

Preview:

The Cosmic Landscape



Astronomy

Preview: The Cosmic Landscape

Introduction

- **Astronomy** – the study of the “heavens”, the realm extending from beyond the Earth’s atmosphere to the most distant reaches of the Universe
 - *Astro* – the stars
 - *onomy* – rules, laws, and body of knowledge
- HUGE field to study! ...literally the largest
 - Included:
 - Planets with volcanoes that make Mt. Everest look like a sand mound
 - Stars with diameters 100x the Sun’s
 - Surfaces that rain acid
 - Enormous galaxies of whirling stars and clouds that make Earth almost invisible in size comparison



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Earth: Our Home!

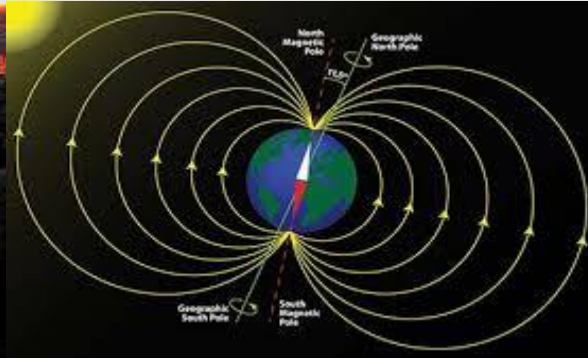
- **Planet** – a body in orbit around a star that is large enough to have taken on a round shape, and that has cleared the path of its orbit of all bodies of comparable size
 - We'll get into this more with solar systems
- **Earth** – our planet 😊
 - Should always be capitalized!
 - Home base, obviously, so almost all studying has to be done from here
 - we can't hop from planet to star to galaxy ourselves, so we have to study it from home (mostly)



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Earth: Our Home!

- Features astronomers focus on:
 - The center of Earth is hot from the lava and boiling water erupting from volcanoes and geysers
 - we can't get there, but it tells us what's going on inside
 - The hot moving motion inside is also what causes the magnetic field that reaches past the surface and out into space around the planet
 - These pull on the needle of a compass and also cause the shapes in the northern lights



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Earth: Our Home!

- Astronomers use what we know about Earth to anticipate similar situations on other planets and areas of the universe
 - Ex: Mars and Venus
- The internal, surface, and atmosphere studies of Earth all help astronomers!



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The Moon

- The Moon is our nearest satellite neighbor in space
- **Satellite** – a body orbiting a planet
 - Not always a machine!
 - We call those machines “satellites” because of how they move up there
- The Moon is a quarter of a million miles away from Earth
 - 384,400 km
- Held in place by Earth’s gravity
- Only about a quarter of Earth’s diameter
 - 1738 km (Earth = 6378 km)



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The Moon

- It's surface is very different from Earth's
 - Airless, pitted ball of rock that shows us the same face every night
- Why are they so different? ... Mass
 - Moon is about $1/80^{\text{th}}$ the mass of Earth
 - 7.349×10^{22} kg (Earth = 5.97×10^{24} kg)
 - This prevents it from having an atmosphere
- The gravity is too low to hold gases around it
 - Can't hold heat without atmosphere and inside doesn't make enough heat to keep replacing what escapes
 - No wind or rain from atmosphere means no erosion on the surface



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The Moon

- Because it hasn't changed in billions of years, it can tell astronomers what Earth was like when it was younger
- This is still the furthest place humans have ever traveled to
 - Mars isn't happening any time soon... we'll talk more later



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PAUSE! Scientific Notation

- Scientific notation is a system that uses the power of ten to help scientists with outrageously large numbers
 - *Trust me, we'll need this*
- Write numbers using 10 to an exponent

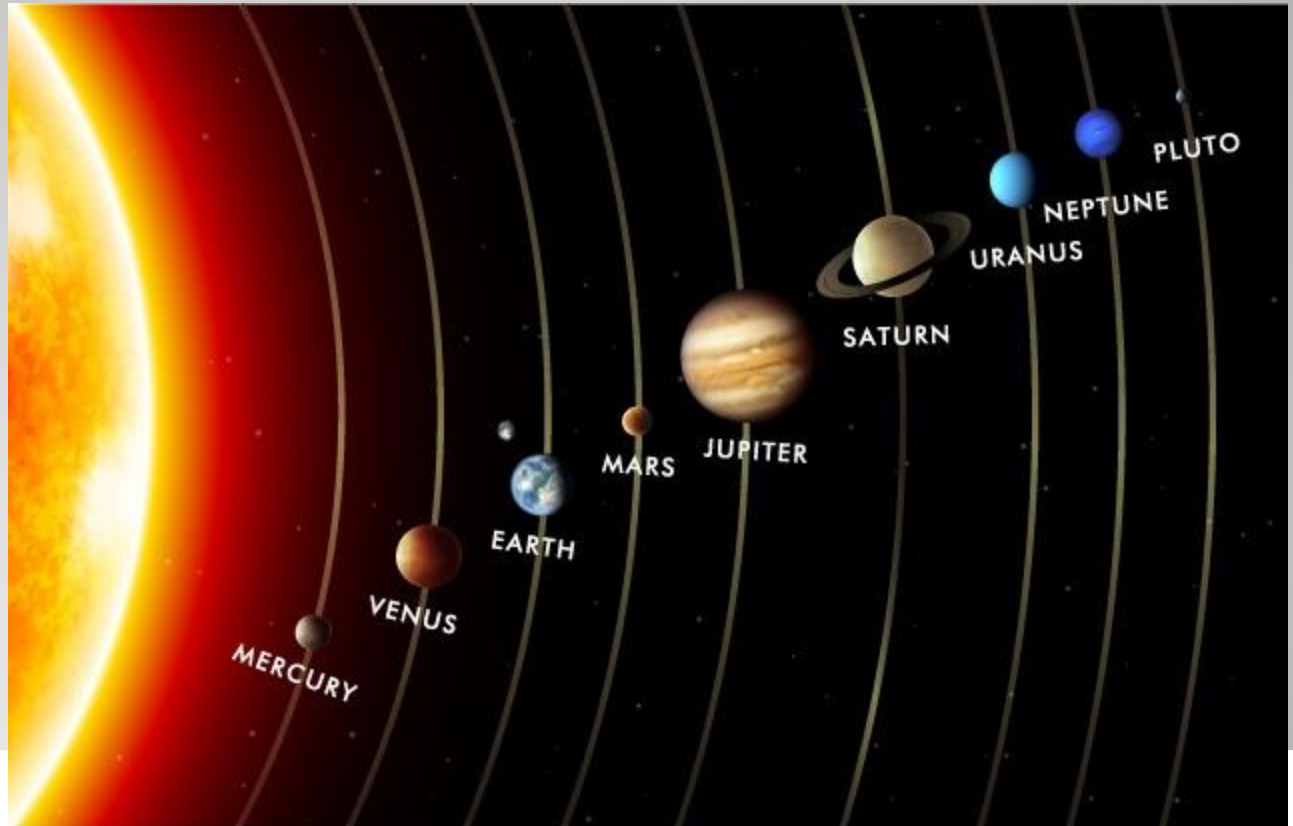
Conversions:

