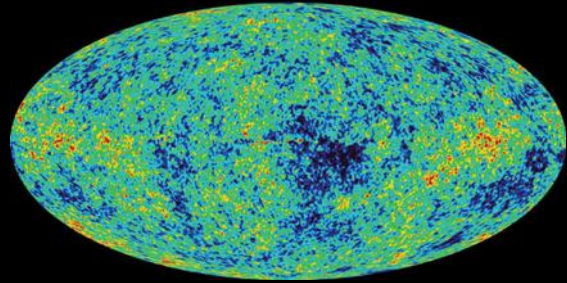


ASTR 311: Exploring the Universe Clicker question solutions



CLICKER: Which faculty do you belong to?

- (a) *Sci & Tech*
- (b) *Arts & Humanities*
- (c) *Social Sci*
- (d) *other*

CLICKER: How did you hear about this course?

- (a) *VIU calendar*
- (b) *recommended (by advisor, friend, etc.)*
- (c) *course website or poster on campus*
- (d) *other*

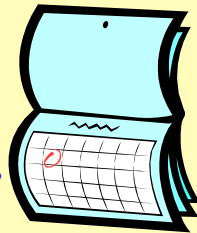
A Sense of Time...

If the Universe is **14 billion years old**, and we represent the **Big Bang** to the **present** on a **12 month calendar**...

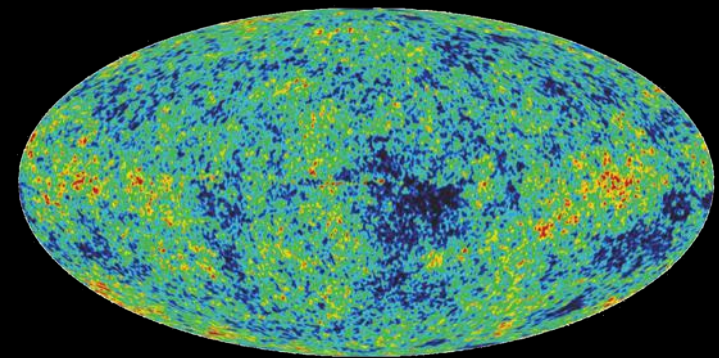
- **Big Bang** took place **Jan 1st**
- **Milky Way** formed in **February**
- **Earth** formed **mid-August**
- **simple life** began in **September**

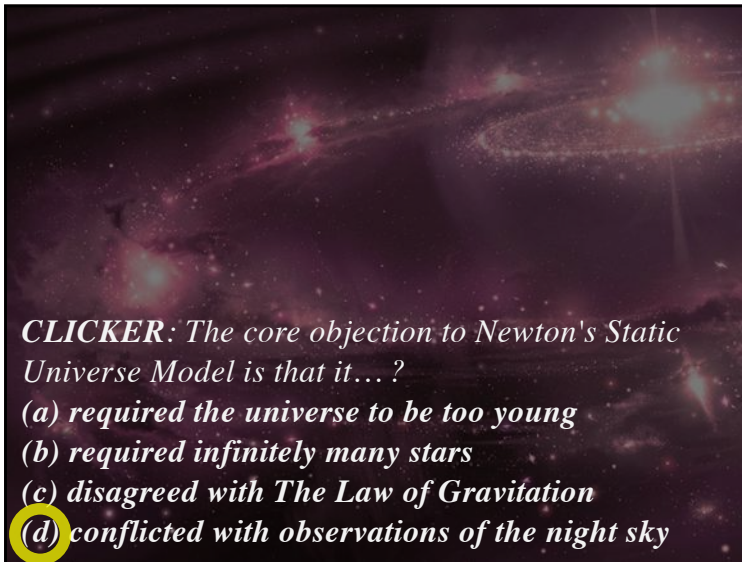
CLICKER: When did humans appear?

- (a) **mid September**
- (b) **early November**
- (c) **late December**



The Universe








CLICKER: The core objection to Newton's Static Universe Model is that it...?


- (a) required the universe to be too young*
- (b) required infinitely many stars*
- (c) disagreed with The Law of Gravitation*
- (d) conflicted with observations of the night sky***

CLICKER: Given the "lab" measured spectra, which of the others represents the same spectra but emitted from a very rapidly receding galaxy?

