

Foundations in Astro

Astronomy

Karl Steffin, 2006

8/8/2024





Upside down World Map

© Copyright Hema Maps Pty Ltd 2003

LEGEND

Capital ■ City, Town ●

Hema Maps Pty Ltd

Ph: +61 7 3340 0000 Fax: +61 7 3340 0099

Web: www.hemamaps.com.au

Email: manager@hemamaps.com.au

Hema Maps NZ Limited

Ph: +64 9 273 6459 Fax: +64 9 273 6479

Email: sales.hema@clear.net.nz

ISBN 1-86500-168-6
9 781865 001685

This class will require you to look at things from a different perspective.

The Big Picture

Astronomy (Greek: Law of the Stars)

The study of the Universe and phenomenon.

We perceive what we are familiar with, what makes sense.

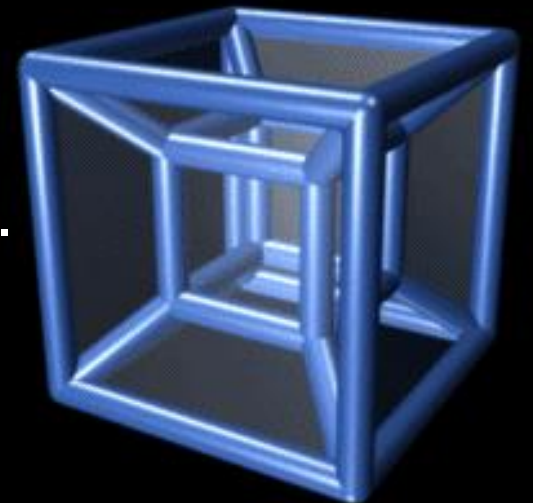
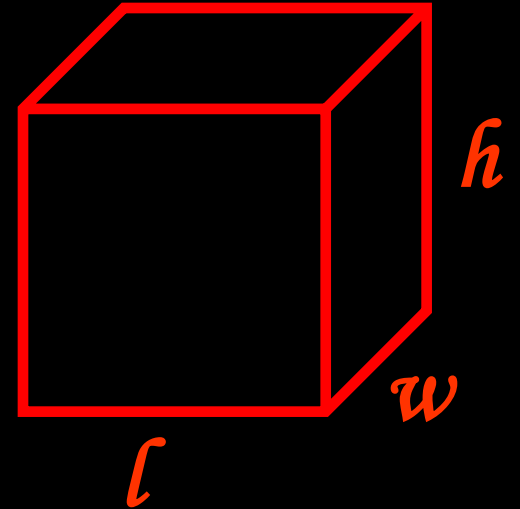
Talking about 'everything' requires agreed upon terms and ideas to progress understanding and discovery forward.

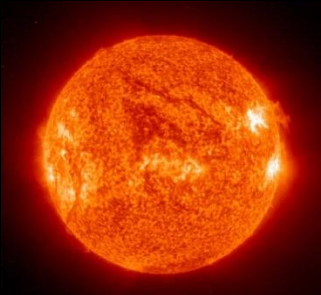
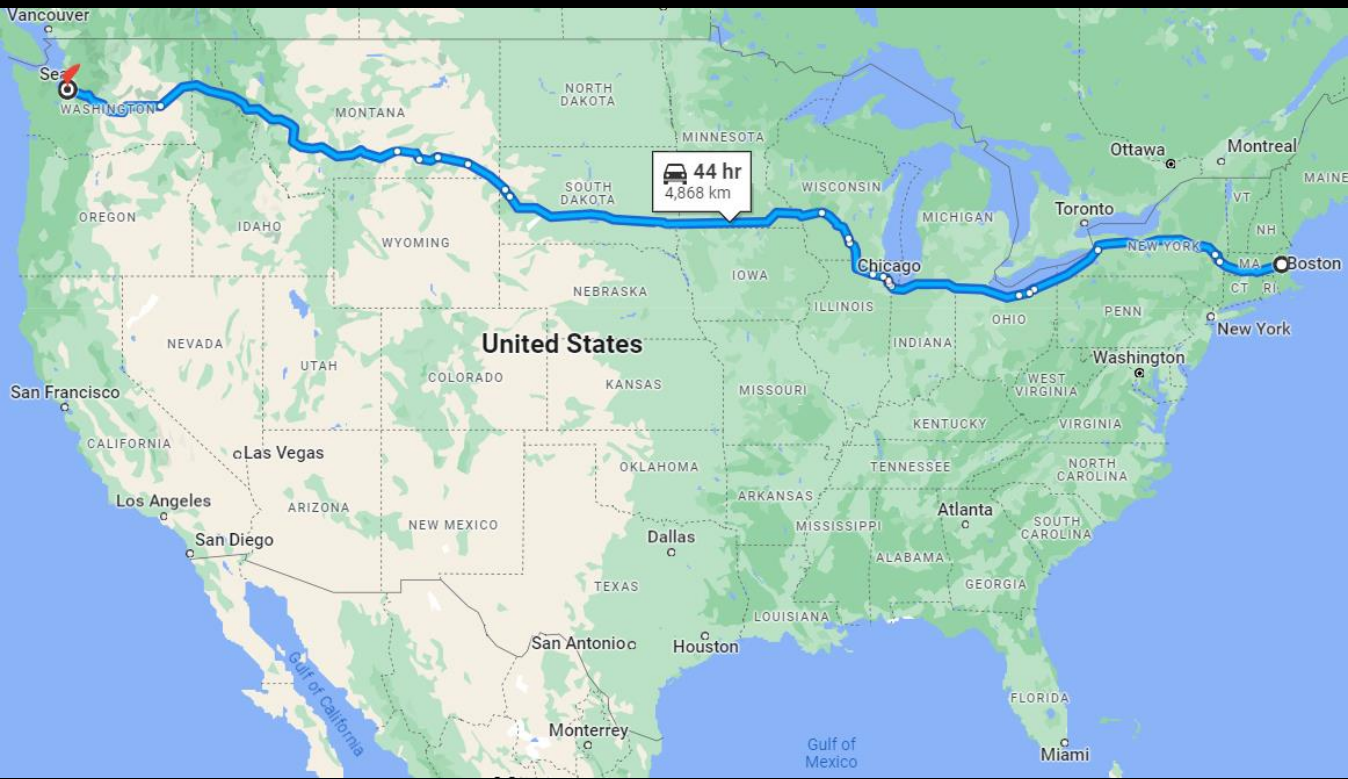
Using terms both correctly and appropriately is key.

You are 530 billion seconds old may not be wrong but more appropriate would be saying your 17 years old

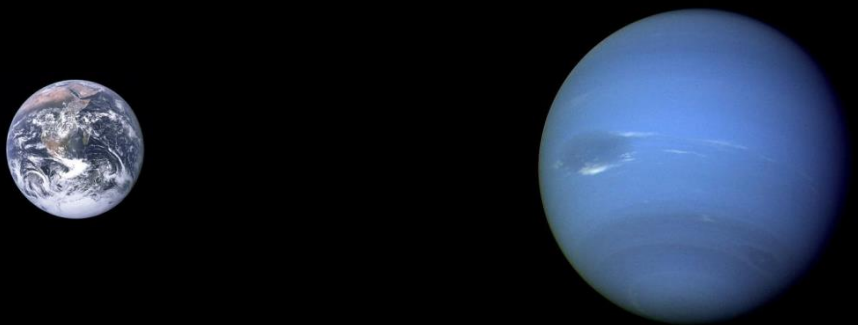
Units of Measure (Length)

- Dimension: A measure in space (3 spatial).
- Measuring from the Sun:
 - ◆ 149,600-kilometers (roughly 93 million miles)
 - ◆ 1 AU (Astronomical Unit)
 - ◆ 1.58×10^{-8} -LY (Light Year)... 8.33-Light Minutes.
- Best Tool For the Job?
 - ◆ km should be used for describing planet features and sizes.
 - ◆ AU should be used for distances between solar objects.
 - ◆ LY should be used for distances between stars.
 - ◆ Parsec can be used for distances of galaxies (and longer).

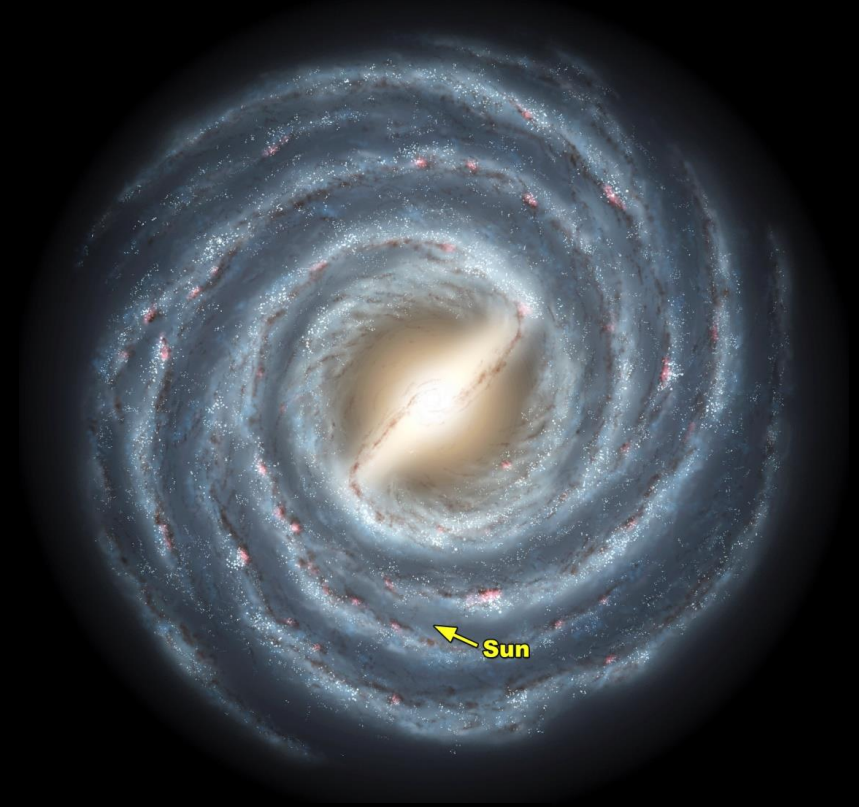




4.25-ly



30-AU



30,675-pc

Units of Measure (Time)