- One digit in front of the decimal $770 = 7.70 \times 10^2$
 - For the amount of places moved to the **left** the exponent **increases**
 - Left handed people are always the positive ones! 😊
 - For the amount of places moved to the **right** the exponent **decreases**

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The Planets

- 8 total planets around the Sun
 - No, Pluto does not count
 - In order:
 - Mercury
 - Venus
 - Earth
 - Mars
 - Jupiter
 - Saturn
 - Uranus
 - Neptune



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The Planets

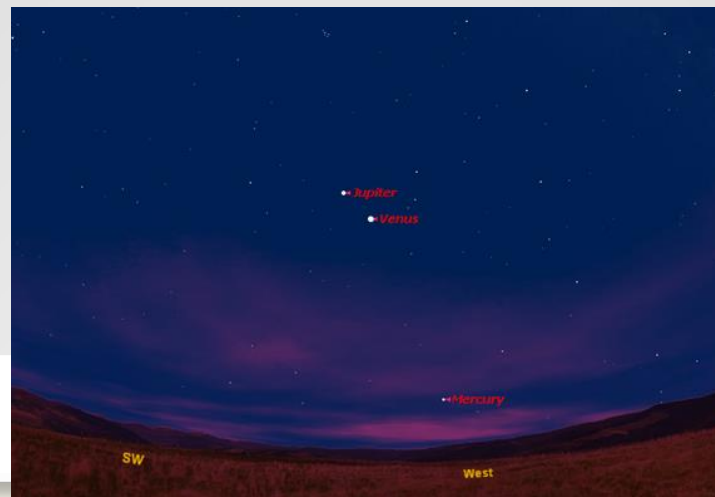
- Tidbit on each:
 - Mercury: ancient craters blasted out by asteroids
 - Venus: dense clouds of sulfuric acid droplets rain down
 - Earth: white clouds, blue oceans, green jungles, and red deserts
 - Mars: huge canyons and deserts spread across with possible ancient lakes and oceans
 - Jupiter: massive storms, one bigger than the whole Earth that has lasted for centuries!
 - Saturn: trillions of icy fragments orbit it making rings
 - Uranus: dark rings circle this one with a lopsided spin from a catastrophe in its distant past
 - Neptune: choking methane clouds whirl in the deep blue atmosphere



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The Planets

- Mercury, Venus, Mars, Jupiter, and Saturn are all visible to the naked eye from Earth (at some point)
 - they will look like stars in the night sky
 - Stars don't move, but the planets will slowly over time because of their orbits around the Sun
 - This is where their names came from
 - Ancient cultures named the “moving stars” after gods and goddesses



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The Planets

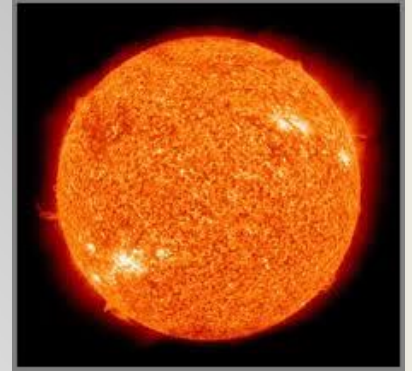
- The names of the days of the week also came from this
 - Ex: Saturday came from Saturn and Miércoles (Wednesday in Spanish) came from Mercury
- As far as we know currently, Earth is the only planet that has the ability to give rise to life forms of any sort
- Jupiter is the largest by far and weighs in at more than the rest of the planets combined... but it's still smaller than the Sun
 - Jupiter is 300x the size of Earth



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The Sun

- **Star** – a massive, gaseous body held together by gravity and generally emitting light through nuclear reactions in its interior



Sun

- More than 300,000x more massive than Earth
 - Sun = volleyball Earth = pinhead Jupiter = nickel
- Contains about 1000x more matter than all of the planets combined