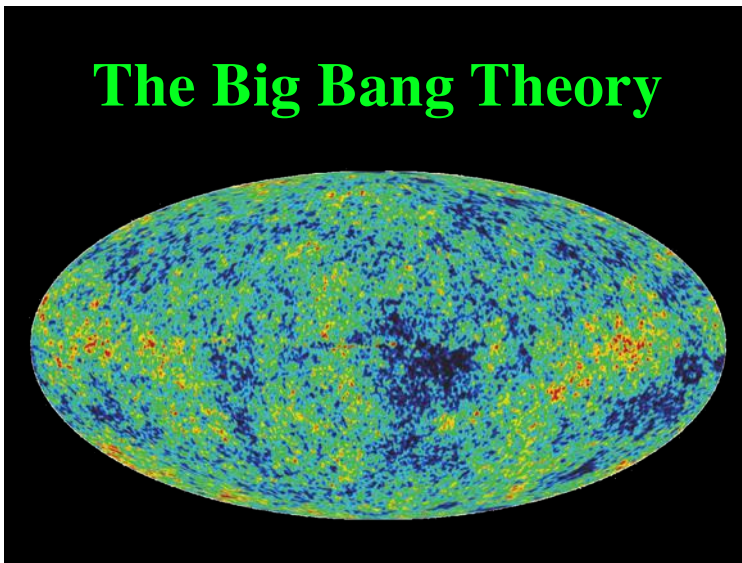
LAB: 

(a) 

(b) 

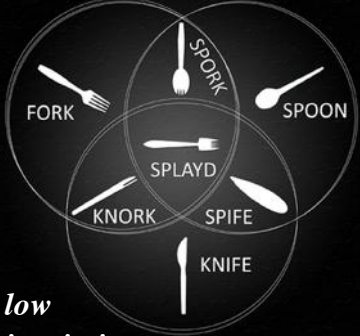
(c) 

The Big Bang Theory




TOWARDS A GRAND UNIFICATION OF CUTLERY

CLICKER: The 4 fundamental forces are NOT currently unified because...?



- (a) temperatures are too low***
- (b) all of the anti-matter is missing*
- (c) gravity does not operate at the atomic level*
- (d) there are other forces yet to be discovered*

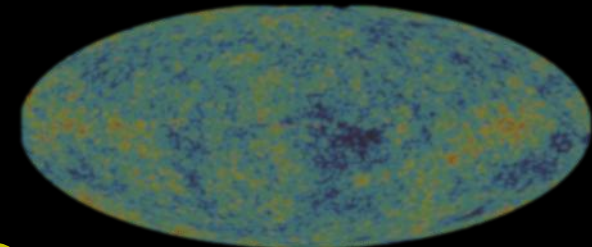
CLICKER: Which of the following best sums up your level of acceptance of the **Big Bang Theory**?

- 
- (a) **100%** (sign me up for the BBT newsletter)
 - (b) *mostly on board* (it DID inspire a hit TV show)
 - (c) *on the fence but open to the idea* (info is good)
 - (d) *critical* ("I want to believe", but...)
 - (e) *no way* (it's more likely **Elvis** is still alive)

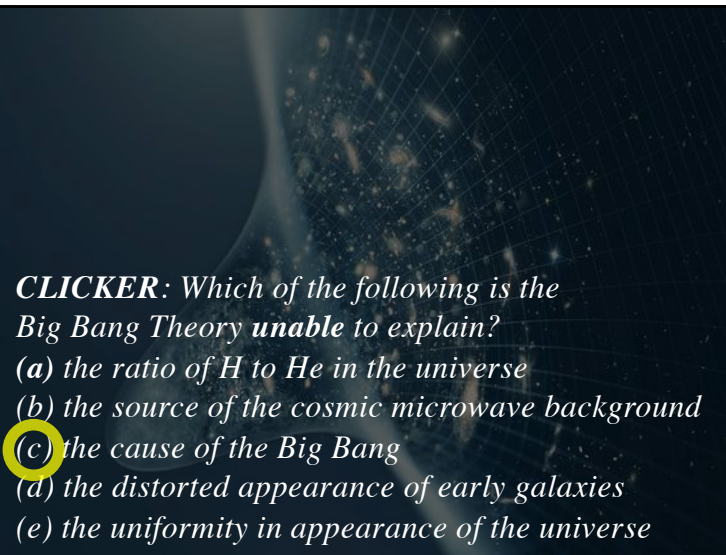
CLICKER: Which era saw the creation of the simplest elements on the Periodic Table?

