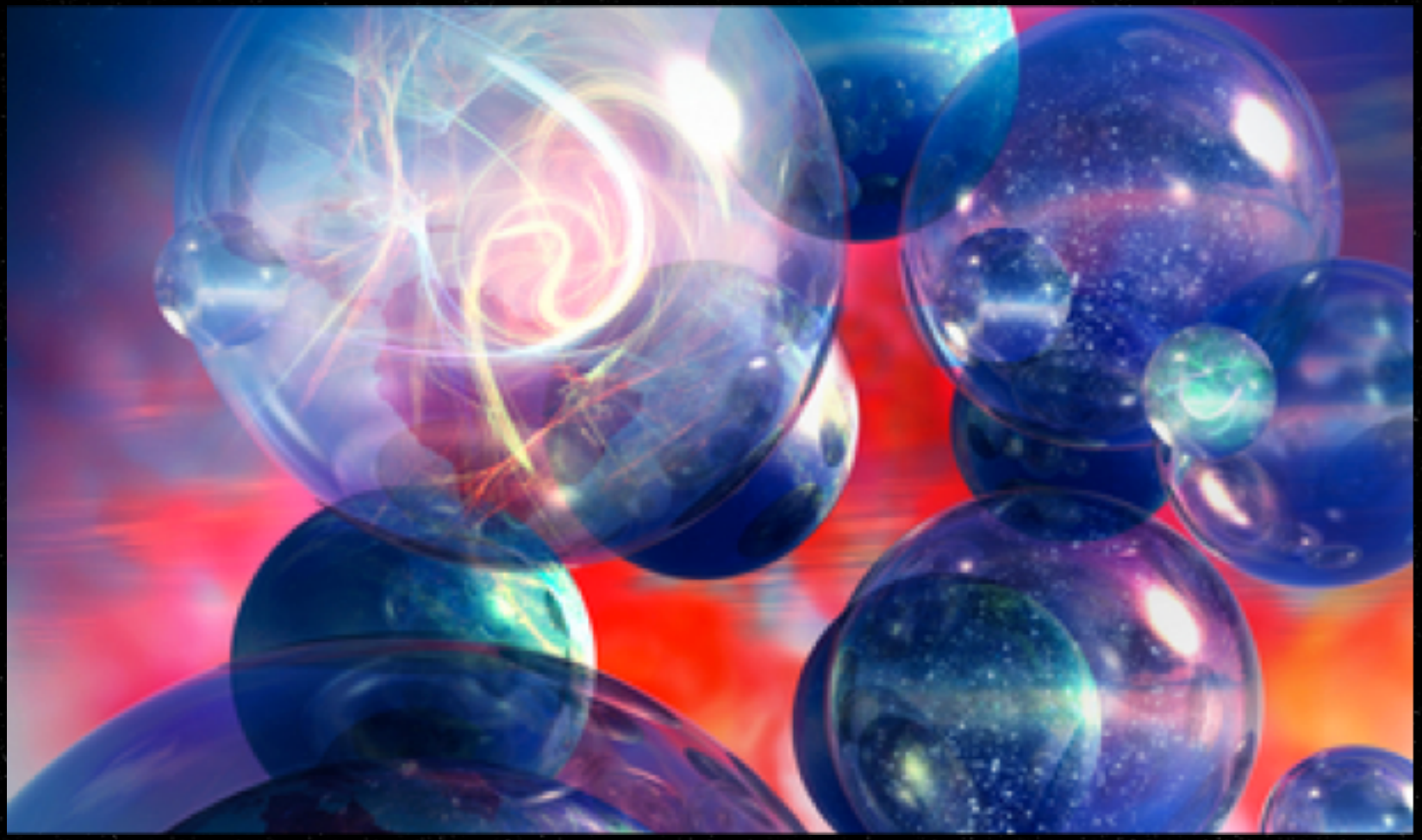
- Parts of the universe are too far away for the light emitted since the Big Bang to have had enough time to reach Earth
  - With time light from distant galaxies will have had more time to travel, so additional regions will become observable
  - However, due to Hubble's law regions sufficiently distant from us are expanding away from us faster than the speed of light
  - Furthermore the expansion rate appears to be accelerating due to dark energy
  - There is a "future visibility limit" beyond which objects will never enter our observable universe at any time in the infinite future
    - this future visibility limit is calculated at a co-moving distance of 19 billion parsecs (62 billion light years)
    - implies the number of galaxies that we can never theoretically observe is limited in the infinite future because of the expansion away of part of the Universe
    - equivalent to walking on a moving walkway like we have at airports

Multiverses

Multiverse or Universe

- Until March 17 of last year the answer was one universe
- After March 17 we have learned
  - That we may have gathered direct evidence of the existence of primordial gravitational waves or ripples in space-time
  - If confirmed = smoking gun evidence that space-time expanded many times faster than the speed of light after the Big Bang
- If confirmed this will give creditable evidence for a Multiverse because:
  - Some parts of the universe expanded faster than others
  - Probably created small bubbles of space-time
  - These small bubbles developed into other universes that have different laws of physics