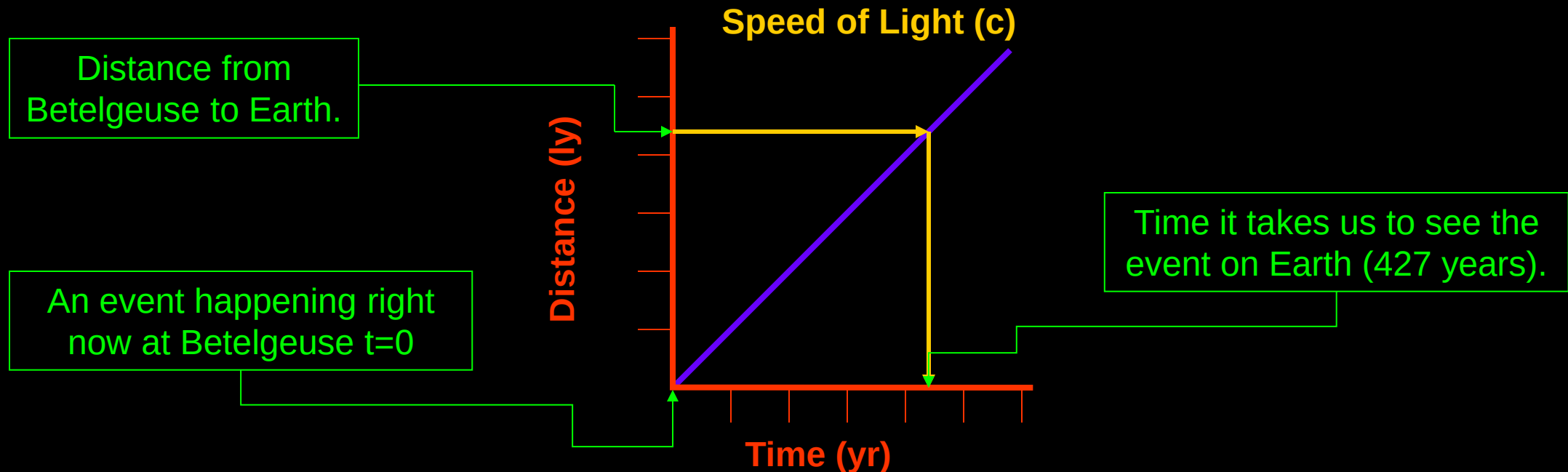
- Event: An occurrence and arbitrary point in time.
- Time: measurable *period* during which an action exists or continues. (s/min/hr)
 - ◆ Day: The time it takes an object to revolve around its own axis. ($D_E = 23.934$ hr)
 - ◆ Year: The time it takes an object to revolve around a star. ($Y_E = 365.25$ day)

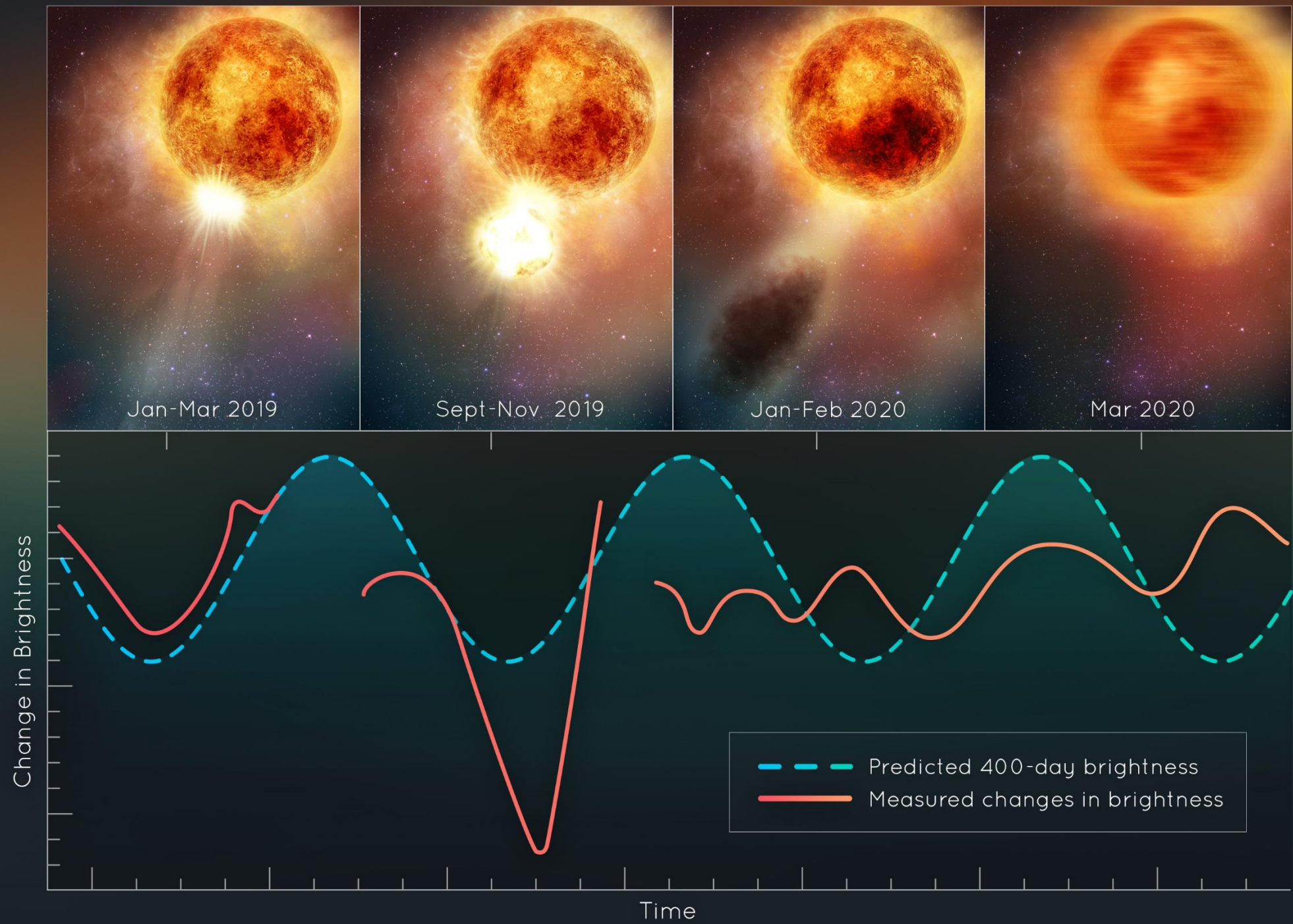


The Fates (Moirai)

Lookback Time

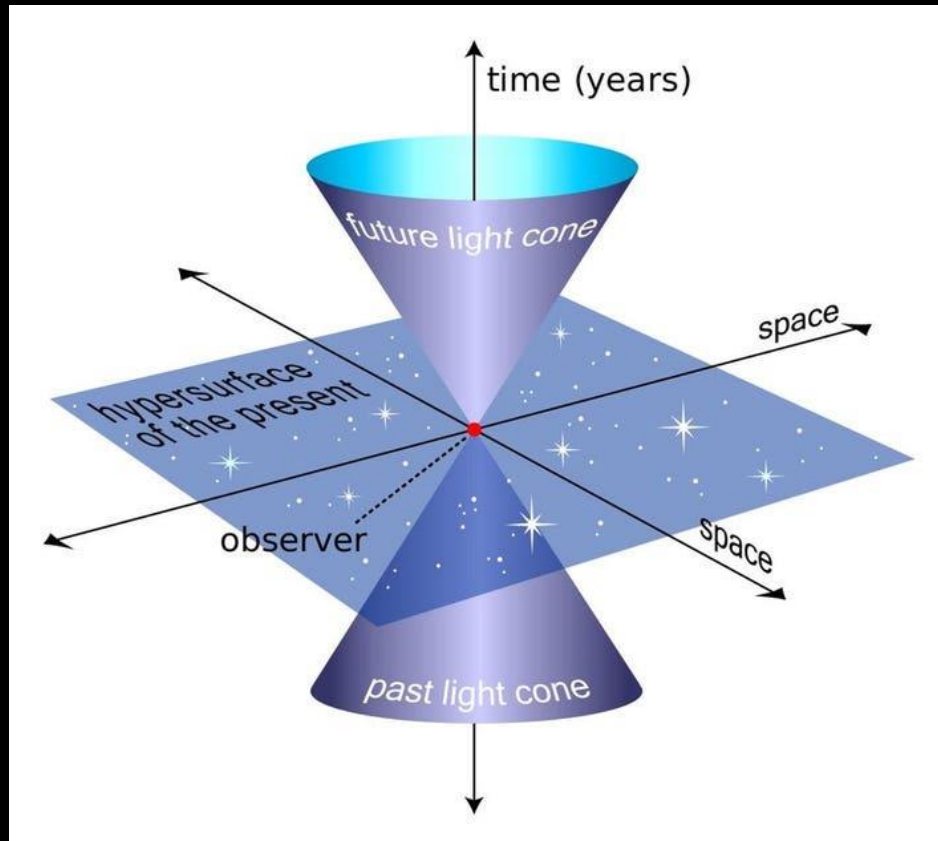
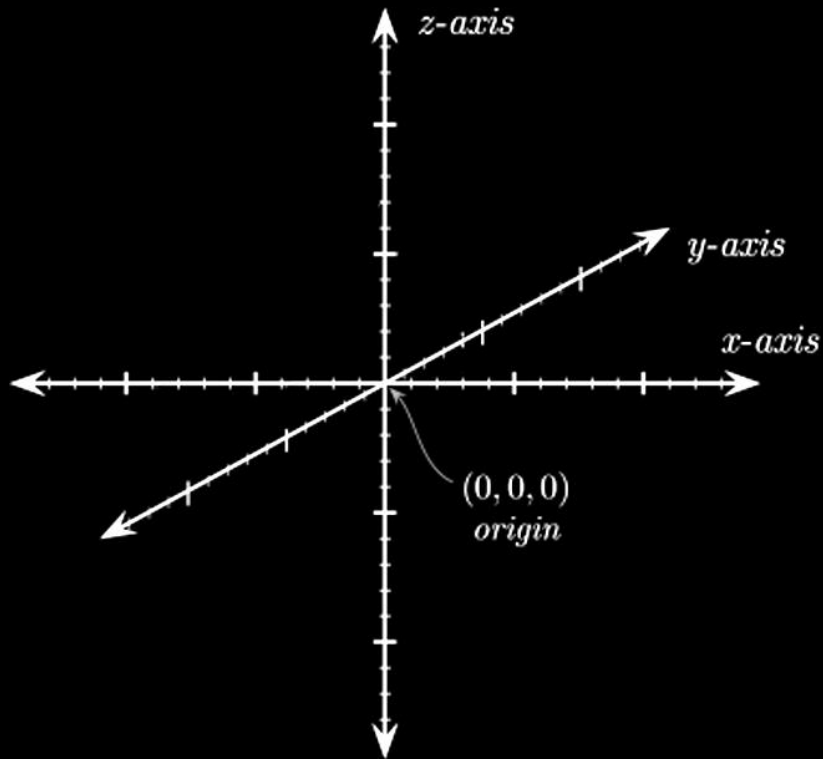
- Using the EM Spectrum to collect information has limits.
 - ◆ Supergiant star Betelgeuse (beetle juice) is 427-ly away. An event happening on Betelgeuse right now would take 427 years for us to see... we would be looking back at what happened.