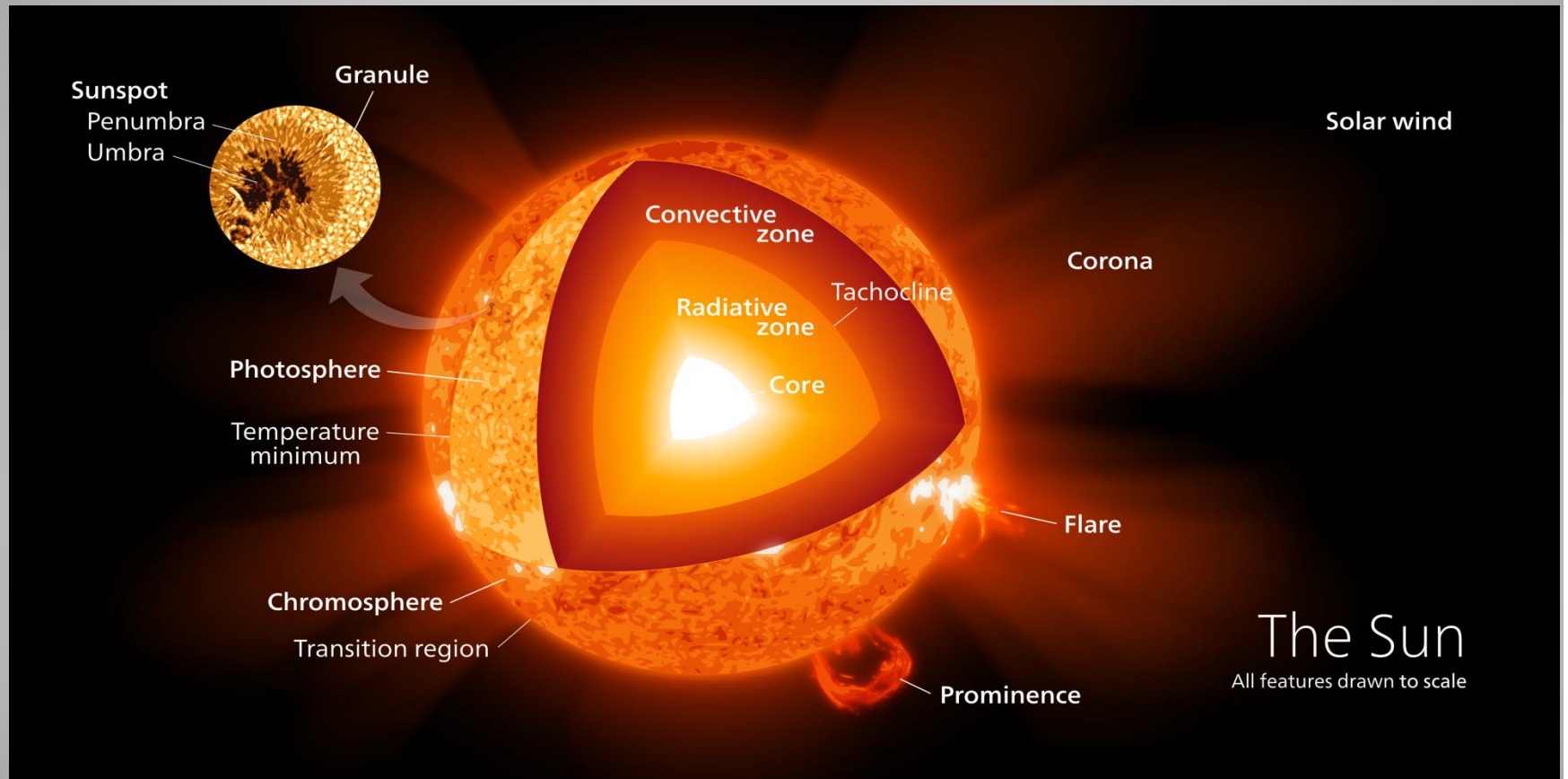
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The Sun

- Generates light energy from nuclear reactions in the core
 - Converts hydrogen into helium (H into He)
- This energy can't last forever
- Its over 4 billion years old at this point
- Studies show that it shouldn't run out for another 5 to 6 billion years and then fade away like a cooling ember
- Not only can astronomy allow scientists to compare currently, but it helps with studying the past and predicting the future of our own solar system

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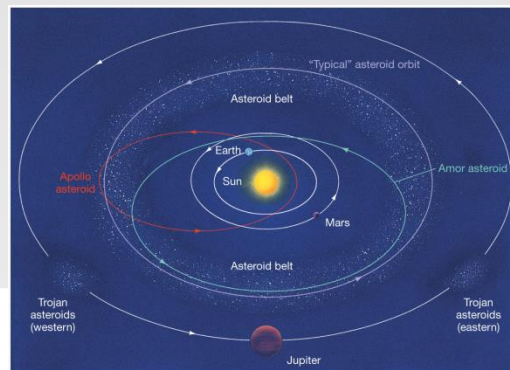
The Sun