- 
- (a) *Dark Ages*
 - (b) **Era of Nucleosynthesis**
 - (c) *Planck Era*
 - (d) *Particle Era*

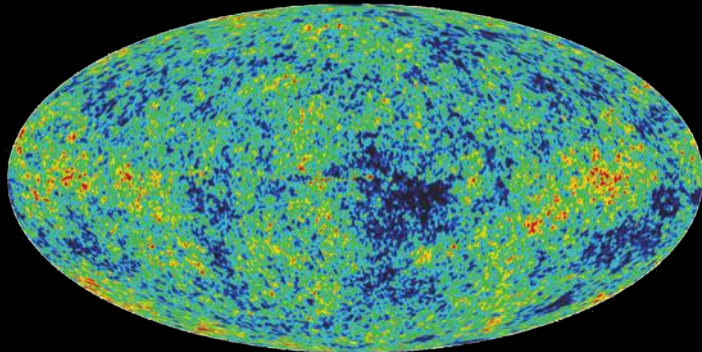
CLICKER: The slight temperature variations seen in the CMB are...?

- 
- (a) **precursors of galaxies & galaxy clusters**
 - (b) *measurement uncertainties*
 - (c) *variations due to dust in the Milky Way*
 - (d) *the signature of matter-antimatter reactions*

CLICKER: Which of the following is the Big Bang Theory *unable* to explain?

- 
- (a) *the ratio of H to He in the universe*
 - (b) *the source of the cosmic microwave background*
 - (c) **the cause of the Big Bang**
 - (d) *the distorted appearance of early galaxies*
 - (e) *the uniformity in appearance of the universe*

The Fate of the Universe



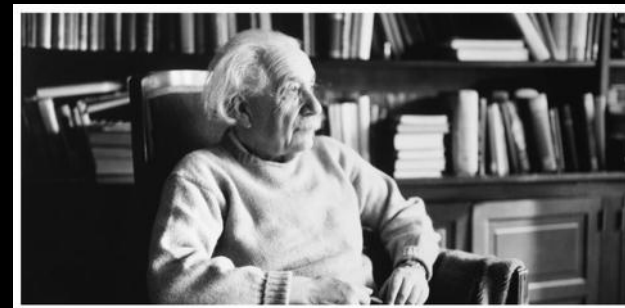
CLICKER: Why did early astronomers expect the expansion of the universe to slow?

- (a) friction*
- (b) run out of energy after 14 billion years*
- (c) interactions with the non-observable universe*
- (d) gravitational pull of all matter & energy*

CLICKER: The rotation curves of spiral galaxies implied to astronomers that

- (a) huge black holes existed in the spiral arms*
- (b) the gravity due to visible matter in galaxies was not enough to hold them together*
- (c) stars in galaxies were static and fixed in place*
- (d) galaxies spun more slowly than expected*

Our Strange Universe

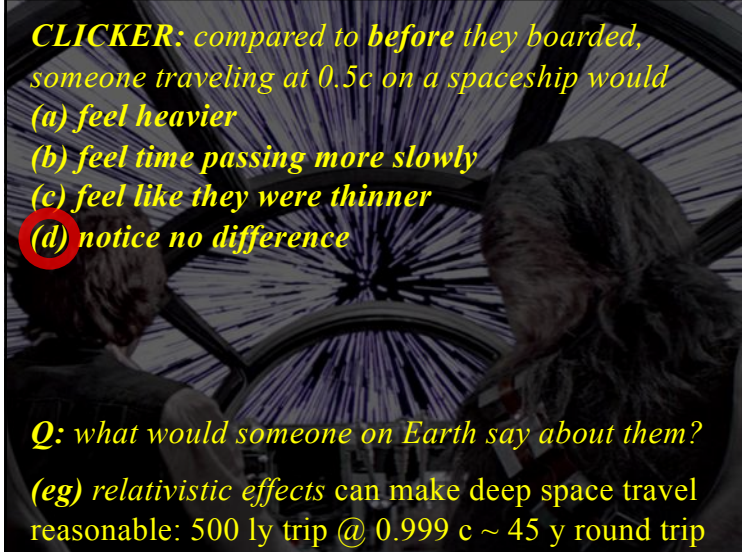


CLICKER: compared to before they boarded, someone traveling at $0.5c$ on a spaceship would

- (a) feel heavier*
- (b) feel time passing more slowly*
- (c) feel like they were thinner*
- (d) notice no difference*