Linked together: LWH & Time

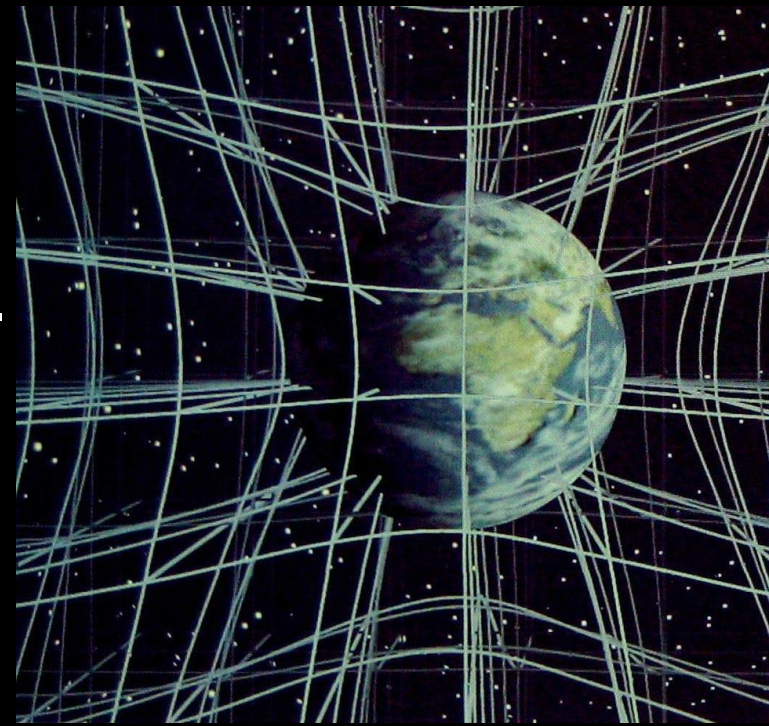
- Space-Time: The combination of 3-D space with 1-D time.



Remember the Sun is about 93-million miles away? Driving without stop at 60 mph would take you 176 years. Velocity/Acceleration are useful tools that combine the dimensions of time and space together.

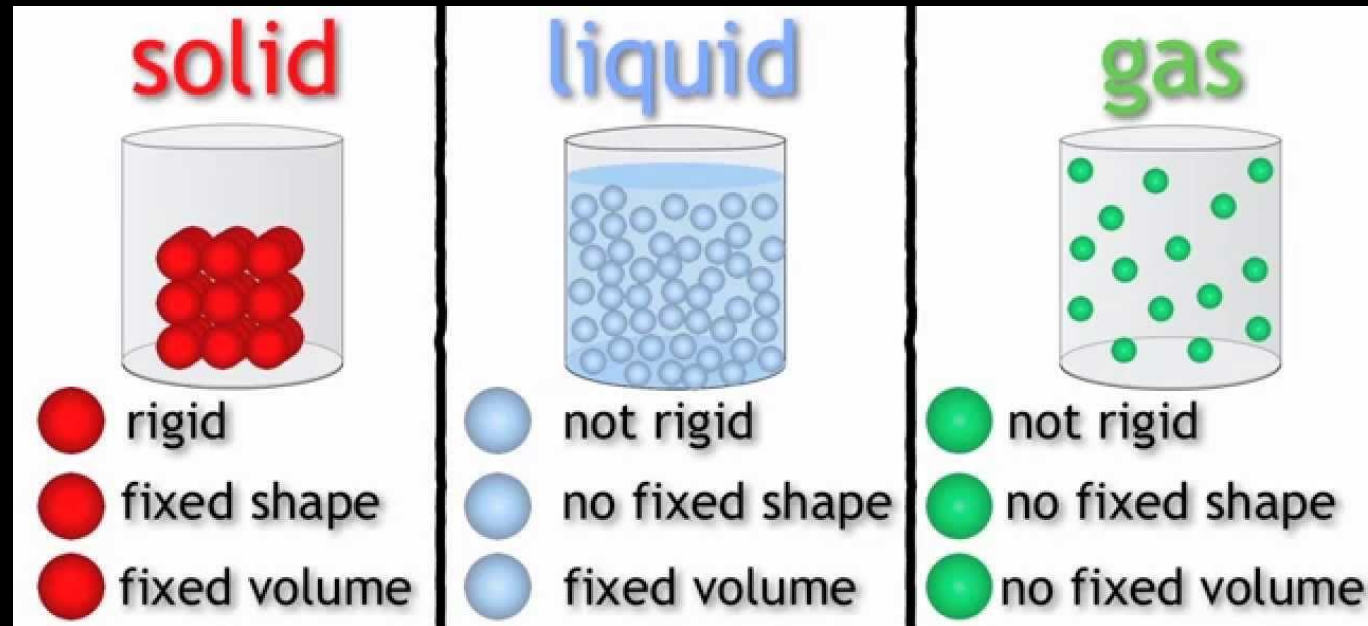
Units of Measure (Stuff)

- Mass: Amount of matter that occupies a place in space.
 - ◆ Anything that takes up space. (Kilogram)
 - ◆ The more mass the more inertia: the resistance of an object changing its movement.
 - ◆ The more mass does not mean more size.
- Mass attracts mass by the basic force of gravity.
- All things with mass have gravitational attraction.



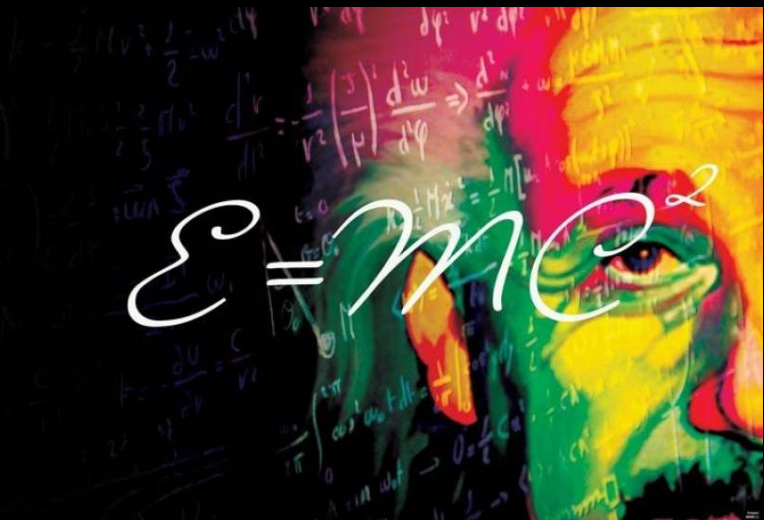
Units of Measure (Energy + Matter)

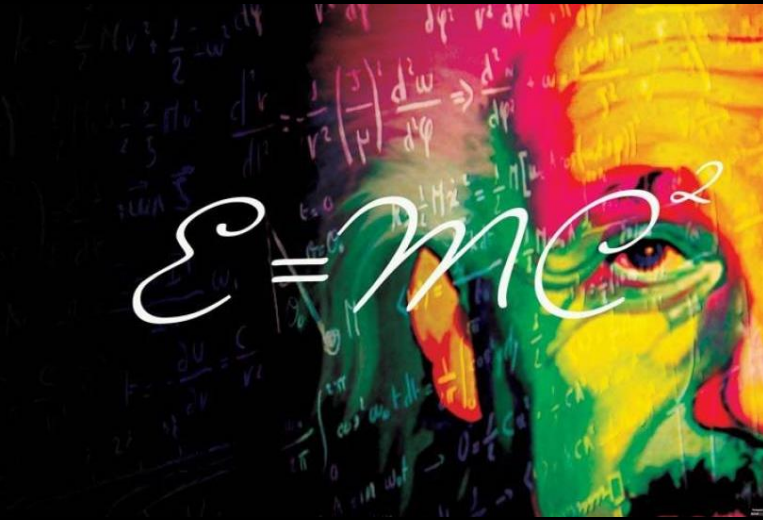
- Energy: Ability of a system to do work. Joule (J)
- Matter: Material that makes up the universe.
- Weird things happen in the Universe:
 - ◆ Plasma: Flowing sea of electrons.
 - ◆ Bose–Einstein condensate: Super cold, collapsed matter.
 - ◆ Some planets rain diamonds While others have ice (Ice XVIII) that is half as hot as the sun!
 - ◆ Superfluid's (Helium-3) can climb walls and don't slow down (no viscosity).

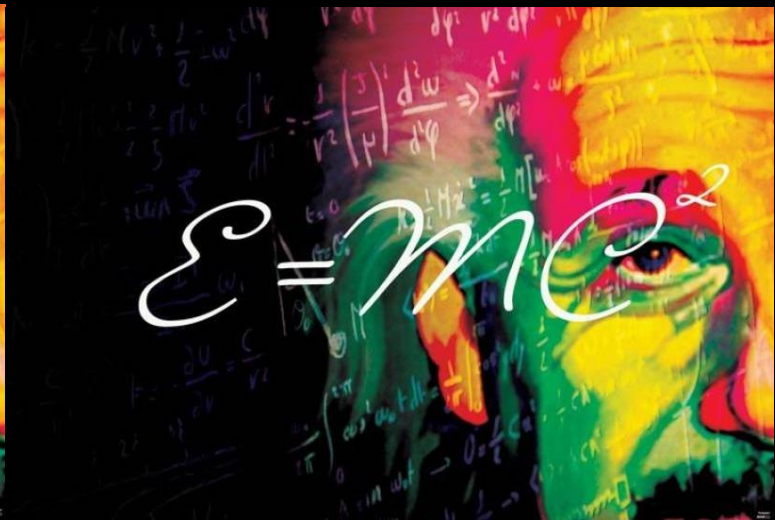


Conservation: The Big Three

- The three laws governs all!
- 1. Energy/Matter can not be created.
- 2. Energy/Matter can not be destroyed.
- 3. Energy/Matter can only be changed.