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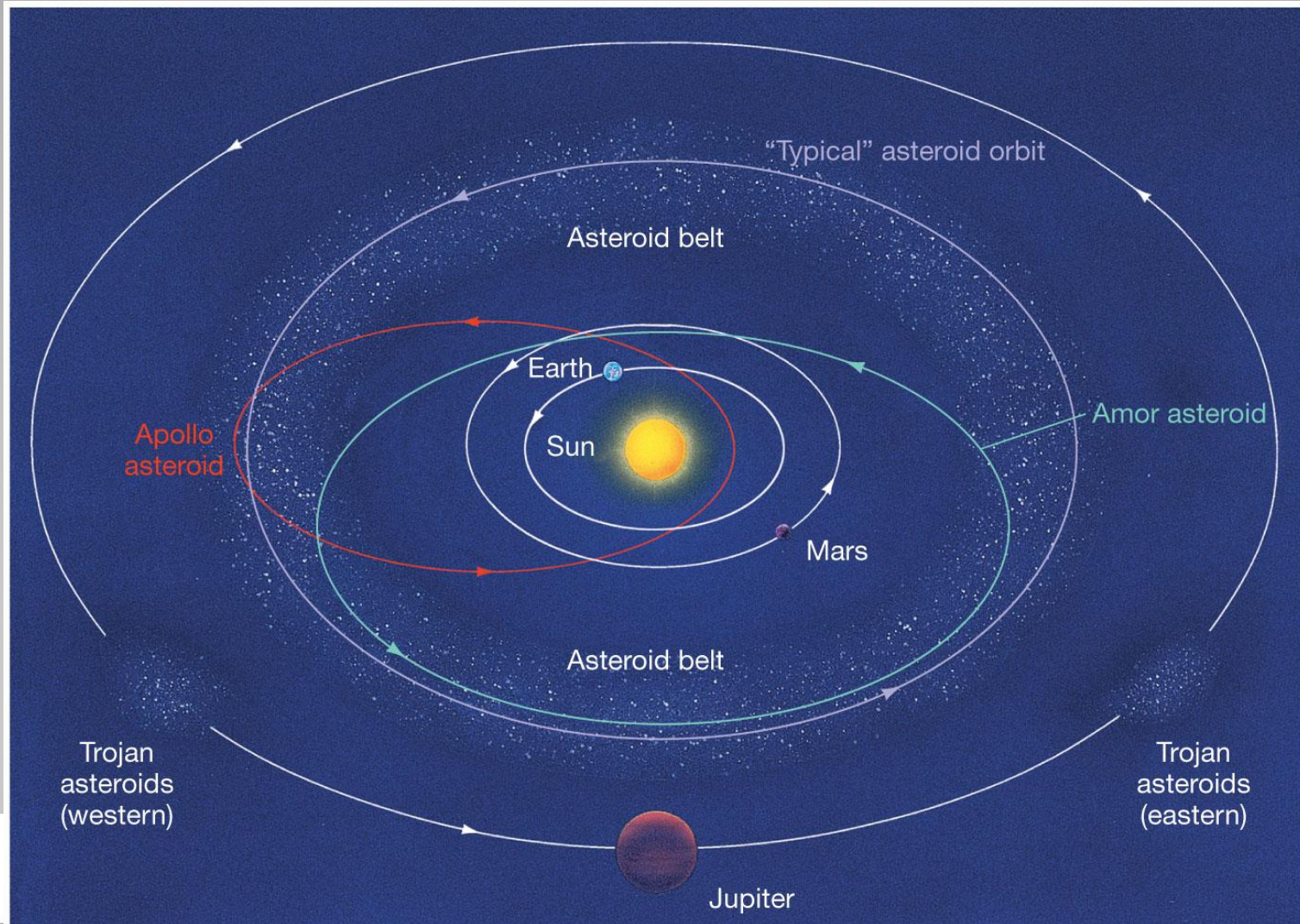
The Solar System

- **Solar System** – the Sun, planets, their moons, and other bodies that orbit the Sun
- Many smaller objects orbit the Sun, also
 - Ex: dwarf planets, asteroids, comets, etc.
- Most asteroids (big chunks of rock) orbit in a beltway between Mars and Jupiter
 - This is where you'll find the first dwarf planet, Ceres



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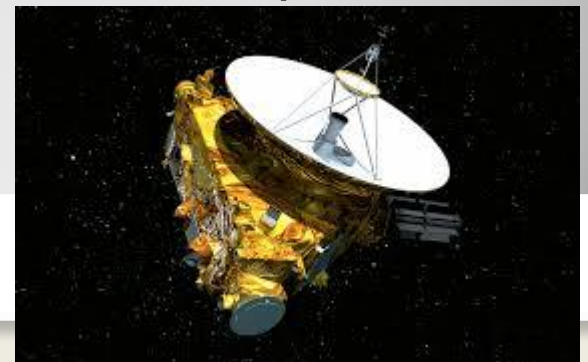
The Solar System



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The Solar System

- Behind Neptune is the new hot topic, Kuiper's Belt
 - This is the second asteroid belt with many unidentified, but definitely icy, objects both large and small
 - There are tons of dwarf planets, including Pluto, here
 - Astronomers didn't know much about this area until the newest spacecraft finally made its way out there
 - ***New Horizons*** space craft
 - Common place for comets (clusters of ice and dust)
- The span of the solar system from the Sun to Neptune is almost 300 billion miles
 - 4.4951×10^9 km!