Might Have Looked Like This

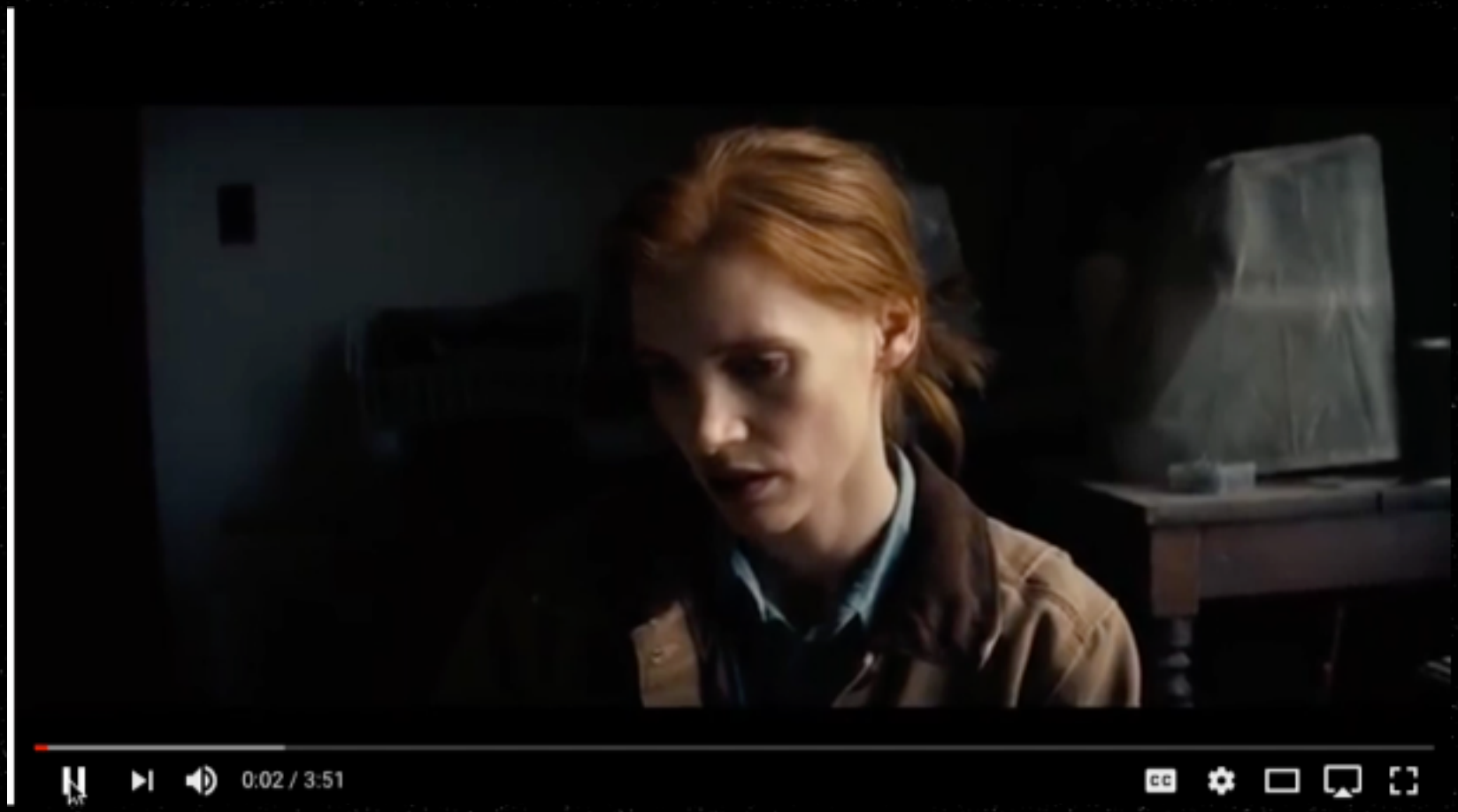


The Enigmas

Summary of Where We Are Now – Dark Matter and Energy

Trailer If You Have Not Seen

A View of Another Universe



Where We Seem to be Going

However!!

- We may have jumped the gun with regard to the gravitational waves
  - The data interpretation did not take into account interference from Galactic Dust which could be the observed effect
  - Further investigations may yet find the gravitational wave signal hidden in this vast amount of noise
  - Thus original data did not contain a significant amount of evidence of the waves to confirm their existence
  - We now have no data for or against the existence of these waves
- Data from the Keck Array (telescope located at the South Pole) will either confirm or maybe not or be inconclusive concerning dust interference

Oh Crud – here we go again

WHAT WILL WE KNOW BY NEXT NEXT YEAR? HMMMM!!!

Stay Tuned For New Developments or Maybe just Maybe

Who Knows for Sure. Maybe We are the Universe

Any Questions That I May or May Not be Able to Answer?