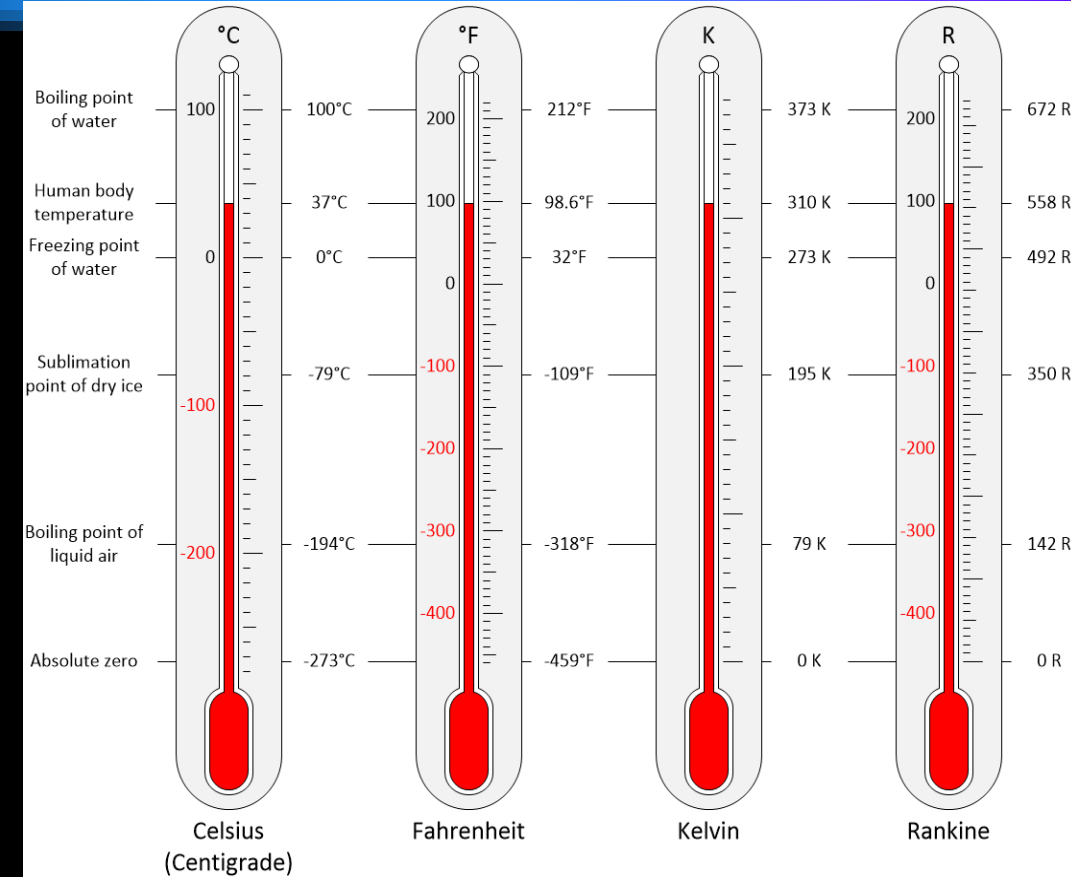

$$E=mc^2$$


$$E=mc^2$$


$$E=mc^2$$

Units of Measure (Heat)

- Temperature: Amount of energy present in matter.
 - ◆ Kelvin ($273.15\text{-K} = 0\text{-}^{\circ}\text{C}$).
 - ◆ $> \text{temp} \rightarrow > \text{movement} \rightarrow \text{'hotter'}$
 - ◆ Absolute Zero: All movement in matter stops (0-K)
- Luminosity: The amount of radiation a body emits per second, how bright an object is (Watts).



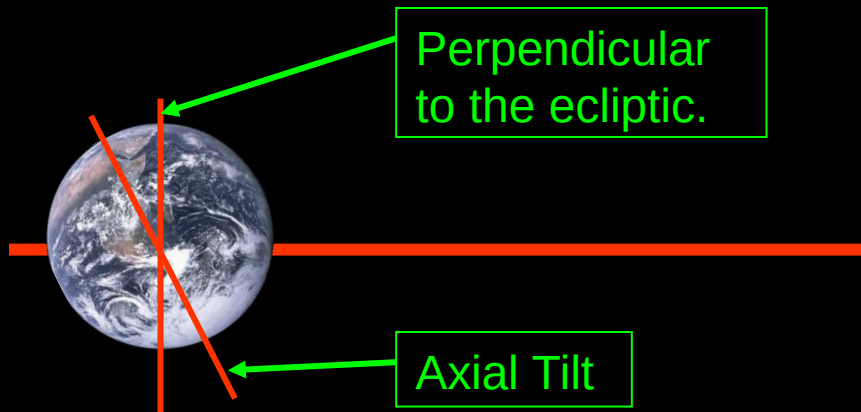
BRIGHTNESS IN LUMENS		220+	400+	700+	900+	1300+
	STANDARD	25W	40W	60W	75W	100W
	HALOGEN	18W	28W	42W	53W	70W
	CFL	6W	9W	12W	15W	20W
	LED	4W	6W	10W	13W	18W

Temperature (K)	Event
38×10^{-12}	Lowest made in a lab
3	Average interstellar
258-388	Life (Human= 310)
273	Asteroid Belt
283	Above Earth
288	Surface Earth (184-330)
5778	Surface of the Sun
16,000,000	Center of the Sun
$8000 - 1 \times 10^8$	Nuclear Bomb (Fat Man)
2×10^9	Hottest made in lab (LHC)
142×10^{32}	Theoretical Max

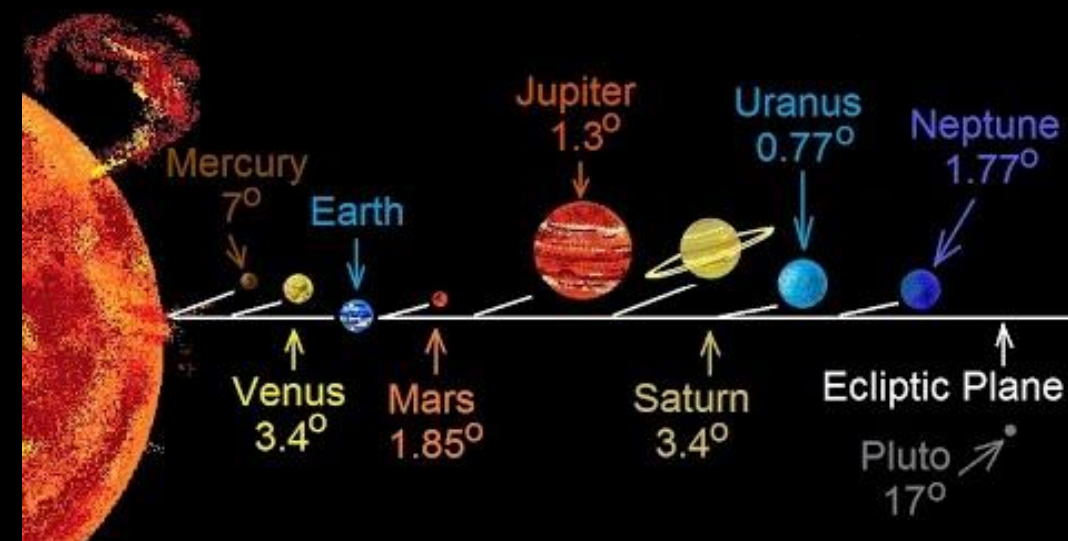
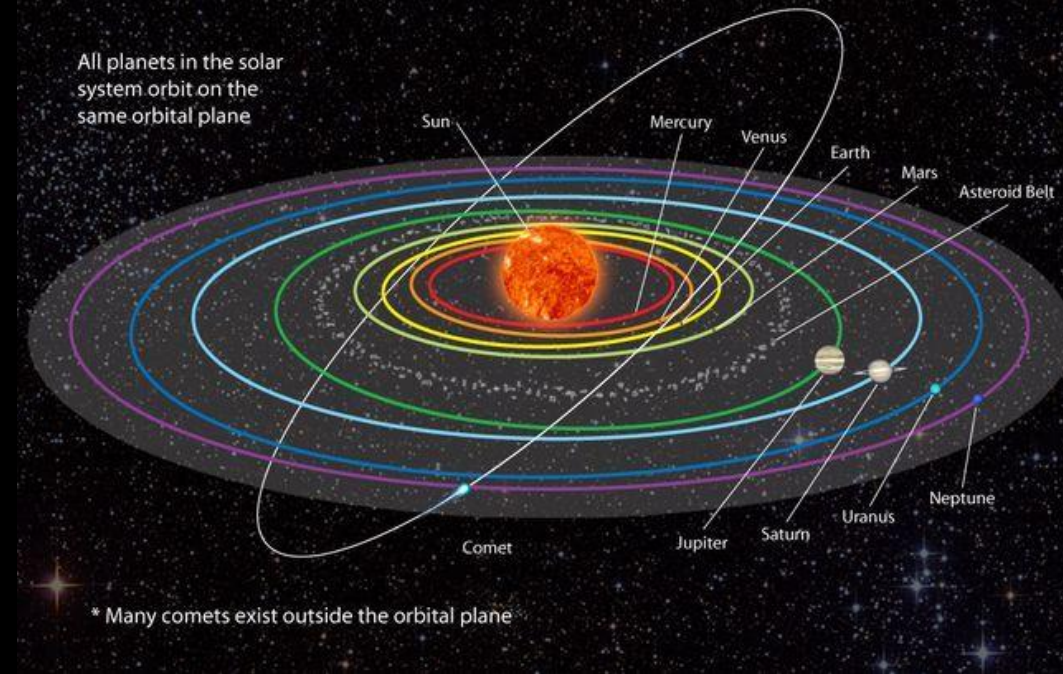


Motion of the Heavens

- Orbit- The path that an object (planet) makes around another object (sun) while under the influence of gravity.
- Ecliptic- The plane that the Earth travels around the Sun. Most of the planets also orbit on the same plane.
- Axial Tilt- The offset of a planet to the ecliptic. A tilt is what causes seasons on planets.

