# Physics 102 - January 19, 2011

- 1 Recitations begin next week
- Jung Duty Class Nextweek
- Questions abt course

### What is a universe?

### Max Tegmark's multiverse taxonomy

# Classified by level of abstraction/complexity



Cosmologist at MIT

#### Level 4: Other mathematical structures Level 1: Regions beyond our cosmic horizon Features: Same laws of physics, different initial conditions Features: Different fundamental equations of physics Assumptions: Infinite space, ergodic matter distribution Assumption: Mathematical existence = physical existence - Microwave background meaurements point to Evidence: - Unreasonable effectiveness of math in physics flat, infinite space, large-scale smoothness - Answers Wheeler/Hawking question: Simplest model "why these equations, not others" Level 3: The Many Worlds of Quantum Physics Level 2: Other post-inflation bubbles Features: Same as level 2 Same fundamental equations of physics, but perhaps different constants, particles and dimensionality ssumption: Physics unitary Assumption: Chaotic inflation occurred Evidence: - Experimental support for unitary physics

- AdS/CFT correspondence suggests that

even quantum gravity is unitary

Decoherence experimentally verified

- Mathematically simplest model

Evidence: - Inflation theory explains flat space, scale-invariant

Explains fine-tuned parameters

fluctuations, solves horizon problem and monopole

problems and can naturally explain such bubbles

# My populist taxonomy – classified according to primary form of separation of the universes

Space-time separated
Dimensionally separated
Faith-based

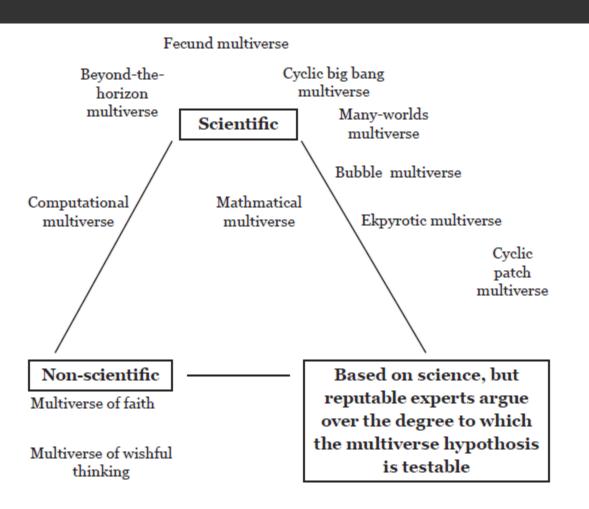


Figure 1.1: Relative degrees to which different multiverse concepts are scientific.

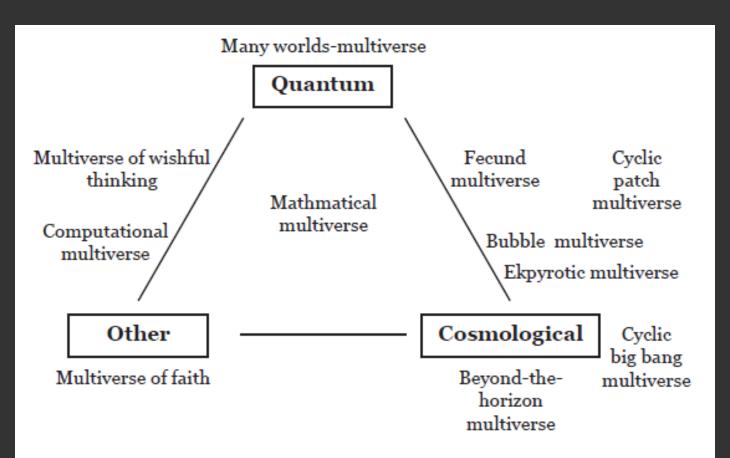


Figure 1.2: Relative degree of quantum versus cosmological character for different multiverse concepts.

# The Hruman Kxperience

line ~ .0015 - 2000 years

Distance 100 microsas - 10000's failes

Mass ~ milligrams -> Many Tons

### Scientific Notation

$$10 = 1 \times 10^{7}$$

$$100 = 1 \times 10^{7} = 10^{2}$$

$$1,000,000 = 1 \times 10^{6} = 10^{6}$$

$$0.1 = 1 \times 10^{-7} = 10^{-7}$$

$$0.00001 = 10^{-7}$$

### See java applet at

http://micro.magnet.fsu.edu/primer/java/scienceopticsu/powersof10/index.html

Length:		
Distance	Length (m)	
Radius of visible universe	$1 \times 10^{26}$	
To Andromeda Galaxy	2 x 10 <sup>22</sup>	
To nearest star	4 x 10 <sup>16</sup>	
Earth to Sun	1.5 x 10 <sup>11</sup>	
Radius of Earth	6.4 x 10 <sup>6</sup>	
Sears Tower	$4.5 \times 10^{2}$	
Football field	$1.0 \times 10^{2}$	
Tall person	$2 \times 10^{0}$	
Thickness of paper	1 x 10 <sup>-4</sup>	
Wavelength of blue light	4 x 10 <sup>-7</sup>	
Diameter of hydrogen atom	1 x 10 <sup>-10</sup>	
Diameter of proton	1 x 10 <sup>-15</sup>	

### Time

Interval	Time (s)
Age of universe	$5 \times 10^{17}$
Age of Grand Canyon	3 x 10 <sup>14</sup>
32 years	1 x 10 <sup>9</sup>
One year	$3.2 \times 10^7$
One hour	$3.6 \times 10^3$
Light travel from Earth to Moon	1.3 x 10 <sup>0</sup>
One cycle of guitar A string	2 x 10 <sup>-3</sup>
One cycle of FM radio wave	6 x 10 <sup>-8</sup>
Lifetime of neutral pi meson	1 x 10 <sup>-16</sup>
Lifetime of top quark	4 x 10 <sup>-25</sup>

### Mass:

Object	Mass (kg)
Milky Way Galaxy	$4 \times 10^{41}$
Sun	$2 \times 10^{30}$
Earth	6 x 10 <sup>24</sup>
Boeing 747	4 x 10 <sup>5</sup>
Car	$1 \times 10^{3}$
Student	$7 \times 10^{1}$
Dust particle	1 x 10 <sup>-9</sup>
Top quark	3 x 10 <sup>-25</sup>
Proton	2 x 10 <sup>-27</sup>
Electron	9 x 10 <sup>-31</sup>
Neutrino	1 x 10 <sup>-38</sup>

However if you do careful observations... even at "human" Scales nature has some surprises

bicycle wheel demo

Support Wheel not rotating

Falls

wheel does

Not fall

rather moves

to the Side!

Surprise!

How are (Science Retigion) the same?

How are

Mifferent?