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Astronomical Units

- **Astronomical Unit (AU)** – the average distance from Earth to the Sun
 - About 93 million miles (150 million kilometers)
 - Ex: Earth = 1 AU from the Sun
 - Mercury = .4 AU from the Sun
 - Neptune = about 30 AU from the Sun

$$\text{km} = \text{AU} \times 1.496 \times 10^8 \text{ km}$$

$$\text{AU} = \text{km} / 1.496 \times 10^8 \text{ km}$$

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Astronomical Units

$$\text{km} = \text{AU} \times 1.496 \times 10^8 \text{ km}$$

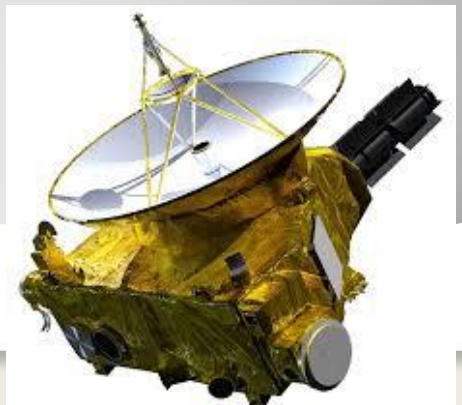
$$\text{AU} = \text{km} / 1.496 \times 10^8 \text{ km}$$

- Ex: Find the distance from Mars to the Sun in AUs
 - Mars = 2.279×10^8 km from the Sun
 - Mars = 2.279×10^8 km / 1.496×10^8 km
 - Mars = **1.52 AU** from the Sun

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Astronomical Units

- Some comets on the outskirts of Kuiper's Belt can be every bit of 100,000 AU away from the Sun
- The *Voyager* space craft (launched in 1977) held all of the records for speed and distance traveled by a spacecraft
- Now, these records are split between *Juno* and *New Horizons* as of July 2016
 - *Juno*: spacecraft sent to study Jupiter that arrived July 4, 2016
 - *New Horizons*: sent to study Kuiper's Belt and Pluto that reached Pluto on July 14, 2015



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Light-years

- Once astronomers start to study the outer skirts of our solar system, AUs end up being really large numbers
- **Light-year** – a unit of distance equal to the distance that light travels in one year
 - 2.998×10^8 m/s (actually its 299,792,458 m/s)
 - This is NOT a unit of time... a light-year is how FAR something is away



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The Milky Way

- **Milky Way Galaxy** – cloud of several hundred billion stars with a flattened shape like the solar system
- The galaxy that the Sun and our system belong to
- Other *spiral arms* of our galaxy can be seen from Earth and look milky in the night sky



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The Milky Way

- spans about 100,000 ly across
- The Sun orbits about 27,000 ly from the center at about 150 miles per second! (woah....)
- Some stars in the Milky Way are 100x larger than the Sun, others 100x smaller
- Stars intermingle with gas and dust clouds ← much bigger than our solar system!
 - Size comparison: our solar system to the galaxy is a grain of sand to an entire coastline



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The Milky Way

- The stars of the galaxy are extremely spread out
 - The closest is 4.2 ly away (25 trillion miles)
 - Distance comparison: both the Sun and the nearest star are both the size of a pinhead, they would be 35 miles apart and the space in between them would be nearly empty!



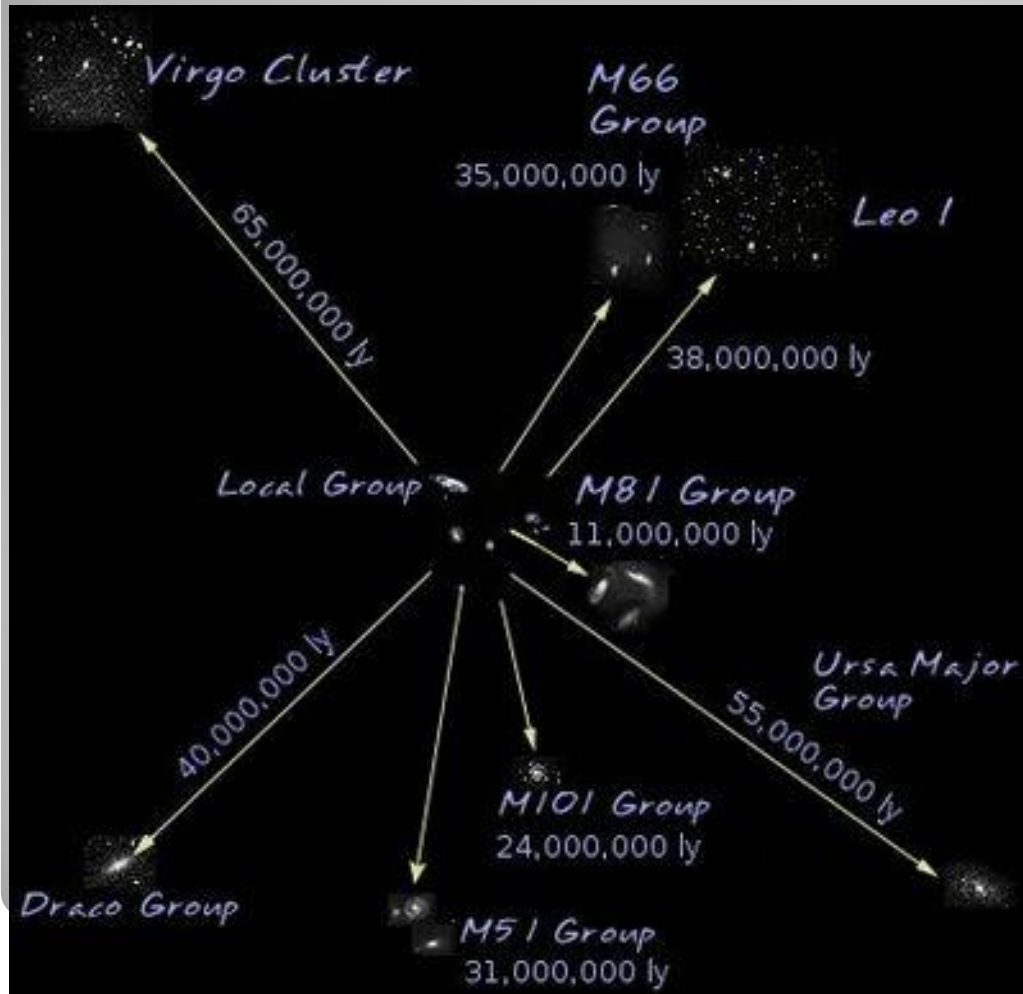
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Galaxy Clusters and the Universe