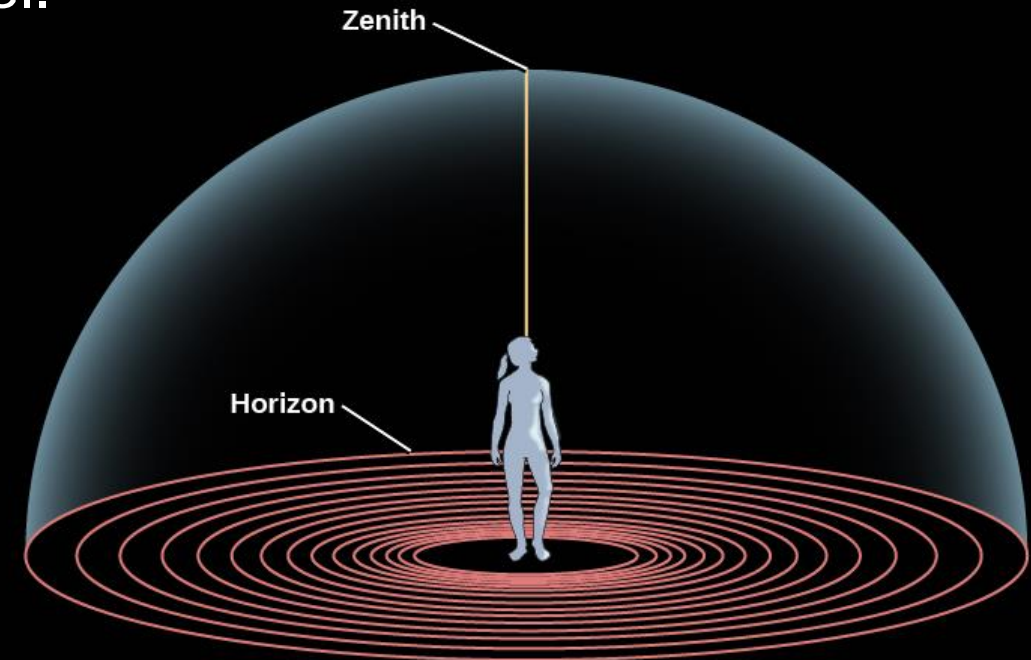


Orbital Plane



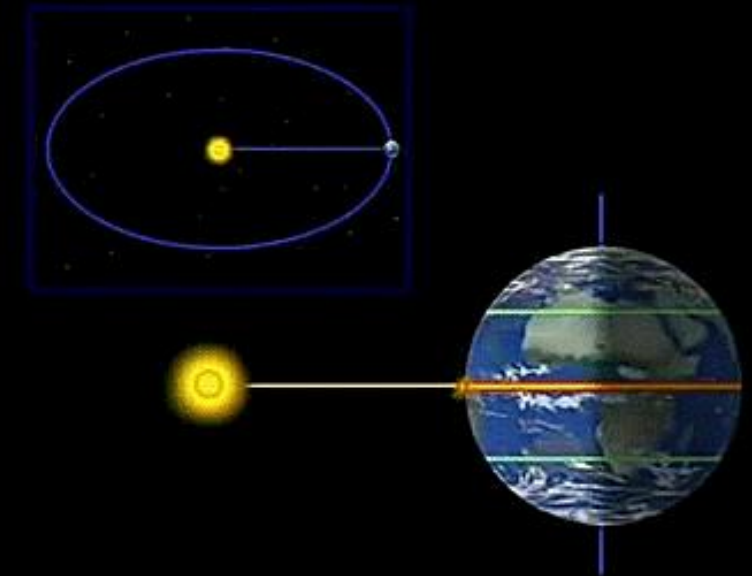
A Look from Earth

- Horizon- The line that separates the earth from the sky.
- Zenith- The line straight up from where you are standing.
- Kármán line- Space begins at 100-km above sea-level (FAI)
 - ◆ US- Space beings at 80-km above sea level.



A Look from Earth

- Exosphere- The transition from the Earth to Space.
- Escape Velocity- The speed an object must travel in order to break free from the pull of gravity. ($V_e = 11.2 \text{ km/s} \rightarrow 25,054 \text{ mph}$)
- Equinox- When the Sun crosses the equator; equal day and night. (3+9/21)
- Solstice- When the Sun is furthest from the equator; longest **day** and **night** in Northern Hemisphere (6+12/21)



A Look from Earth: The Moon

Near Side



Far Side



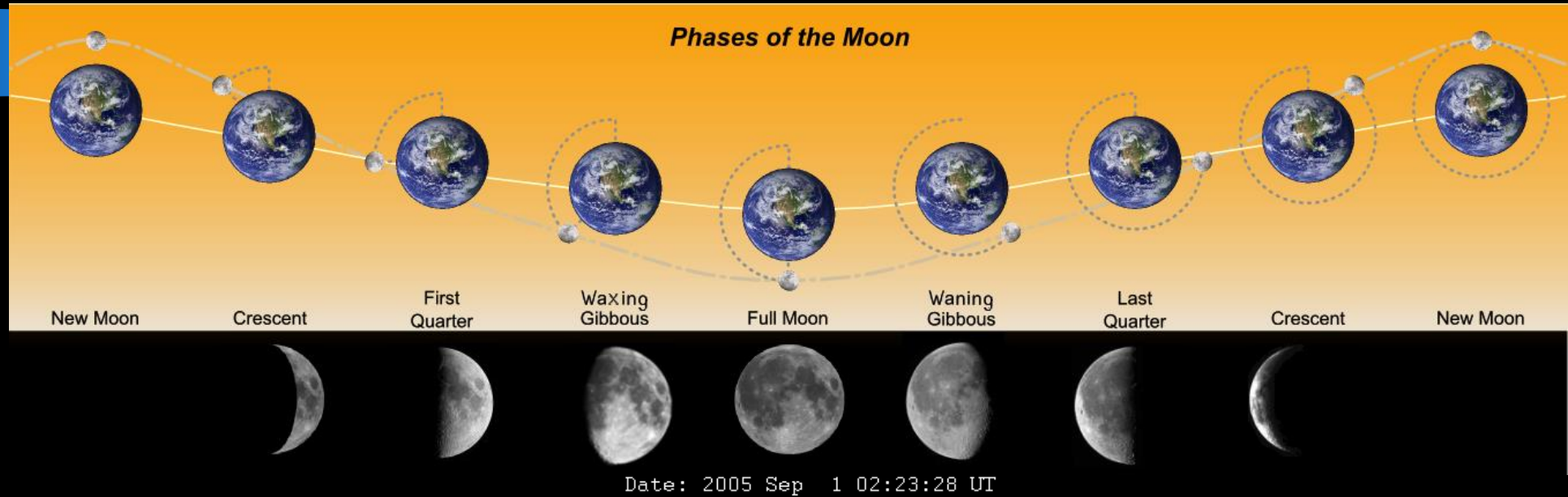
Phases (of the Moon)

- Full Moon- Moon is fully illuminated.
- New Moon- Moon is not illuminated.
- Crescent- Moon is partially illuminated
- Gibbous- Moon is mostly illuminated.
- Waxing- The process in which the moon is becoming more illuminated (New→Full).
- Waning- The process in which the moon is becoming less illuminated (Full→New).

MOON PHASES



Another Look



Full Moon's by Month

Month	Names (Native or Folk Lore)
January	Moon After Yule, Old
February	Snow, Hunger, Wolf
March	Sap, Crow, Lentin
April	Grass, Egg
May	Planting, Milk
June	Rose, Flower, Strawberry
July	Thunder, Hay
August	Green Corn, Grain
September	Fruit, Harvest (if closest to the equinox)
October	Hunter, Harvest (if closest to the equinox)
November	Frosty, Beaver
December	Moon Before Yule, Long Night
Blue (Black)	The second full moon in the same month. (perigee/Super)

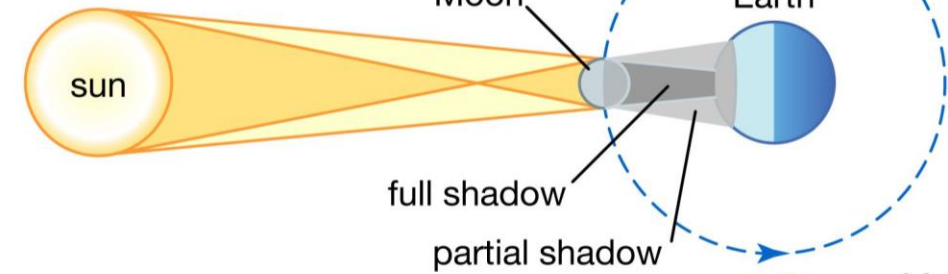
Aligning the Moon

- The moon's orbit is tilted and crosses the Earth's ecliptic twice every cycle.
- Lunar Cycle- The moon orbits the Earth every 29.5 days.
- Eclipse- When the Sun-Moon-Earth line up and either sun or moon's light is blocked.