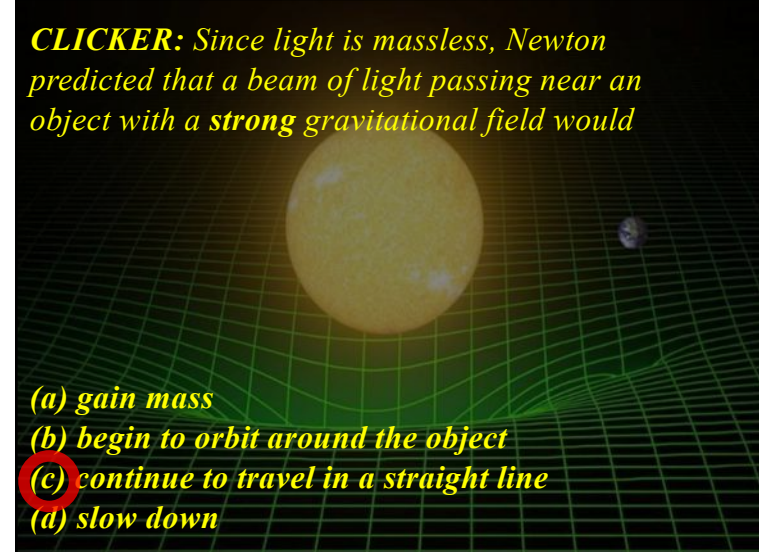
Q: what would someone on Earth say about them?

(eg) relativistic effects can make deep space travel reasonable: 500 ly trip @ $0.999c \sim 45$ y round trip

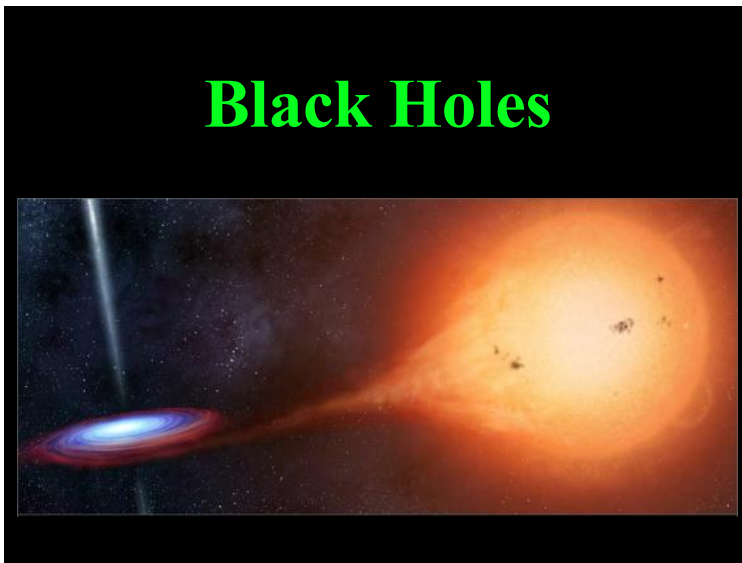


CLICKER: Since light is massless, Newton predicted that a beam of light passing near an object with a strong gravitational field would

- (a) gain mass*
- (b) begin to orbit around the object*
- (c) continue to travel in a straight line*
- (d) slow down*



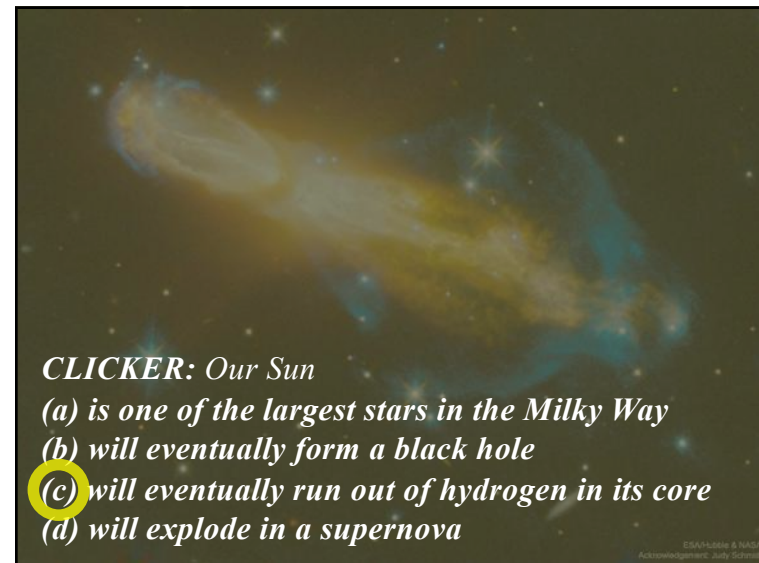
Black Holes



CLICKER: Our Sun

- (a) is one of the largest stars in the Milky Way*
- (b) will eventually form a black hole*
- (c) will eventually run out of hydrogen in its core*
- (d) will explode in a supernova*