- **Galaxy Clusters** – a group of galaxies held together by their mutual gravity
- The Milky Way belongs to the *local group*
 - The local group is the “local” group of several dozen galaxies
 - These can still be a few million light years in diameter
- **Virgo Supercluster** – the cluster of galaxy clusters in which the Milky Way is located
- **Universe** – the largest astronomical structure we know of which contains all matter, all energy, and encompasses all space

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Galaxy Clusters and the Universe



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Galaxy Clusters and the Universe

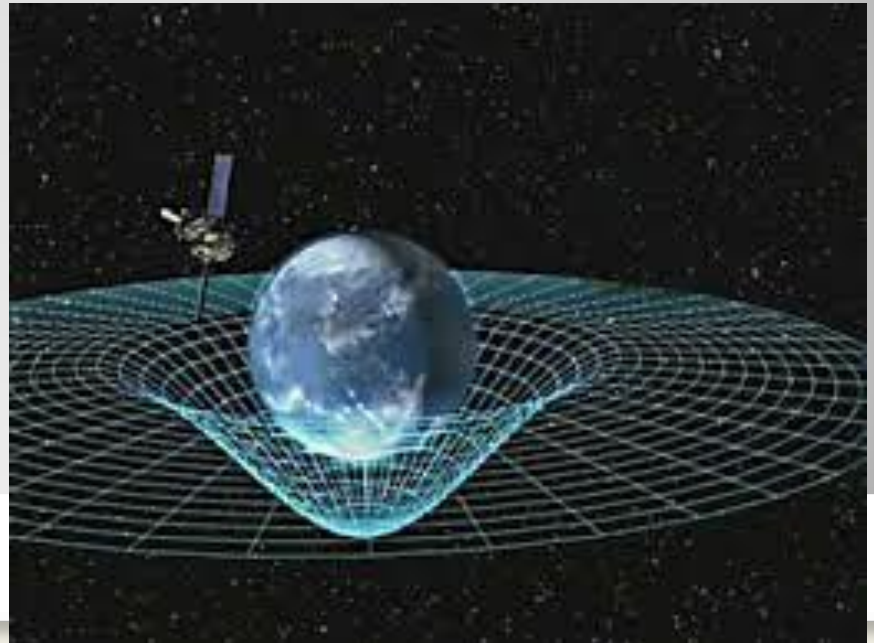
- Astronomers think that the visible universe is about 13.8 billion years old
 - That's the light from the most distant visible galaxies that takes nearly the age of the Universe to reach us , so what we see is them when they first formed
- Even though we have a figure for the visible universe, that doesn't mean we know the extent of the full universe
- Astronomers don't fully understand how the orderly structure of the universe originated, they do know it is gravity related



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Forces and Matter

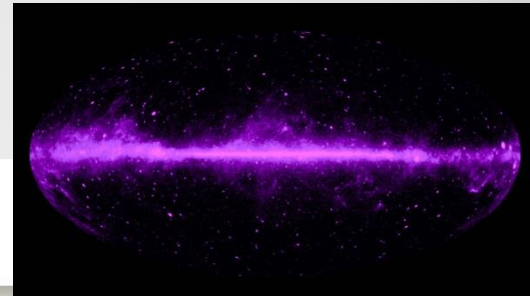
- **Gravity** – the force of attraction that is between two bodies and is generated by their masses
 - You experience this everyday in multiple ways even though you may not realize it
 - The same force that pulls a falling book to the floor is the same force that keeps satellites in orbit



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The Still Unknown Universe

- Evidence shows astronomers that the bulk of the universe is full of dark matter
- **Dark Matter** – matter that emits no detectable radiation but whose presence can be deduced by its gravitational attraction on other bodies
 - Got its name because it gives off a type of energy astronomers have never seen anywhere around us or territories that we know of
 - Its completely black and non detectable
 - Seems to outweigh illuminated matter 5 to 1!