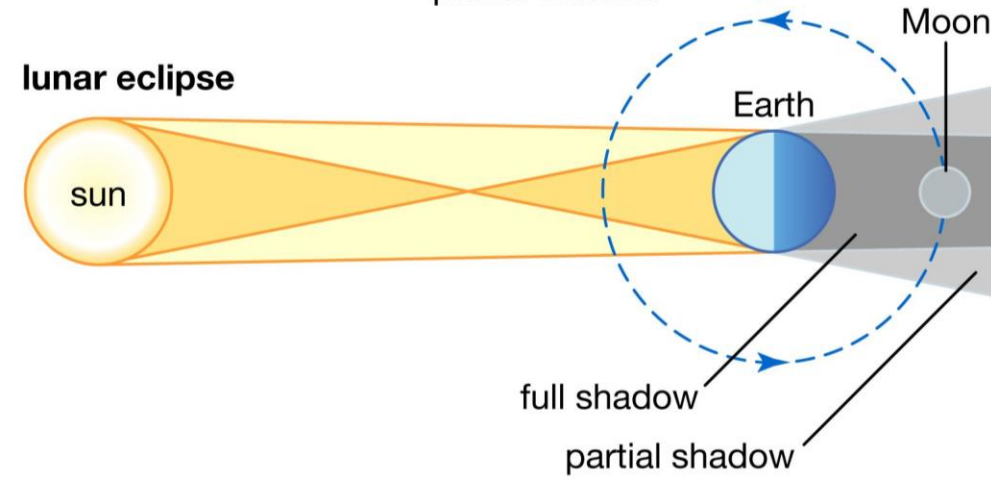
The moon's orbit is tilted.



solar eclipse



lunar eclipse





Randy Brewer

October 27, 2004

Upcoming Total Lunar Eclipses:

3/14/25 (Americas)

9/7/25 (Asia, W. Australia)

3/3/26 (Pacific, W USA, NZ)

12/31/28 (Asia, W. Australia)



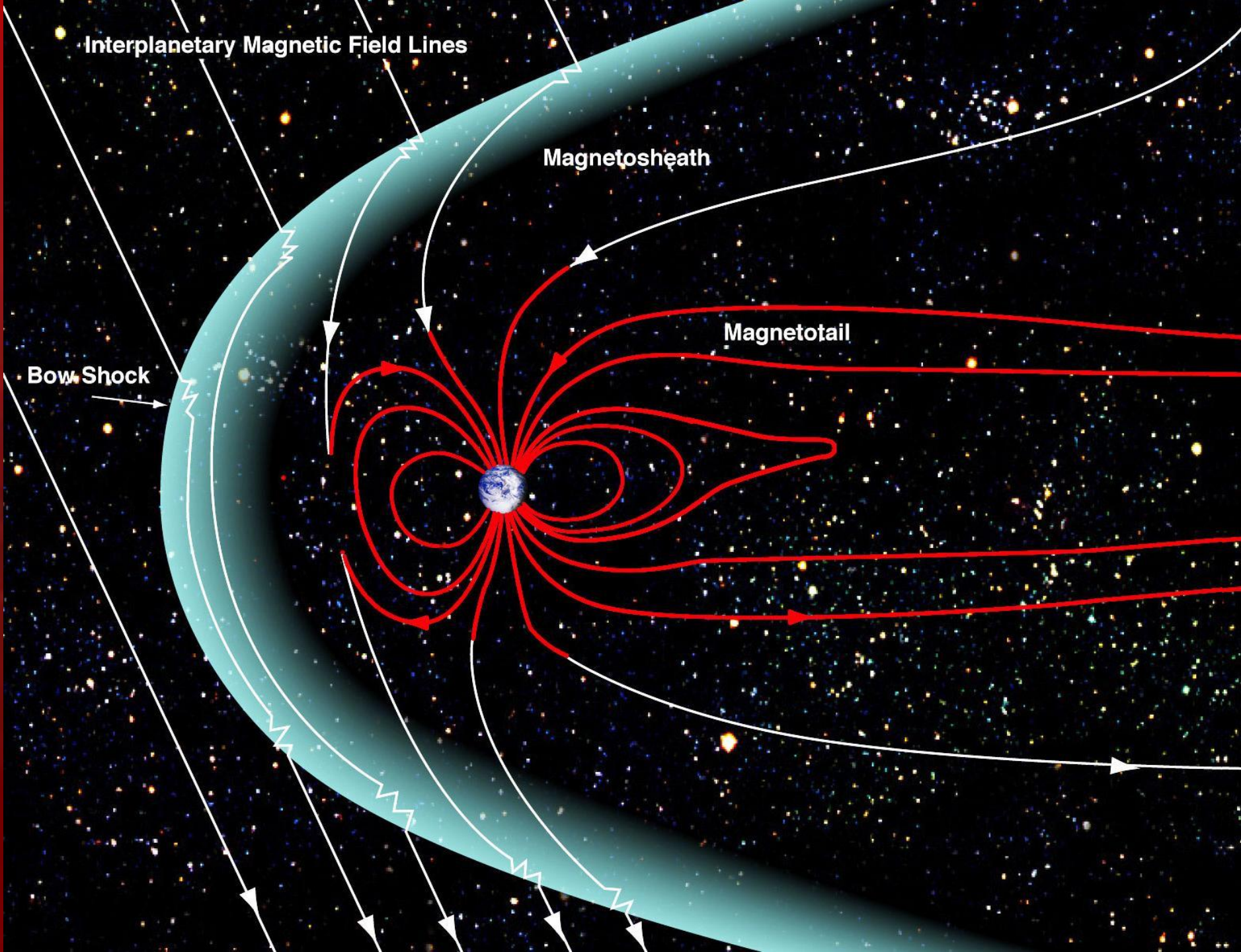
Upcoming Total Solar Eclipses:

8/12/26 (Arctic, G/I Land, Spain)	8/2/27 (S Europe, N Africa)
7/22/28 (Australia)	11/25/30 (S Africa, Australia)

Solar (Stellar) Winds



- The sun emits energetically charged particles in the form of plasma.
 - ◆ These particles travel outward in all directions and can interact with anything in its path.
- Stars and planets with magnetospheres can deflect these charged particles.
- Strong solar Winds can be responsible for electronic disturbance and failure on Earth.



Light up the sky: Aurorae



- An Aurora/Eos (Roman/Greek titaness of dawn) is a bright glowing of the sky due to particles in the magnetosphere interacting with solar winds.
 - ◆ Normally seen at night following the magnetic field lines.
 - ◆ Aurora Borealis (north wind)- ‘Northern Lights’ Seen from Sept-Oct and Mar-Apr.
 - ◆ Aurora Australis (of the south)- Seen in the southern hemisphere.
 - ◆ Aurora’s have been found on Jupiter and Saturn which have greater Magnetic fields.

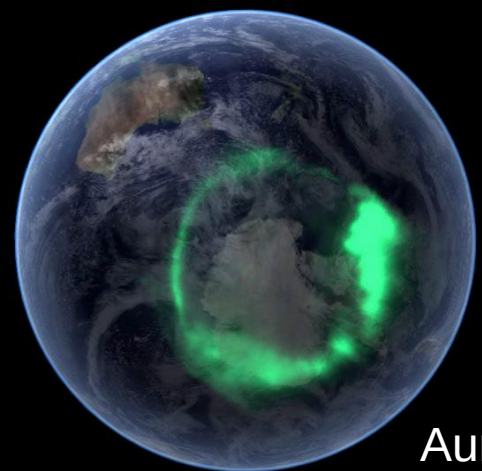


Aurora Borealis (Sweden)



↑Seattle (May 2017)

↓Flagstaff (April 2023)



Jupiter Aurora



Aurora Australis



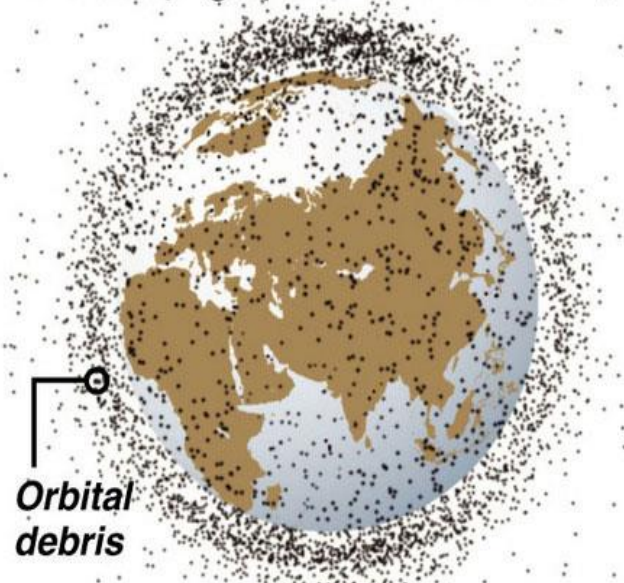
Other 'Stuff' in the Sky: Natural

- Planetesimals- Small objects orbiting in the solar system.
- Planet- (Gr: Wanderer) A large mass orbiting a star.
- Satellite- Any object orbiting another object.
- Star- A large mass of plasma that currently produces or has produced energy through nuclear fusion.
- Nebula- An interstellar cloud of dust, gas and plasma.
- Galaxy- A grouping of stars, nebulae, and other stuff bound by gravity.
- Universe- The known boundaries of all things and events.

Other 'Stuff' in the Sky: Space Junk

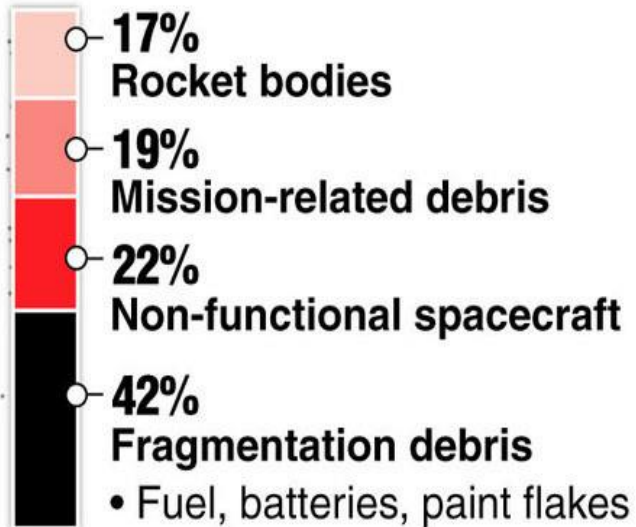
Space debris

Orbital debris, any man-made, nonfunctional object orbiting Earth, is cluttering space and can sometimes cause trouble.