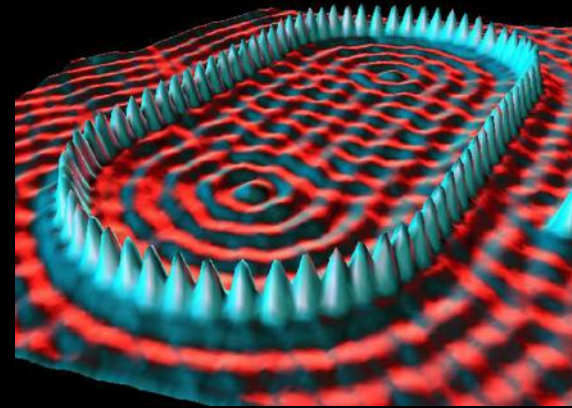
ESA-Hubble & NASA
Acknowledgements: Judy Schmidt



CLICKER: We believe the center of the Milky Way also contains a super massive black hole because...

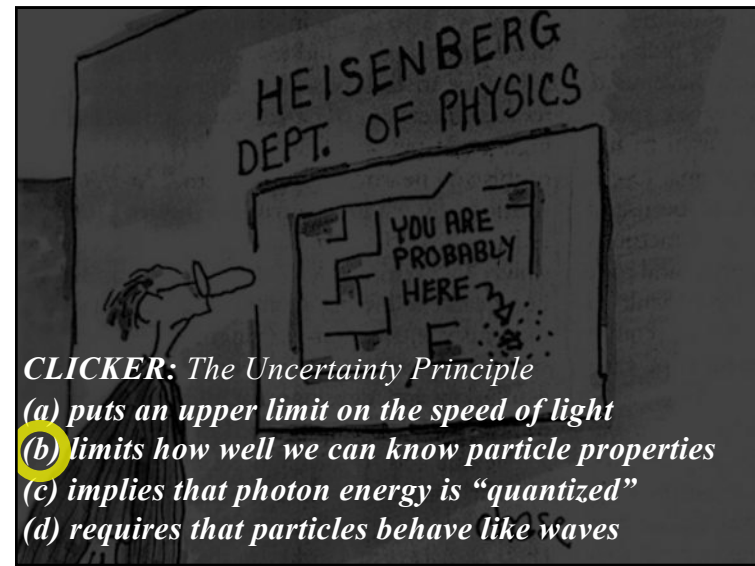
- (a) we have directly imaged it*
- (b) it emits powerful beams of visible light*
- (c) stars orbit incredibly quickly near the center*
- (d) the BH visibly lenses nearby star images*

Quantum Theory



CLICKER: Which of the following is correct?

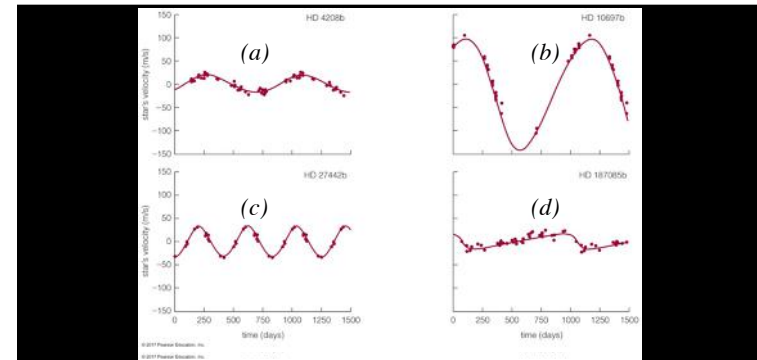
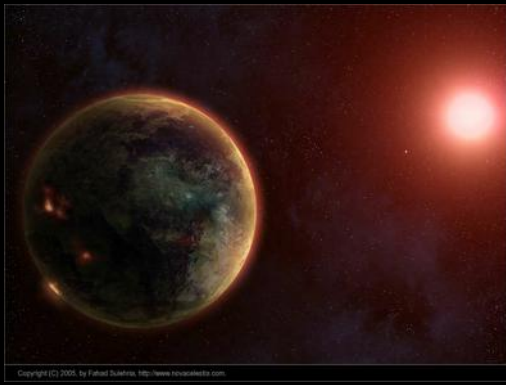
- (a) probability is at the core of quantum mechanics*
- (b) multiple, parallel universes do really exist*
- (c) time runs from past to present to future*
- (d) only certain particles behave like waves*



CLICKER: The Uncertainty Principle

- (a) puts an upper limit on the speed of light*
- (b) limits how well we can know particle properties*
- (c) implies that photon energy is "quantized"*
- (d) requires that particles behave like waves*

The Search for Extraterrestrial Life



CLICKER: assuming the same sized star for each graph above, which curve above shows:

- the planet with the fastest orbit **c**
- the planet with the most elliptical orbit **d**
- the planet with the largest mass **b**