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The Still Unknown Universe

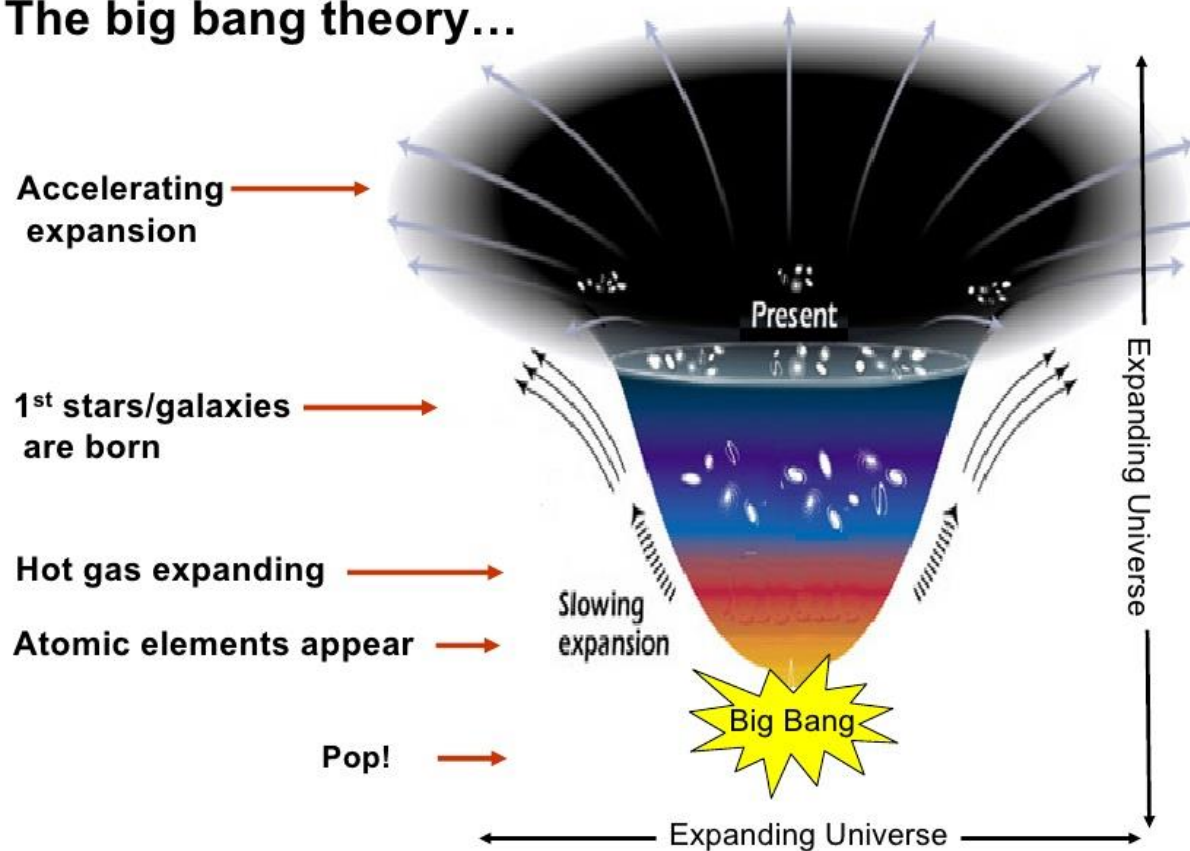
- Particles much larger than our protons, neutrons, and electrons are what astronomers think *could* be out there
 - This justifies the high gravity explanation
- Galaxies in the universe are moving apart through the great cosmic expansion
- **Big Bang** – an evidential event that created the universe
 - Occurred about 13.8 billion years ago and generated the expanding motion that we observe today!
 - Full scientific theory (just like the cell theory)



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The Still Unknown Universe

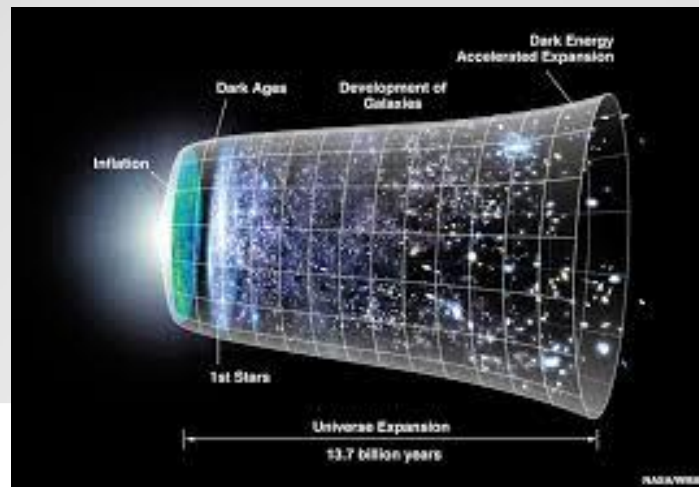
The big bang theory...



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The Still Unknown Universe

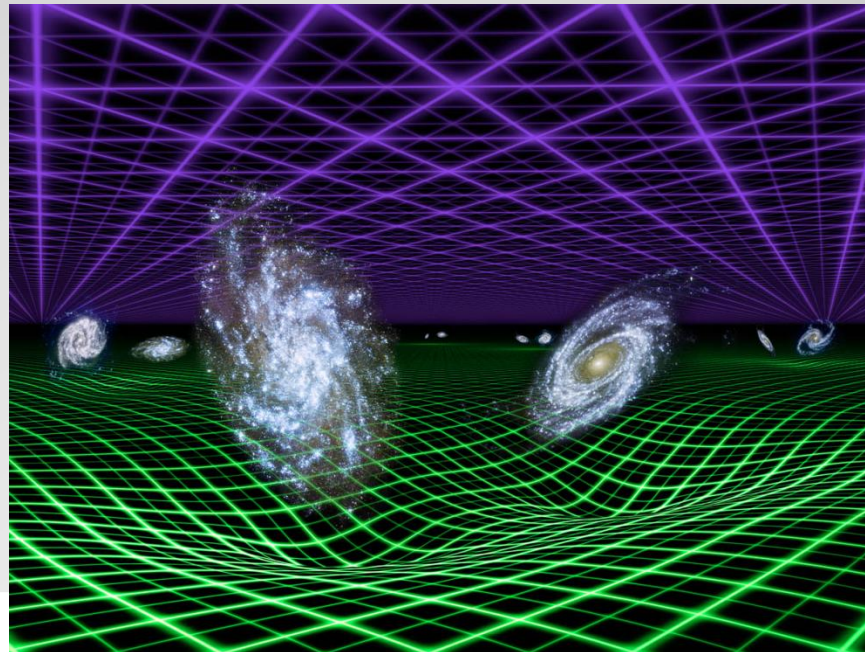
- The rate of expansion is speeding up
 - Something stronger is overtaking the gravity between the galaxies and causing them to spread apart
- **Dark Energy** – a form of energy detected by its effect on the expansion of the universe
 - The nature and properties (characteristics) are unknown