- Low Earth orbit region of space, within 1,240 mi. (2,000 km) of Earth's surface, is most concentrated area for orbital debris

Breakdown of debris

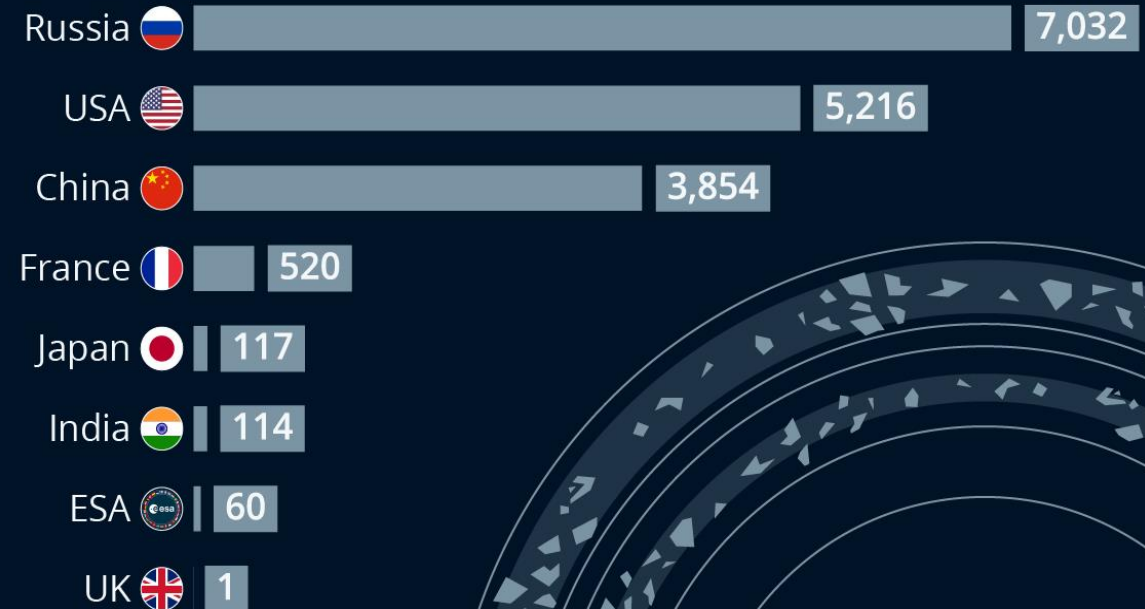


- **11,000 objects** greater than 4 in. (10 cm)
- **100,000 objects** between 0.4-4 in. (1-10 cm)

Source: NASA

Who's Responsible for Space Junk?

Number of spent rocket bodies and other pieces of debris

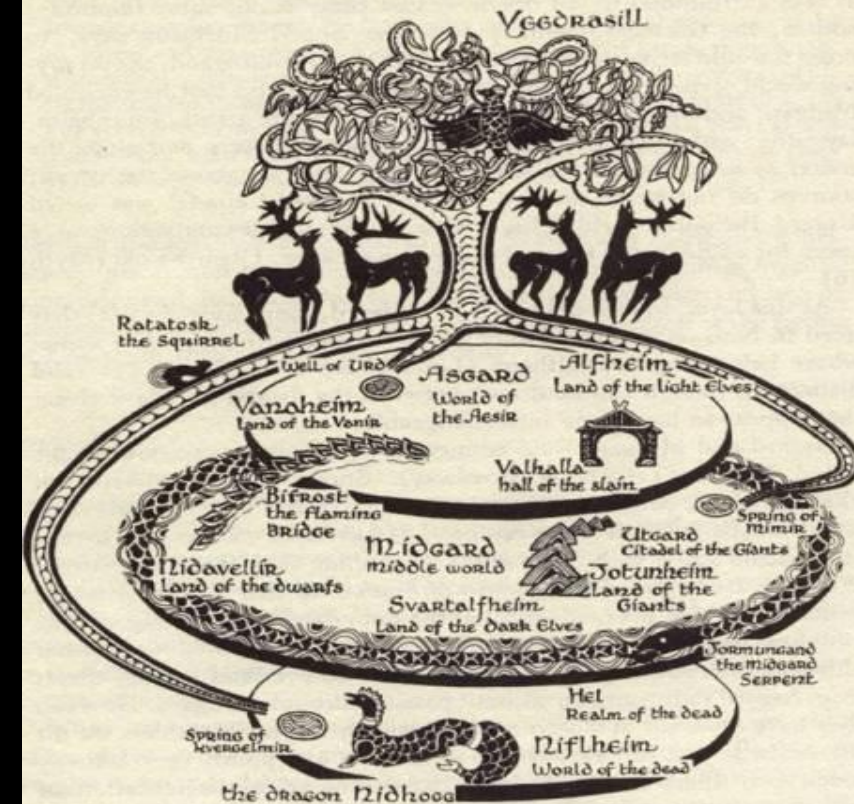


* as of 4 Feb 2022

Source: Orbital Debris Quarterly News, NASA

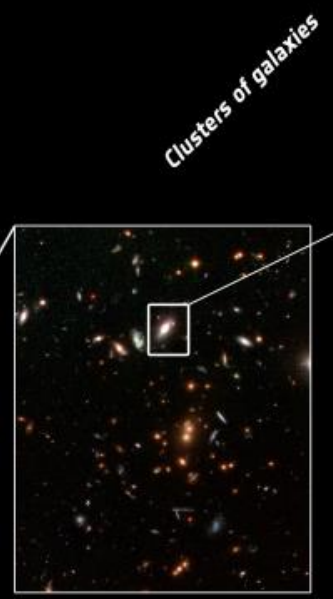
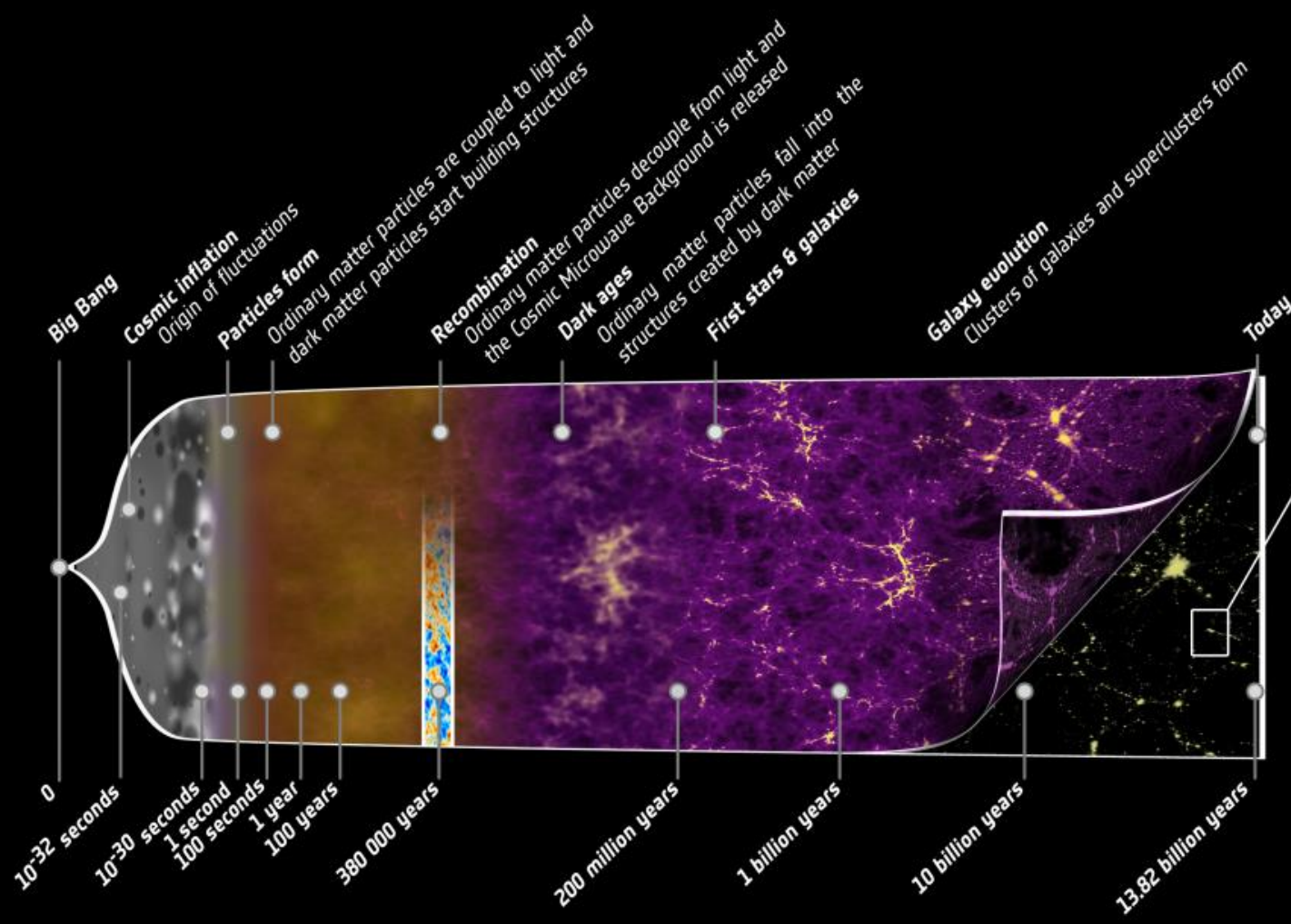
Cosmology

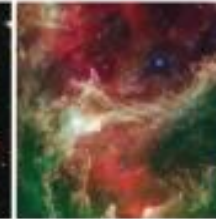
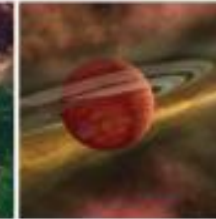
- Cosmology- The study of **humanities** place in the **Universe** and the **history** and **future** of the Universe.
- Cosmos- (Gr: order) The harmony of the Universe.
- Chaos- (Gr: Unpredictable) The 'emptiness' of order. Mistaken for disorder in early translations of the word.
- Entropy- The gradual decline from order to disorder.



Cosmological Theories

- Big Bang- The idea that everything started (13.7 billion-yr) with an infinitely hot and dense singularity (1D point in space)
- Big Crunch- The idea that if gravity overpowers expansion of the universe all things will come back together.
- Steady-State Theory- Failed model that states the look of the Universe does not change over time. For this to be true matter must be created (~ 100 H per yr in the MWG).



January	February	March	April	May	June	July	August	September	October	November
										

Big Bang occurs.

Milky Way Galaxy forms.

Our solar system forms. Life on Earth begins.

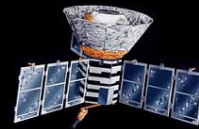
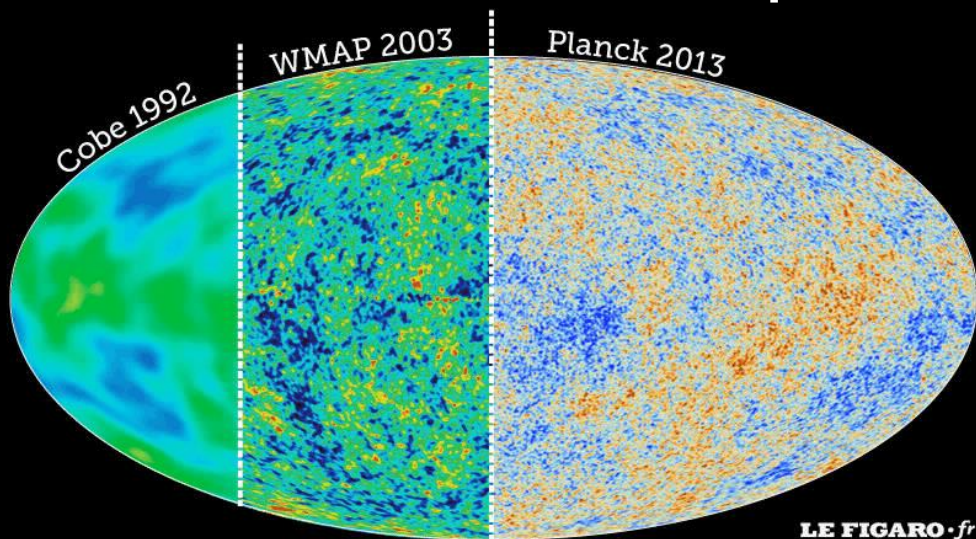
Earth's atmosphere becomes oxygenated.

First complex life forms appear.

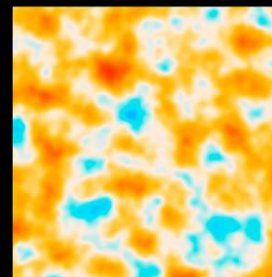
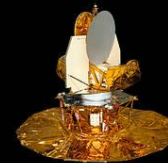
December						
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19 Vertebrates appear.	20 Land plants appear.	21
22	23	24	25 Dinosaurs appear.	26 Mammals appear.	27	28
29	30 Dinosaurs become extinct.	31 Humans appear.				

Cosmological End Game

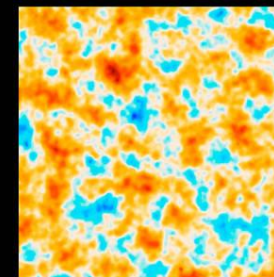
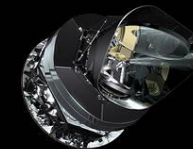
- Since the Big Bang, the Universe has been expanding.
- The fate of the Universe centers around one big idea:
Will gravity's pull to bring everything together be stronger than the expansion of the Universe?



COBE



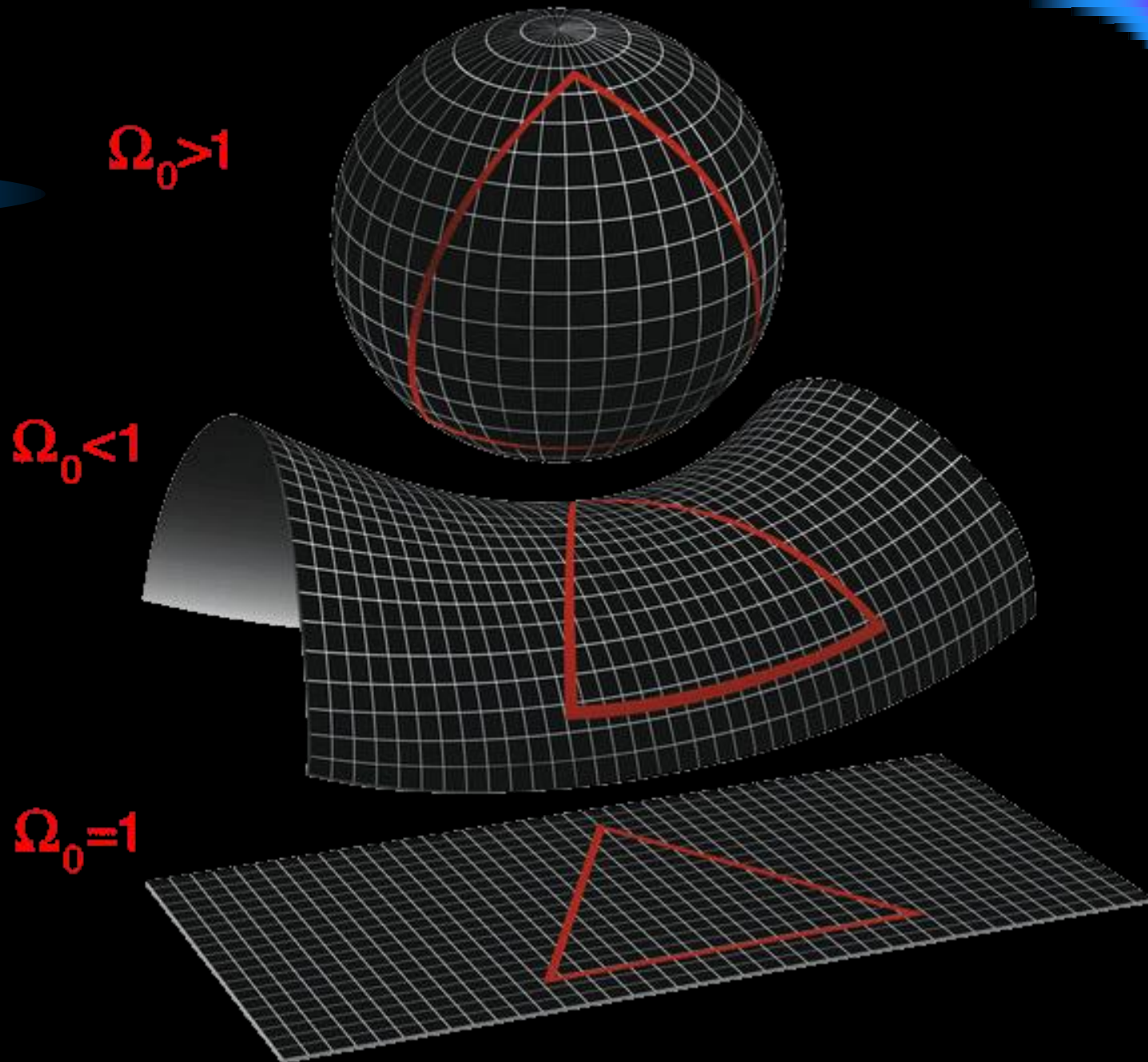
WMAP



Planck

The Shape of Things

- Predictions as to the shape of our Universe can be made using math based on the interactions between mass and expansion.



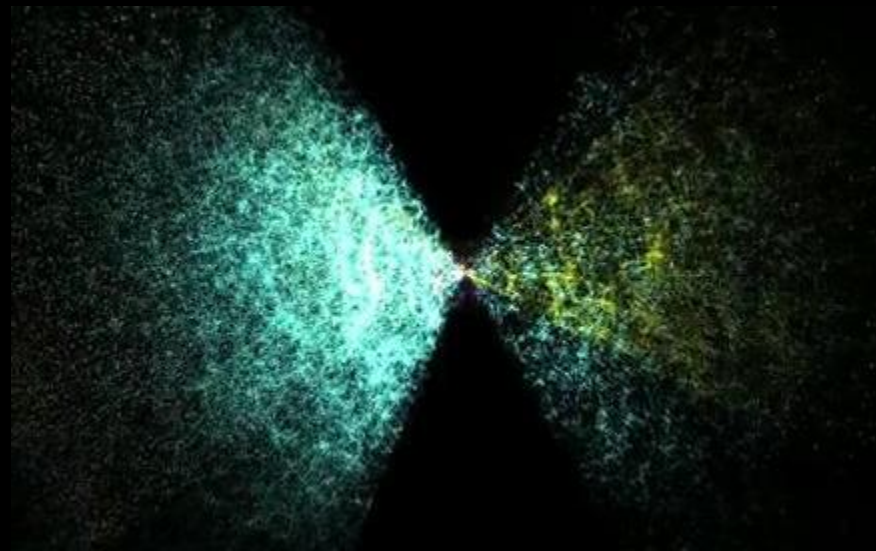
Cosmological Theories

- Recollapsing/Closed Universe- If the mass of the Universe is greater than the expansion, gravity will collapse into the 'Big Crunch'.
- This Type of Universe would look like a sphere in shape.



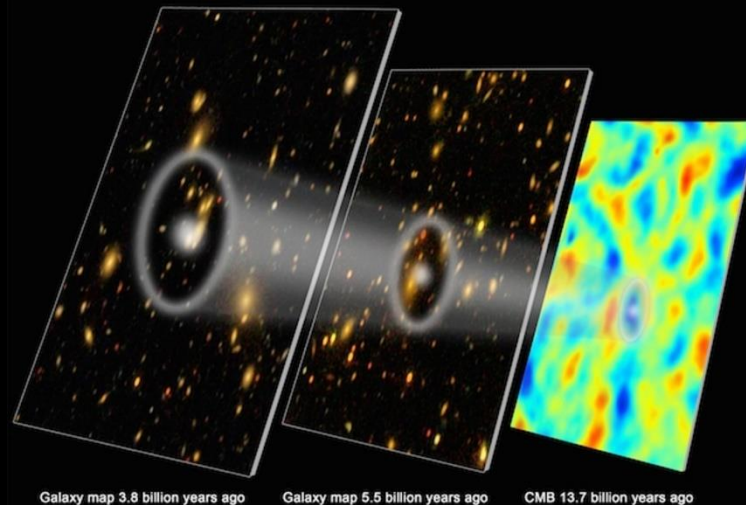
Cosmological Theories

- Coasting/Open Universe- If the mass of the Universe is less than the expansion, the Universe will not collapse but instead will expand forever.
- This Type of Universe would look like an open surface of a saddle.



Cosmological Theories

- Critical Universe- If the mass of the Universe equals the expansion, the Universe will not collapse but instead will expand less and less until $t=\infty$ when it comes to a stop.
- This Type of Universe would look like a flat tabletop.



Cosmological Theories

- Accelerating Universe- If the mass of the Universe is less than the expansion and certain repulsion forces add to the expansion, the Universe will not collapse but instead will expand forever accelerating faster and faster over time.
- This Type of Universe could look like any of the other three shapes.