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The Still Unknown Universe

- After calculations, the luminous mass we can detect only accounts for 1% of the universe as we know it
 - What we see of the universe is like footprints of an invisible creature: a being who leaves tracks, but whose build and nature we don't know



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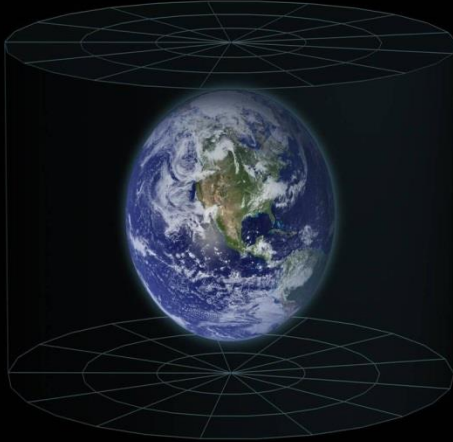
The Scale of the Universe

Object	Approximate Radius
Earth	6,400 km
Sun	700,000 km
Earth's Orbit	150 million km (1 AU)
Solar System to Neptune	30 AU
Milky Way Galaxy	50,000 ly
Local Group	2.5 million ly
Local Supercluster	50 million ly
Visible Universe	13.8 billion ly (and growing)

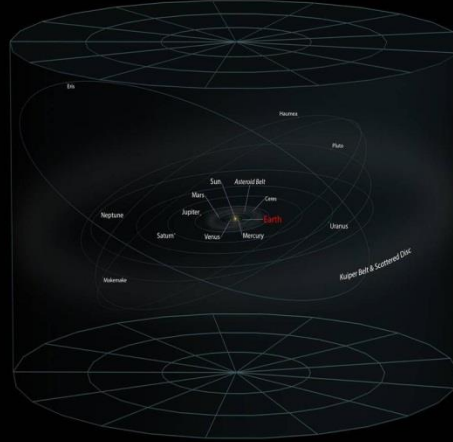
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The Scale of the Universe

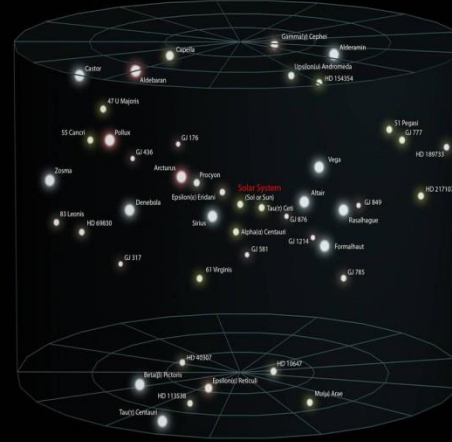
Earth



Solar System



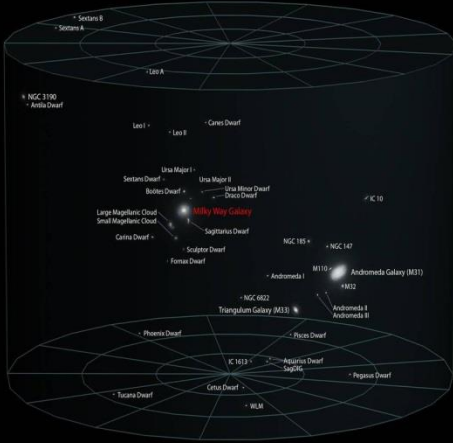
Solar Interstellar Neighborhood



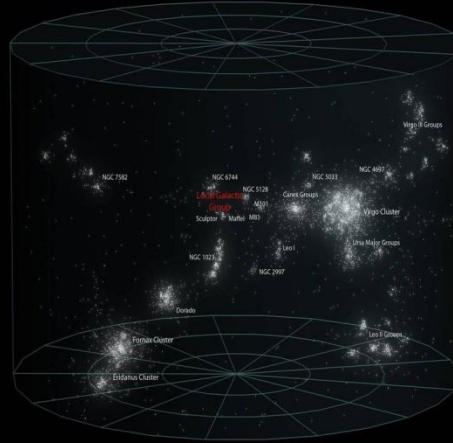
Milky Way Galaxy



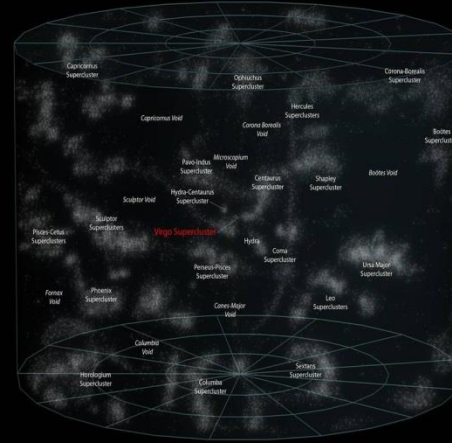
Local Galactic Group



Virgo Supercluster



Local Superclusters



Observable Universe

